【特許請求の範囲】
【請求項１】　笹及び／又は竹のパルプから製造してなる笹・竹紙において、該笹・竹紙の製造工程中に所定量の笹・竹粉末及び珪藻土粉末を混合したことを特徴とする笹・竹紙．
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、例えば空気浄化紙、消臭紙、水の沪過紙等様々な用途に用いて好適な笹・竹紙に関する．
【０００２】
【従来の技術】我が国において笹・竹（以下笹と総称する）は豊富な天然資源であって様々な用途に用いられているが、これらを原料とした笹・竹紙も知られている．従来の笹・竹紙は、一般に乾燥した笹を適当な長さに切断し、これを水と苛性ソーダで煮沸してリグニンを溶化し、笹のパルプを生成した後水により洗浄したパルプを紙漉き器を用いて漉く方法により製造している．
【０００３】
【発明が解決しようとする課題】ところで、前述した従来技術にあっては、木材パルプを用いる製紙方法とほぼ同様の方法を用いているため、笹の香が殆ど失われてしまうという欠点がある．また、従来の笹・竹紙は木材パルプ紙に見られない笹の繊維による風合いを楽しむ程度にしか利用されていないという問題点もある．
【０００４】本発明は上述した従来技術の欠点、問題点に鑑みなされたもので、多方面に利用することができ、また我が国において豊富な笹・竹、珪藻土の有効利用ができる笹・竹紙を提供することを目的とする．
【０００５】
【課題を解決するための手段】上述した課題を解決するために構成された本発明の手段は、笹及び／又は竹のパルプから製造してなる笹・竹紙において、該笹・竹紙の製造工程中に所定量の笹・竹粉末及び珪藻土粉末を混合したことにある．
【０００６】
【作用】笹・竹粉末を混合することによって笹・竹の香を発散し、また珪藻土粉末を混合することによって気液体の吸収能力を有する．
【０００７】
【実施例】以下、本発明の実施例を詳述する．まず、材料として使用する笹及び／又は竹には採取する年に生育した若笹、若竹を用いるのが好ましい．採取した後、笹の幹、葉はカビによって黒色に変化するのを防ぐために、日陰で十分に乾燥させる．乾燥した笹はカッター等の適宜の切断手段を用いて５～１０ｍｍの切断片に形成する切断片形成工程を行う。
【０００８】次に、適当量の切断片を耐熱性容器に入れ、これに適当量の水と投入した切断片の量に対して重量比２０％の苛性ソーダを加えて約３～６時間煮沸し、リグニンを溶出して笹・竹パルプを生成する．この煮沸時間はリグニンが溶出してセルロースが分離し易くなる程度を目安とする．
【０００９】次に、得られたパルプを水で洗浄してアルカリ分を除去した後、ビーターに入れて解繊し、更に乾燥して笹の繊維を生成する．他方、製造しようとする笹・竹紙の用途、例えば消臭紙、空気浄化紙、沪過紙、壁紙等といった用途に応じて笹の幹、葉を１００～３００メッシュに粉砕し、笹の粉末を用意する、また、珪藻土は酸処理或は公知の焼成処理を行って白色化すると共に、乾燥して粉末状にしておく．
【００１０】しかる後、水１００ｇ、笹の繊維２０ｇ、糊空木の粘液１ｇを混合し、これに前記笹の粉末５～１０ｇ及び珪藻土粉末５～１０ｇを添加し、十分に撹拌して笹の懸濁液を作る．この笹の粉末及び珪藻土粉末の添加量が多すぎると所謂腰がなく、簡単に裂けてしまう笹・竹紙が出来てしまうので注意を要する．
【００１１】上述の如くして笹の懸濁液を生成したら漉き網に製造しようとする紙の厚さ、約１～５ｍｍ分の笹の懸濁液を均一に注ぎ込み、６０℃以下の温度でゆっくりと乾燥して固化させることにより、本実施例による笹・竹紙を製造する．なお、上述した乾燥方法としては、２４時間程度の時間をかけて自然乾燥させてもよいし、温風を使用して８時間程度の強制乾燥の方法を採ってもよい．
【００１２】叙上の如くして製造された笹・竹紙は成分に笹粉末を加えてあるから、従来の製造方法では失われてしまった笹の香を発散することができる．また、珪藻土粉末を加えることにより笹・竹紙を多孔質にできる結果、気液体の吸収能力を持つことができる．
【００１３】そこで、本実施例の笹・竹紙は上述した特質を活かした利用の仕方として、下記の例を挙げることができる．１に、笹・竹紙を名刺サイズに裁断し、５ｍｍほどの厚さになるように数枚重ねて布袋に入れたものを直接肌に貼ったり、下着に付着したり或は枕元に置いたりすることにより、森林浴的効果を図る．
【００１４】２に、笹・竹紙を例えば３ｍｍ四方の大きさに裁断し、この裁断片を湿気や折損から保護するためにポリエチレン等の通気性のある材料で包んで靴の内側や靴下に貼付けて、消臭効果を図る．３に、５ｍｍ程度の厚さに製造した笹・竹紙を内装紙として壁、天井に貼付することにより、森林浴的効果、防音効果、空気浄化効果、電磁波軽減効果等を図る．
【００１５】４に、１ｍｍ程度の厚さに製造した笹・竹紙を水道の蛇口に取付け、水道水中に含まれている塩素を除去する沪過紙として用いる．これにより１ｐｐｍの塩素濃度を０，２ｐｐｍ程度に低減できる．
【００１６】なお、本発明による笹・竹紙は実施例で述べた使用例に限られるものではなく、使用者の着想によって種々の用途に使用できるものである．

Kimberly Clark EX1002, p. 1958
PGR2026-00078

【００１７】

【発明の効果】本発明は以上詳述した如くであって、笹・竹紙の製造工程において笹・竹粉末及び珪藻土粉末を加えるようにしたから、風合いだけであった従来の笹・竹紙にはなかった笹・竹の香を持った笹・竹紙にできる。また、気液体の吸収能力を有するから、消臭、防音、空気浄化、沪過等の目的に使用することができる。更に、我が国において豊富に繁殖しているにも拘らず十分に活用されていない笹・竹を有効利用できるし、豊富に埋蔵している珪藻土を使用するから、天然資源の活用と製紙コストの低減を図ることができる。

Bamboo grass/bamboo paper

Abstract

PURPOSE:To provide the bamboo grass/bamboo paper capable of exhibiting effects such as forest bathing, deodorization and air purification and capable of being used in various fields such as filter paper and wall paper for preventing sounds and reducing electromagnetic waves.
CONSTITUTION:Dried bamboo grasses and/or bamboos are cut into 5-10mm long pieces with a cutter, etc., and a proper amount of the cut pieces are fed in a heat-resistant vessel containing water, mixed with sodium hydroxide in an amount of 20wt.% based on the weight of the fed cut pieces, and subsequently the mixture is boiled for approximately 3-6hr. When lignin in the bamboo glass/bamboo is eluted to facilitate the decomposition of the cellulose tissues, the pulp is washed with water for the removal of the alkali, subjected to the decomposition of the pulp tissues and subsequently dried to produce the bamboo grass/bamboo dry fibers. 100 pts.wt. of water, 20 pts.wt. of the bamboo grass/bamboo fibers, 1 pt.wt. of the solution of hydrenges paniculata Sieb. 1-5 pts.wt. of bamboo grass/bamboo powder having a particle size of 100-300 mesh, and 1-5 pts.wt. of diatomaceous earth powder are mixed with each other, and subsequently sufficiently stirred to produce a fiber suspension. The fiber suspension is processed into paper on a paper-producing net, dehydrated and dried to provide the bamboo grass/bamboo paper.

JPH05321190A

Japan

Find Prior Art Similar

Other languages: Japanese

Inventor: Shingo Kikuchi, 慎吾 菊地

Current Assignee : Individual

Worldwide applications

1992 JP

Application JP14846992A events

1992-05-14	Application filed by Individual
1992-05-14	Priority to JP14846992A
1993-12-07	Publication of JPH05321190A
2001-07-09	Application granted
2001-07-09	Publication of JP3184999B2
2016-07-09	Anticipated expiration
Status	Expired - Fee Related

Info: Cited by (7), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Claims (1)

Hide Dependent
translated from Japanese

[Claims] 1. Bamboo grass / bamboo paper manufactured from bamboo and / or bamboo pulp, characterized in that a predetermined amount of bamboo grass / bamboo powder and diatomaceous earth powder are mixed during the manufacturing process of the bamboo grass / bamboo paper. · Bamboo paper.

Description

translated from Japanese

Detailed Description of the Invention

[0001]

BACKGROUND OF THE INVENTION 1. Field of the Invention The present invention relates to bamboo and bamboo paper suitable for various purposes such as air purifying paper, deodorant paper, water filter paper and the like

[0002]

2. Description of the Related Art In Japan, bamboo grass and bamboo (collectively referred to as bamboo grass) are abundant natural resources and are used for various purposes, and bamboo grass and bamboo paper made from these are also known.
Conventional bamboo and bamboo paper are generally prepared by cutting dry bamboo into appropriate lengths, boiling this with water and caustic soda to dissolve the lignin, producing bamboo pulp, and then washing the pulp with water using a paper strainer. It is manufactured by using the straining method

[0003]

By the way, in the above-mentioned prior art, since a method substantially similar to the paper making method using wood pulp is used, there is a drawback that the aroma of bamboo grass is almost lost. .. There is also a problem that conventional bamboo and bamboo paper are used only to the extent that they can enjoy the texture of bamboo fibers, which is not found in wood pulp paper

The present invention has been made in view of the above-mentioned drawbacks and problems of the prior art, and can be used in various fields.
It is also an object of the present invention to provide bamboo and bamboo paper which can effectively utilize abundant bamboo and bamboo and diatomaceous earth in Japan.

[0005]

[Means for Solving the Problems] The means of the present invention configured to solve the above-mentioned problems is a bamboo / bamboo paper manufactured from bamboo and / or bamboo pulp, and a process for manufacturing the bamboo / bamboo paper. It is that a predetermined amount of bamboo powder and bamboo powder and diatomaceous earth powder were mixed therein.

[0006]

[Function] By mixing bamboo powder and bamboo powder, the aroma of bamboo and bamboo is emitted, and by mixing diatomaceous earth powder, it has the ability to absorb gas and liquid.

[0007]

EXAMPLES Examples of the present invention will be described in detail below. First, as bamboo grass and / or bamboo used as a material, it is preferable to use young bamboo grass and young bamboo grown in the year of collection. After harvesting, the stems and leaves of bamboo shoots should be thoroughly dried in the shade to prevent the mold from turning black. The dried bamboo shoot is subjected to a cut piece forming step of forming a cut piece of 5 to 10 mm by using an appropriate cutting means such as a cutter.

Next, an appropriate amount of cut pieces is placed in a heat-resistant container, and an appropriate amount of water and caustic soda in a weight ratio of 20% with respect to the amount of cut pieces are added to this and boiled for about 3 to 6 hours. ,
Lignin is eluted to produce bamboo and bamboo pulp. This boiling time is based on the extent that lignin is eluted and cellulose is easily separated.

Next, the obtained pulp is washed with water to remove the alkali content, placed in a beater for disintegration and further dried to produce bamboo fibers. On the other hand, depending on the intended use of bamboo / bamboo paper, for example, deodorant paper, air purifying paper, filter paper, wallpaper, etc., 100 to 300 bamboo trunks and leaves are used.
Bamboo powder is prepared by crushing it into a mesh, and diatomaceous earth is whitened by acid treatment or known baking treatment, and dried to be powdered.

Then, 100 g of water, 20 g of bamboo fiber,
Mix 1 g of glutinous wood mucus and add 5 to 1 of the above-mentioned bamboo powder.
0 g and 5 to 10 g of diatomaceous earth powder are added, and the mixture is thoroughly stirred to form a bamboo suspension. If the added amount of the powder of bamboo grass and the diatomaceous earth powder is too large, so-called stiffness and bamboo paper that easily tears can be formed, so caution is required.

When the bamboo suspension is produced as described above, the bamboo suspension having a thickness of about 1 to 5 mm, which is the thickness of the paper to be produced, is uniformly poured into the mesh net, and the temperature is kept at 60 ° C. or lower. The bamboo and bamboo paper according to this example is manufactured by slowly drying and solidifying. In addition, as the above-mentioned drying method,
It may be naturally dried for about 24 hours,
You may employ the method of forced drying for about 8 hours using warm air.

Since bamboo powder and bamboo paper produced as described above have bamboo powder added to their components, the aroma of bamboo which has been lost by the conventional production method can be released. In addition, since bamboo grass and bamboo paper can be made porous by adding diatomaceous earth powder, it is possible to have a gas-liquid absorbing ability.

Therefore, the bamboo / bamboo paper of this embodiment can be used in the following examples ss a way of utilizing the above characteristics. 1, cut bamboo and bamboo paper into business card size, 5m
The effect of forest bathing is achieved by putting several pieces stacked in a cloth bag so as to have a thickness of about m on the skin directly, attached to underwear, or placed on the bedside.

2, bamboo and bamboo paper are cut into a size of, for example, 3 mm square, wrapped with a breathable material such as polyethylene to protect the cut pieces from moisture and breakage, and attached to the inside of shoes or socks. To achieve deodorizing effect. By attaching bamboo / bamboo paper with a thickness of about 5 mm to the walls and ceiling as an interior paper, the effects of forest bathing, soundproofing, air purification, electromagnetic wave reduction, etc. are achieved.

In 4, a bamboo / bamboo paper manufactured to a thickness of about 1 mm is attached to a tap of a tap and used as a filter paper for removing chlorine contained in tap water. As a result, the chlorine concentration of 1 ppm can be reduced to about 0.2 ppm.

The bamboo / bamboo paper according to the present invention is not limited to the use examples described in the embodiments, but can be used for various purposes according to the idea of the user.

[0017]

EFFECTS OF THE INVENTION The present invention is as described in detail above. Since bamboo grass powder and bamboo powder and diatomaceous earth powder are added in the manufacturing process of bamboo grass paper, the conventional bamboo grass
Bamboo paper and bamboo paper with a scent of bamboo that can not be found in bamboo paper can be made. Further, since it has a gas-liquid absorbing ability, it can be used for the purpose of deodorization, soundproofing, air purification, filtration and the like.
Furthermore, since bamboo and bamboo, which are abundantly bred in Japan but not fully utilized, can be effectively used, and diatomaceous earth that is abundantly abundant is used, utilization of natural resources and reduction of papermaking costs Can be planned.

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WO2007008675A1 *	2005-06-30	2007-01-11	Kwon-Hyok Lee	Process for producing pulp utilizing bamboo and pulp and papers produced using the same
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KR100866041B1 *	1998-06-17	2008-10-30	나일 화이버 펄프 앤드 페이퍼 인코. 포레이티드	Arundo donax pulp, paper products, and particle board
CN100447772C *	2007-02-06	2008-12-10	新郑金广信有限责任公司	Production technology of thermomechanical bamboo pulp
EP2758593A4 *	2011-09-21	2015-04-29	Kimberly Clark Co	Tissue product comprising bamboo
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Family To Family Citations

* Cited by examiner, † Cited by third party, ‡ Family to family citation

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JP4208047B2	2009-01-14	Method for producing paper containing licorice
KR100302284B1	2001-12-17	Manufacturing method of loquat tea
SU741778A3	1980-06-15	Method of manufacturing smoking material from tobacco plants
JPH10310992A	1998-11-24	Paper containing bamboo grass leaf component blended therein
KR101088386B1	2011-12-01	Paper including green tea and manufacturing method of the same

Priority And Related Applications

Priority Applications (1)

Application	Priority date	Filing date	Title
JP14846992A	1992-05-14	1992-05-14	Bamboo and bamboo paper

Applications Claiming Priority (1)

Application	Filing date	Title
JP14846992A	1992-05-14	Bamboo and bamboo paper

Legal Events

Date	Code	Title	Description
2004-05-25	R250	Receipt of annual fees	Free format text: JAPANESE INTERMEDIATE CODE: R250
2005-05-17	R250	Receipt of annual fees	Free format text: JAPANESE INTERMEDIATE CODE: R250
2006-04-25	R250	Receipt of annual fees	Free format text: JAPANESE INTERMEDIATE CODE: R250
2007-05-15	R250	Receipt of annual fees	Free format text: JAPANESE INTERMEDIATE CODE: R250

2008-05-20	FPAY	Renewal fee payment (prs date is renewal date of database)	**Free format text:** PAYMENT UNTIL: 20090511 **Year of fee payment:** 8
2009-04-16	FPAY	Renewal fee payment (prs date is renewal date of database)	**Free format text:** PAYMENT UNTIL: 20090511 **Year of fee payment:** 8
2009-04-21	FPAY	Renewal fee payment (prs date is renewal date of database)	**Year of fee payment:** 9 **Free format text:** PAYMENT UNTIL: 20100511
2010-05-25	FPAY	Renewal fee payment (prs date is renewal date of database)	**Free format text:** PAYMENT UNTIL: 20110511 **Year of fee payment:** 10
2011-05-24	FPAY	Renewal fee payment (prs date is renewal date of database)	**Free format text:** PAYMENT UNTIL: 20120511 **Year of fee payment:** 11
2012-05-11	LAPS	Cancellation because of no payment of annual fees	

Concepts

machine-extracted

Download Filter table

Name	Image	Sections	Count	Query match
Bambusa arundinacea		title,claims,abstract,description	85	0.000
Bambusa tulda		title,claims,abstract,description	85	0.000
Phyllostachys viridis		title,claims,abstract,description	85	0.000
Bambuseae		title,claims,abstract,description	84	0.000
bamboo		title,claims,abstract,description	84	0.000
Ischaemum muticum		title,claims,abstract,description	21	0.000
powder		claims,abstract,description	21	0.000
Kieselgur		claims,abstract,description	11	0.000
silicium dioxide		claims,abstract,description	11	0.000
manufacturing process		claims,description	4	0.000
sodium hydroxide		abstract,description	9	0.000
water		abstract,description	9	0.000
fiber		abstract,description	7	0.000
suspension		abstract,description	5	0.000
boiling		abstract,description	4	0.000
lignin		abstract,description	4	0.000
air purification		abstract,description	3	0.000
bathing		abstract,description	3	0.000
mixture		abstract,description	3	0.000
alkali		abstract,description	2	0.000
cellulose		abstract,description	2	0.000
cellulose		abstract,description	2	0.000
deodorization		abstract,description	2	0.000
decomposition reaction		abstract	2	0.000
tissues		abstract	2	0.000
Bambusa		abstract	1	0.000
Hydrangea paniculata		abstract	1	0.000

⊗ exhibiting	abstract	1	0.000
⊗ glass	abstract	1	0.000
⊗ particle	abstract	1	0.000
Show all concepts from the description section			

Data provided by IFI CLAIMS Patent Services

(19) 대한민국특허청(KR)
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대전광역시 유성구 신성동 한울A 109-804
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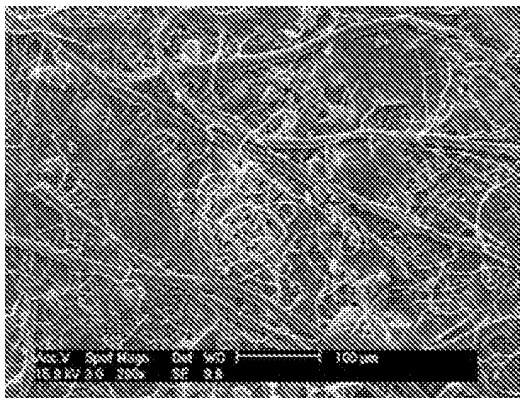
전체 청구항 수 : 총 6 항 심사관 : 김정희

(54) 컬이 형성된 홍조류 섬유를 포함하는 한지

(57) 요 약

본 발명은 한지의 생산과정에서 탈수성을 증가시키기 위하여 인위적으로 컬을 형성한 홍조류 섬유를 배합하는 한지 생산기술에 관한 것이다. 본 발명에 따라 컬이 형성된 홍조류 섬유를 포함하는 한지는 불투명도와 평활도가 우수할 뿐만 아니라 탈수성이 양호하여 초지가 수월하다는 장점이 있으며, 한지의 맛을 그대로 살릴 수 있고 기존의 한지처럼 보존성이 우수하여 서적 용지, 사전 용지, 보존용 인쇄용지 및 서예용이나 고급 화선지 등으로 사용할 수 있다.

대 표 도 - 도5



Kimberly Clark EX1002, p. 1965
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특허청구의 범위

청구항 1

컬을 형성한 홍조류 섬유를 포함하여 제조된 탈수성이 향상된 한지.

청구항 2

청구항 1에 있어서,

상기 컬을 형성한 홍조류 섬유는 한지 총 중량에 대해 1~50중량% 함유됨을 특징으로 하는 한지.

청구항 3

청구항 1에 있어서,

상기 컬을 형성한 홍조류 섬유는 ISO 백색도가 50~99%인 것을 특징으로 하는 한지.

청구항 4

청구항 1에 있어서,

상기 컬을 형성한 홍조류 섬유는 니더(Kneader) 또는 디스퍼서(Disperser)를 이용하여 컬을 형성한 것임을 특징으로 하는 한지.

청구항 5

청구항 1에 있어서,

상기 한지는 수록지 또는 기계 한지인 것을 특징으로 하는 한지.

청구항 6

홍조류 섬유에 니더(Kneader) 또는 디스퍼서(Disperser)를 이용하여 컬을 형성하여 탈수성을 향상시킨 홍조류 섬유를 포함하는 한지 제조방법.

청구항 7

삭제

명 세 서

발명의 상세한 설명

기 술 분 야

<1> 본 발명은 컬이 형성된 홍조류 섬유를 포함하는 한지에 관한 것이다.

배 경 기 술

<2> 한지는 닥나무, 삼지닥나무, 안피 및 마 등의 인피섬유를 원료로 하여 제조되는 우리나라 고유의 종이이다. 인피섬유는 화학펄프로 사용하는 침엽수의 섬유길이(3㎜)나 활엽수의 섬유길이(1㎜)보다 훨씬 긴 섬유길이(10㎜)를 가지고 있어서 목재 펄프에 비하여 조직 자체의 강도가 뛰어나고 섬유의 결합성도 뛰어나서 질긴 종이를 만들 수 있다.

<3> 한지는 일반종이보다 부드러운 감촉, 유연한 접힘, 강인성 및 먹물에 대한 발묵현상이 뛰어나고, 모든 색상을 발현할 수 있으며, 빠른 흡수성으로 물속에서도 질기며, 방음성과 계절에 따른 방한성과 보온성 등이 뛰어나 오랜 세월이 지나도 종이의 특성이 변하지 않는 성질을 가지고 있다. 특히 한지는 천년을 견디는 종이로 알려져 있으며, 무구정광대다라니경의 경우 8세기에 만들어진 것으로 알려져 천년이 지난 지금도 여전히 문화재적 가치를 지니는 한지로 기록되고 있다.

<4> 전통한지는 옛날 방식으로 만들어진 한지로서, 전통한지의 제조방법은 다음과 같다.

Kimberly Clark EX1002, p. 1967
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<5> 먼저 닥나무, 삼지닥나무, 안피 등 한지 원료를 겨울철에 수확한다. 수확된 한지 원료를 닥무지 공정 처리한다. 닥무지 공정은 수증기를 이용하여 한지 원료를 찌는 과정으로, 원료로부터 인피섬유가 들어있는 껍질을 잘 벗겨내기 위한 것이다. 닥무지 공정이 끝나면 원료의 껍질을 벗겨낸다. 벗겨진 껍질을 흑피라고 한다. 흑피를 맑은 물로 충분히 세척한 후, 칼로 표피의 검은 부분들을 제거한다. 검은 부분과 먼지 및 불순물들이 깨끗이 제거된 껍질을 백피라고 한다.

<6> 상기 백피를 자비처리한다. 백피는 다양한 약품에 의해 자비처리될 수 있는데, 천연약품으로는 볏짚, 메밀대, 목화대, 콩대, 고추대 등을 태워서 잿물을 내려서 만든 육재를 사용할 수 있고, 일반 화학약품으로는 가성소다를 사용할 수 있다. 자비처리란 백피에 육재나 가성소다를 가하여 약 100℃에서 충분히 삶는 과정을 말한다. 천연약품인 육재 대신 일반 화학약품인 가성소다를 사용하여 자비처리한 백피는 더 깨끗하고 처리가 쉽지만 전통한지의 원료로는 볼 수 없다.

<7> 자비처리가 끝난 한지 원료는 세척공정을 거쳐 한지 원료에 포함된 모든 가용성 불순물들을 제거한다.

<8> 가용성 불순물이 제거된 한지 원료에 표백공정을 실시한다. 표백공정에는 햇빛을 이용한 일광표백과 차아염소산나트륨이나 이산화염소 등을 이용한 약품표백이 있다. 약품표백을 실시하는 경우 한지 원료의 셀룰로오스 분자량이 현저히 감소하여 오랜 보존성을 자랑하는 한지의 특성을 쉽게 잃어버릴 수 있다.

<9> 표백공정 후, 티고르기 작업을 실시하여 충분히 표백되지 못한 불순물들을 제거하여 한지 원료 섬유 처리를 완료한다.

<10> 상기 한지 원료 섬유에 고해 공정을 실시한다. 고해 공정은 닥방망이라는 몽둥이로 한지 원료 섬유를 쳐서 계속 짓이기는 공정으로, 한지의 강도를 높이고 한지의 균일성을 높이기 위한 필수적이며 전통적인 공정이다. 최근에는 한지 원료 섬유들의 길이를 짧게 만들며 균일성을 높이는 칼비터와 같은 기계들이 사용되고 있다.

<11> 상기 고해 공정이 끝난 한지 원료 섬유를 지통에 넣고 대나무살로 만들어진 발로 한지를 뜬다. 이때 한지 원료 섬유는 닥풀이라는 천연첨가제와 함께 혼합하여 한지를 뜬다. 닥풀은 황촉규라는 식물의 뿌리에서 즙 형태로 얻어지며, 한지 원료 섬유와 함께 사용되는 경우 한지의 강도나 균일성을 향상시킨다. 상기 닥풀 대신에 PAM(polyacrylamide) 또는 PEO(polyethyleneoxide) 등을 사용할 수도 있다. 한지를 뜨는 방법은 외발뜨기와 쌍발뜨기가 있는데, 보통 외발뜨기가 한국의 전통적인 한지제조방식이라고 알려져 있다. 외발뜨기 방식은 쌍발뜨기보다 강도가 더 우수하고 균일한 한지를 만들 수 있다. 외발뜨기나 쌍발뜨기로 제조된 한지의 물기를 뺀 후 뜨거운 철판에서 건조시키거나 햇빛으로 목판 위에서 건조시켜 한지를 완성한다.

<12> 상기 전통적인 처리과정으로 닥 섬유 등을 이용하여 한지를 제조하는 경우 인장강도, 파열강도, 내절도 등의 강도가 우수하고, 1000년 이상 보존할 수 있는 보존성이 우수한 한지를 제조할 수 있다. 이러한 한지는 빛, 바람 및 습기 등과 같은 자연현상과 친화성이 강하여 바람이 잘 통하고 습기를 잘 흡수하여 예로부터 창호지로 많이 사용하여 왔다. 한지는 질과 호칭에 따라서 용도가 구분되는데, 문에 바르는 창호지, 족보, 불경, 고서의 영인(影印)으로 사용되는 복사지, 사군자나 화조(花鳥)를 그릴 때 사용되는 화선지(畵宣紙), 연하장이나 청첩장 등에 사용되는 태지(苔紙) 등 다양한 종류가 있다.

<13> 최근에는 전통한지의 원료에 폐지나 기타 저렴한 원료를 포함하여 저렴한 개량 한지를 제조하기도 한다. 일 예로, 감귤껍질, 유채꽃 잎사귀의 분말 및 삼을 이용한 다양한 한지가 개발되고 있다.

<14> 그러나, 상기와 같은 전통적인 한지의 제조방법은 한지의 보존성에 있어서는 매우 우수하지만, 제조 과정이 까다롭고 인건비가 많이 드는 단점이 있다.

<15> 또한, 한지는 저평량으로 불투명도가 매우 낮다. 이러한 한지의 불투명도를 높이기 위하여, 종래에는 한지를 두껍게 만들거나 탄산칼슘, 백토, 탈크, 이산화티탄과 같은 충전제를 첨가하여 사용하여 왔다. 그러나, 한지를 두껍게 만들 경우, 불투명도를 높일 수 있으나 가격이 매우 높아지게 되는 문제점이 생긴다. 또한, 충전제를 사용하는 경우 저평량 한지 내에 충전제를 지속적으로 보유하기가 매우 어렵고, 일단 보유한다고 하더라도 접촉 등 가벼운 충격에 의해 한지에 포함된 충전제가 빠져나와 오염을 일으킬 수 있으며, 한지의 강도가 크게 훼손되어 개선효과를 얻기가 매우 어렵다.

<16> 또한, 한지는 붓을 이용한 서예에는 적합하지만 대량 인쇄용으로 사용하기에는 평활도가 낮은 문제점이 있다. 종래에는 한지의 평활도를 높이기 위하여 면풀칠한 종이를 여러 장씩 겹쳐 놓고 도침기로 골고루 내리쳐 한지의 조직이 치밀해지고 표면에 윤이 나도록 도침 공정을 수행하였다. 그러나 상기 도침 공정에는 많은 기술과 인력을 투입해야 하므로 비경제적이다.

<17> 따라서, 한지의 불투명도 및 평활도를 개선하기 위한 연구가 요구되고 있다.

<18> 한편, 홍조류는 엽록소 외에 홍조소와 남조소를 함유하고 있어 붉은빛 또는 자줏빛을 띤 해초로서, 다른 조류보다 비교적 깊은 물에 서식하고, 크기가 비교적 작으며, 종류는 4000여 종으로 매우 다양하다. 홍조류는 녹조류나 갈조류보다 서식 범위가 넓어 얕은 수심에서부터 광선이 닿는 깊은 수심에까지 자생한다. 홍조류는 해조류 중에서도 근양사라고 불리우는 섬유를 많이 포함하고 있으며, 이들 섬유는 지름이 수 마이크론으로 모든 홍조류에서 거의 일정한 크기를 가지고 있다. 또한, 홍조류 섬유는 백색도 및 불투명도가 우수하고 홍조류 섬유 간 결합 능력도 우수하다. 홍조류 섬유의 결정성은 셀룰로오스 섬유와 유사하며, 특히 표백된 홍조류 섬유의 열적 특성은 셀룰로오스 섬유보다 더 우수하다. 홍조류로는 김, 우뭇가사리, 개우무, 새발, 꼬시래기, 가시우무, 비단풀, 단박, 도박, 국수나물, 돌가사리, 석묵 및 지누아리 등이 있다. 홍조류의 내부 젤 추출물은 식품의 첨가제, 건강보조식품, 한천 재료 등으로 활용되고 있다.

<19> 본 발명자들은 홍조류 섬유를 포함하는 한지를 발명하였다. 홍조류 섬유를 포함하는 한지를 제조하면 불투명도와 평활도가 우수한 한지를 제조할 수 있다.

<20> 그러나, 상기 홍조류 섬유를 포함하는 한지는 불투명도 및 평활도가 우수한 반면 홍조류 섬유의 탈수성이 매우 좋지는 않아 그 생산성이 낮은 단점이 있으며, 특히 기계한지를 제조하는 경우 양산하는 데 문제가 있다.

<21> 이러한 홍조류 섬유의 탈수성을 개선하기 위하여 고분자 전해질로 구성된 탈수촉진제를 적용할 수 있다. 그러나, 탈수촉진제를 가하는 경우 한지의 균일성이 저해될 뿐만 아니라, 화학 첨가제로 인해 한지가 갖는 친환경성이 훼손된다는 문제점이 있다.

<22> 현재까지 홍조류 섬유의 탈수성을 개선하여 한지에 적용한 연구 및 개발 사례는 거의 전무한 상태이다.

발명의 내용

해결 하고자하는 과제

<23> 따라서, 본 발명은 불투명도 및 평활도가 우수하면서도 탈수성이 개선된 홍조류 섬유를 포함하는 한지를 제공하려는 것을 그 목적으로 한다.

과제 해결수단

<24> 본 발명자들은 한지의 불투명도 및 평활도를 개선하기 위하여 혼합되는 홍조류 섬유의 탈수성 개선 방안을 연구하던 중 기계적인 처리로 섬유에 컬을 형성시킴으로써 탈수성을 개선시킬 수 있음을 밝히고, 컬을 형성시킨 홍조류 섬유를 한지 원료 섬유에 혼합하여 한지를 제조하였으며, 상기 홍조류 섬유를 포함하는 한지가 불투명도와 평활도뿐만 아니라 탈수성이 우수함을 확인하고 본 발명을 완성하였다.

<25> 본 발명은 탈수성이 개선된 홍조류 섬유를 포함하는 불투명도와 평활도가 우수한 한지를 제공한다.

<26> 본 발명은 컬을 형성한 홍조류 섬유를 포함하여 제조된 탈수성이 향상된 한지에 관한 것이다.

<27> 또한, 본 발명은 상기 컬을 형성한 홍조류 섬유가 한지 총 중량에 대해 1~50중량% 함유됨을 특징으로 한다. 1중량% 미만 함유되면 탈수성 향상 등의 효과가 미미하고, 50중량%를 초과하면 한지의 성질을 나타낸다고 하기가 어렵다.

<28> 또한, 본 발명은 상기 컬을 형성한 홍조류 섬유의 ISO 백색도가 50~99%인 것을 특징으로 한다. 백색도가 50% 미만이면 인쇄용지 등으로 사용이 어렵고, 99%를 초과하면 홍조류 섬유의 표백 처리에 과다한 약품과 비용이 소요되므로 비경제적이다.

<29> 또한, 본 발명은 상기 컬 형성 공정에 다양한 방법과 장치를 이용할 수 있으나, 바람직하게는 니더(Kneader) 또는 디스퍼서(Disperser)를 이용한 것임을 특징으로 한다.

<30> 또한, 본 발명은 상기 한지의 종류에 특별한 제한은 없으나, 바람직하게는 상기 한지가 수록지 또는 기계 한지인 것을 특징으로 한다.

<31> 또한, 본 발명은 홍조류 섬유에 컬을 형성하여 탈수성을 향상시킨 홍조류 섬유를 포함하는 한지 제조방법에 관한 것이다.

<32> 또한, 본 발명은 상기 홍조류 섬유의 컬 형성 공정이 니더(Kneader) 또는 디스퍼서(Disperser)를 이용하는 것임

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을 특징으로 한다.

<33> 이하, 본 발명에 대해 상세히 설명한다.

<34> 본 발명에 따른 한지는 탈수성이 개선된 홍조류 섬유를 한지 총 중량에 대해 1~50 중량% 포함하는 것을 특징으로 한다.

<35> 본 발명에 따른 한지는 한지 원료 섬유와 탈수성이 개선된 홍조류 섬유를 혼합하여 고해 공정, 발뜨기 공정, 탈수 공정 및 건조 공정을 거쳐 통상적인 방법으로 수록지 또는 기계 한지로 제조될 수 있다. 상기 발뜨기 공정에서는 홍조류 섬유의 탈수성이 개선된 만큼 굳이 탈수가 용이한 발을 사용할 필요가 없으며, 기존의 홍조류 섬유의 낮은 탈수성을 조절할 수 있도록 탈수성이 높은 발을 선택하여 사용할 필요가 없다. 외발뜨기나 쌍발뜨기 방식을 이용하여 수록지로 제조할 수 있고, 또는 초지기를 이용하여 기계 한지로 제조할 수 있다.

<36> 상기 한지 원료 섬유는 닥나무, 삼지닥나무, 안피 및 마 등의 인피섬유를 원료로 하여 전통적인 방법으로 제조한다. 즉, 닥나무, 삼지닥나무, 안피 및 마로 이루어진 군으로부터 선택된 1종을 닥무지 공정, 자비처리, 세척 공정, 표백 공정 및 티고르기를 거쳐 한지 원료 섬유를 제조한다.

<37> 상기 홍조류 섬유는 대한민국 등록특허공보 제 10-754890호 및 제 10-811183호에 기재되어 있는 방법으로 제조하여 사용한다. 즉, 홍조류를 산성 용액 또는 알칼리성 용액에 일정시간 침지시킨 다음, 물로 세척 후 탈수시키고, 상기 탈수된 홍조류를 추출용매에 일정시간 침지시켜 젤을 추출한 다음, 상기 추출된 젤을 분리하고 잔사를 여러 단계로 표백 처리하고, 이를 수집하여 섬유화시켜서 홍조류 섬유를 얻는다. 이렇게 제조된 홍조류 섬유의 ISO 백색도는 50~99%인 것이 바람직하며, 80~99%인 것이 더욱 바람직하다. 상기 홍조류는 김, 우뭇가사리, 개우무, 새발, 꼬시래기, 가시우무, 비단풀, 단박, 도박, 국수나물, 돌가사리, 석묵 및 지누아리로 이루어진 군으로부터 선택된 1종 이상을 포함한다. 상기 홍조류 섬유는 한지 총 중량에 대해 1~50중량%, 바람직하게는 5~30중량% 포함된다. 만일 홍조류 섬유의 함량이 50중량%를 초과하면 한지라고 하기가 어렵고, 1중량% 미만이면 불투명도와 평활도가 개선되지 않는다.

<38> 홍조류 섬유는 섬유의 길이가 짧고 폭이 좁은 이유로 지료의 탈수성이 불량한 단점이 있었으나, 본 발명의 기계적인 처리를 거쳐 섬유가 휘고 비틀리는 컬(curl)이 형성되면 컬이 형성되지 않은 홍조류 섬유보다 탈수성이 양호하고 불투명도가 더욱 개선되는 장점이 있다.

<39> 불투명도는 평량이 높을수록 더 커지는데, 본 발명에 따른 컬이 형성되어 탈수성이 개선된 홍조류 섬유를 포함하는 한지는 홍조류 섬유를 포함하지 않는 한지에 비해 불투명도와 평활도가 높게 나타난다. 또한, 본 발명에 따른 컬이 형성되어 탈수성이 개선된 홍조류 섬유를 포함하는 한지는 무처리 홍조류 섬유를 포함하는 한지에 비해 평량이 낮아도 불투명도가 높게 나타난다.

<40> 본 발명에 따른 컬이 형성되어 탈수성이 개선된 홍조류 섬유를 포함하는 한지는 홍조류 섬유의 함량이 증가할수록 불투명도와 평활도가 높게 나타난다.

효 과

<41> 본 발명에 따른 기계적 처리를 실시하여 컬을 도입한 홍조류 섬유를 포함하는 한지는 불투명도와 백색도가 우수하므로 서적 용지, 사전 용지, 보존용 인쇄용지로 적합하며, 한지의 맛을 그대로 살릴 수 있고 보존성이 우수하므로 서예용이나 고급 화선지로서도 그 쓰임새를 넓혀갈 수 있다.

발명의 실시를 위한 구체적인 내용

<42> 이하, 본 발명의 이해를 돕기 위하여 바람직한 실시예를 제시한다. 그러나 하기의 실시예는 본 발명을 좀더 쉽게 이해하기 위하여 제공되는 것일 뿐, 실시예에 의하여 본 발명의 내용이 한정되는 것은 아니다.

<43> 실시예 1: 한지 원료섬유 제조 공정

<44> 닥나무를 하루 정도 물에 담가두어서 이물질을 제거한 다음, 증기로 쪄 겉껍질 분리를 용이하게 하여 겉껍질을 벗겨낸 흑피를 10시간 정도 물에 담가 놓은 후 외피를 벗겨 백피를 제조하였다. 백피를 하루 정도 물에 불린 다음 엉킴을 막기 위하여 적당한 길이로 잘라 솥에 넣고, 볏짚, 콩대 등을 태운 재로 만든 잿물에 6시간 동안 삶았다.

<45> 그런 다음 섬유질 외의 당분, 회분 등을 제거하기 위해 흐르는 물에 반나절 정도 침지하거나 물을 2~3회 갈아주면서 잿물을 제거한 다음, 5일 가량 햇빛에 쬐어 흰색이 나타날 때까지 일광 탈색시켰다. 일광 표백한 닥을 건

져내어 물기를 짜낸 뒤 평평한 판에 얹고 닥방망이로 쳐서 뭉친 섬유 다발을 풀어주고 티를 골라내었다.

<46> 실시예 2: 홍조류 섬유 추출 공정

<47> 홍조류를 pH 2-3의 산성용액에 일정시간 침지시켰다가 물로 세척한 후 탈수시켰다. 이 공정을 통하여 홍조류 내의 불순물을 제거하고 홍조류 외피를 연화시켰다.

<48> 세척 및 탈수시킨 홍조류를 추출용매에 침지시켜 홍조류에 함유된 젤 성분을 추출용매로 추출시켰다. 이때 추출용매로는 물, 에탄올, 메탄올, 아세톤 또는 케톤 등을 사용할 수 있다. 홍조류에 포함된 젤 성분의 녹는점이 약 60℃이므로 추출용매의 온도는 60℃이상으로 하는 것이 바람직하다.

<49> 젤 추출물을 제거한 후에는 표백 처리를 실시하였다. 표백 처리는 오존처리를 수행하는데 홍조류가 백색도 기준 60 이상이 될 때까지 오존 처리를 반복 실시하였다. 최종적으로 과산화수소를 이용하고 환원제를 첨가하여 백색도 70 이상의 홍조류 섬유를 얻었다.

<50> 실시예 3: 홍조류 섬유에 컬을 형성하는 공정

<51> 홍조류 섬유의 탈수성을 개선하기 위하여 상기 실시예 2에서 얻은 홍조류 섬유 지료를 25중량%로 농축시켜 니더(kneader)에 공급하였다. 이때, 지료농도가 25중량% 미만이면, 농도가 낮아 니더에서 전단력이 충분히 발생하지 않을 수 있어 바람직하지 않고 지나치게 농도가 높으면 니딩 처리시 지료에 열이 과도하게 발생한다.

<52> 고농도의 지료를 니딩(kneading) 처리하는 것은 길이가 길지 않은 홍조류 섬유에 기계적으로 컬을 형성시키려는 것이다. 공정상, 바람직한 컬을 형성하기 위해서는 니딩 시간을 조정하기 위하여 처리 횟수를 적어도 1회 이상 최대 6회까지 실시하는 것이 바람직하고, 더욱 바람직하게는 2회 내지 3회 반복 수행한다. 본 실시예에서는 3회 니딩 처리하였고, 지료의 파열강도는 40%, 인장강도는 30% 정도 증가하였다.

<53> 니딩 처리시 공정온도는 60 내지 70℃에서 수행하는 것이 바람직하다. 본 실시예에서는 70℃로 3회 일본 야마모토백마제작소의 니더(kneader)를 이용하여 니딩 처리하였다.

<54> 니딩 처리된 지료에 농축시 회수해 두었던 백수를 가하여 다시 희석하여 1중량% 농도로 조정하고 2300rpm의 교반기로 10분간 완전히 해리시켰다.

<55> 실시예 4: 컬 형성 홍조류 섬유를 포함하는 한지 제조 공정

<56> 상기 실시예 1에서 얻어진 닥섬유 80중량부를 지통에 넣고, 여기에 상기 실시예 3에서 얻어진 컬이 형성된 홍조류 섬유 20중량부를 가하여 통상적인 방법 즉, 고해 공정, 발뜨기 공정, 탈수 공정 및 건조 공정을 거쳐 한지 수록지를 제조하였다.

<57> 비교예 1 : 무처리 홍조류 섬유를 포함하는 한지 제조

<58> 상기 실시예 1에서 얻어진 닥섬유 80중량부를 지통에 넣고, 여기에 실시예 3의 공정을 거치지 아니한 실시예 2의 홍조류 섬유 20중량부를 첨가하여 통상적인 방법으로 한지 수록지를 제조하였다.

<59> 비교예 2 : 닥섬유만을 포함하는 한지 제조

<60> 상기 실시예 1에서 얻어진 닥섬유 100중량부를 지통에 넣고, 통상적인 방법으로 한지 수록지를 제조하였다.

<61> 실험예 1 : 한지의 물리적 및 광학적 성질 측정

<62> 본 발명에 따른 한지 및 비교예 1, 2 한지의 물리적 및 광학적 성질을 측정하기 위하여 하기와 같은 실험을 수행하였다.

<63> 상기 실시예 4 및 비교예 1~2에서 제조한 한지의 광학적 성질은 TAPPI standard T402 om-88에 따라 23±1℃, 상대습도 50±2%로 조절된 항온·항습실에서 조습 처리 후 측정하였다. 조습 처리된 시편을 TAPPI standard에 의거하여 Technidyne사의 컬러 터치(Color-Touch)를 이용하여 백색도(TAPPI T 452 om-98)와 불투명도(TAPPI T 452 om-96) 등의 광학적 성질을 측정하였다.

<64> 기계적 처리 전·후에 홍조류 섬유가 나타내는 탈수성을 측정하기 위하여 지료의 여수도를 Canadian Freeness Test법(TAPPI T 227 om-99)에 근거하여 측정하였다. 아울러 기계적 처리 전후에 홍조류 섬유가 나타내는 탈수성을 측정하기 위하여 지료의 보수도를 TAPPI USEFUL METHOD UM 256에 근거하여 측정하였다. 기계적 처리 전후에 홍조류 섬유가 나타내는 컬 정도를 측정하기 위하여 TECHPAP사의 섬유장 분석기 (MorFi)를 이용하여 측정하였다. 컬(%)을 계산하기 위한 공식을 도 1에 설명하였다. 컬(%)는 직선 상태에서 벗어난 섬유 형상의 전

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체적인 백분율을 나타낸다. 수학식 1은 컬(%)을 구하는 식으로서, CL은 섬유의 직선 거리를 나타내며, P는 외경을 의미한다.

수학식 1

<65> $$Curl = 100 \times \frac{(P - 2CL)}{P}$$

<66> 한지의 광학적 성질은 표 1에 나타내었으며, 여수도는 표 2에 나타내었다.

표 1

<67>

	백색도	불투명도
실시예 4 (컬 형성 홍조류 섬유 함유 한지)	80	85
비교예 1 (무처리 홍조류 섬유 함유 한지)	75	75
비교예 2 (일반 닥나무 한지)	70	65

표 2

<68>

	보수도	여수도(mL CSF)	컬(%)
실시예 4	4.9	100	26
비교예 1	6.3	30	14

<69> 표 1에 나타난 바와 같이 본 발명에 따른 기계적 처리를 실시한 홍조류 섬유를 포함하는 한지(실시예 4)의 불투명도와 백색도는 기존 홍조류 섬유를 포함하는 한지(비교예 1)나 닥섬유만을 포함하는 한지(비교예 2)에 비해 현저히 높게 나타났다. 일반적으로 홍조류 섬유를 포함하는 한지는 닥섬유만을 포함하는 한지보다 불투명도와 백색도가 높은데 본 발명의 기계적 처리를 실시한 한지는 홍조류 섬유를 포함하는 한지보다 더 우수한 불투명도와 백색도를 나타내었다.

<70> 또한, 표 2에 나타난 바와 같이 컬을 형성한 홍조류 섬유는 보수도가 20% 이상 저하되어 물을 적게 함유하며 섬유의 컬이 80% 이상 증가한 이유로 무처리 홍조류 섬유보다 여수성이 3배 이상 증가하여 종이 제조공정의 탈수성이 우수한 것으로 나타났다.

<71> 상기한 바와 같이, 본 발명에 따른 기계적 처리를 실시하여 컬을 형성한 홍조류 섬유를 포함하는 한지는 무처리 홍조류 섬유를 포함하는 한지보다 불투명도와 백색도 및 탈수성이 크게 증가함으로써, 한지의 불투명도와 백색도 및 생산효율 개선에 크게 기여한 것으로 사료된다.

도면의 간단한 설명

<72> 도 1은 컬(%)를 측정하는 방법에 관한 설명도이다.

<73> 도 2는 컬을 형성하기 전의 홍조류 섬유 사진이다.

<74> 도 3은 닥섬유 100% 한지를 확대한 사진이다.

<75> 도 4는 컬을 형성하지 않은 홍조류 섬유 20중량%와 닥섬유 80중량%로 제조된 한지의 확대사진이다.

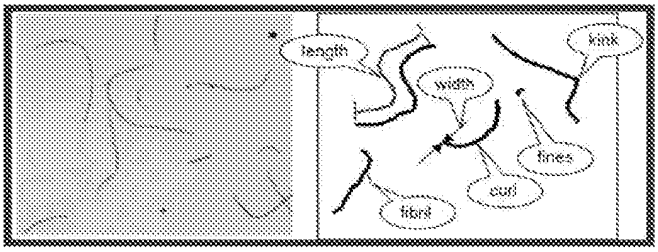
<76> 도 5는 컬을 형성한 홍조류 섬유 20중량%와 닥섬유 80중량%로 제조된 한지의 확대사진이다.

Kimberly Clark EX1002, p. 1972
PGR2026-00078

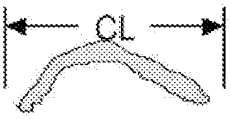
도면

도면1

The Curl (%)is the overall percent deviation of the fiber's morphology from being a straight line:

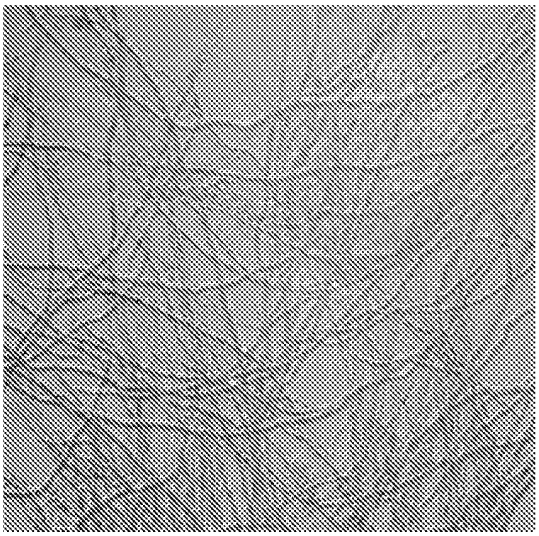


CL is Caliper Length,
P is exterior Perimeter.



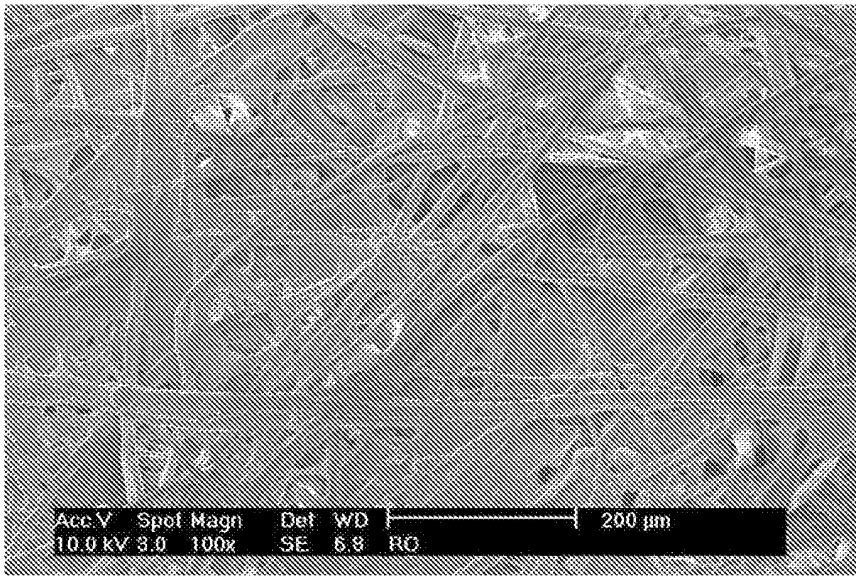
$$\text{Curl} = \frac{100 \times (P - 2CL)}{P}$$

도면2

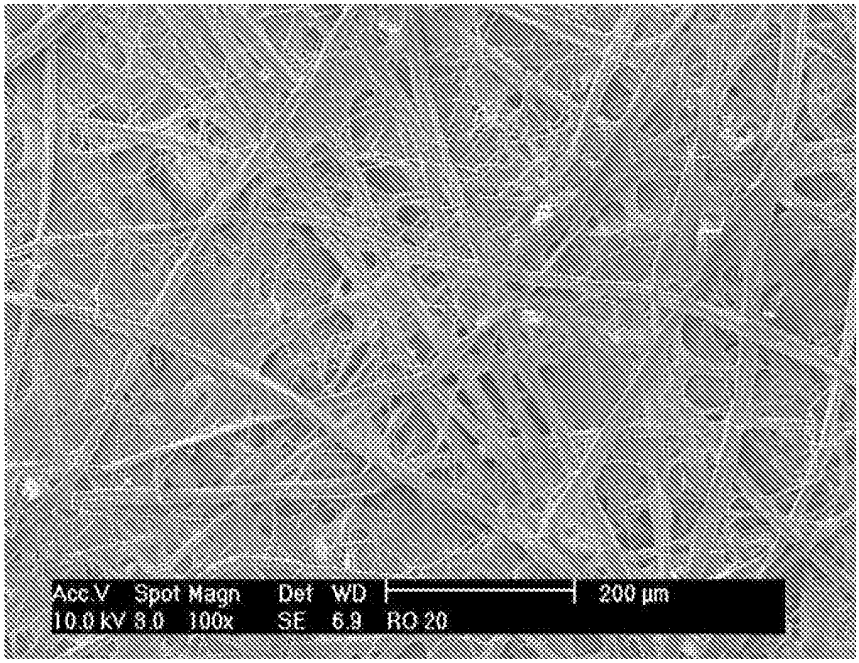


Kimberly Clark EX1002, p. 1973
PGR2026-00078

도면3

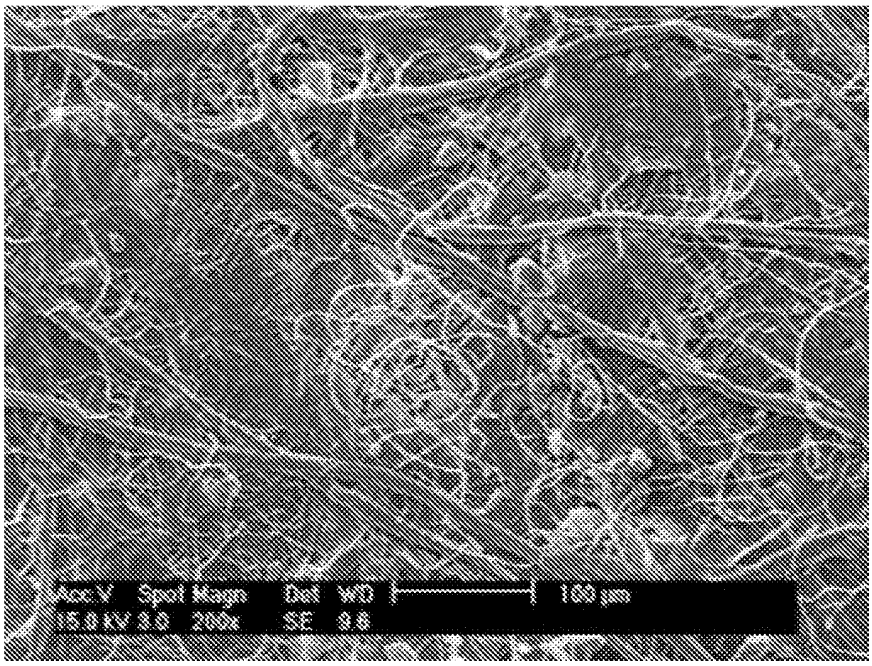


도면4



Kimberly Clark EX1002, p. 1974
PGR2026-00078

도면5



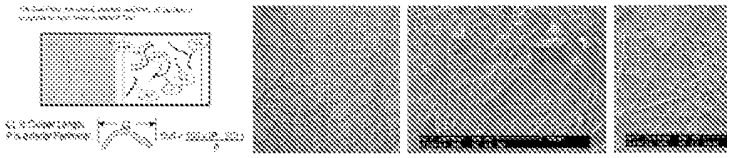
Kimberly Clark EX1002, p. 1975
PGR2026-00078

Korean paper comprising curled red algae fiber

Abstract

PURPOSE: Korean paper including curled red algae fiber is provided to improve dehydration property by using dehydration accelerator, and offer opacity and smoothness while offering environmentally friendly effects. CONSTITUTION. Korean paper having improved dehydration property contains curled red algae fiber of 1~50 weight% based on the whole weight of the Korean paper. The ISO whiteness of the fiber is 50~99%. The curl of the red algae fiber is formed by a kneader or a dispenser. The Korean paper has the improved dehydration property by the kneader or the dispenser.

Images (5)



KR100933462B1

South Korea

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Other languages: Korean

Inventor: 류정용, 조범욱, 송봉근

Worldwide applications

2009 KR

Application KR1020090062861A events

2009-07-10 Application filed by 대한민국(문화체육관광부장관)

2009-07-10 Priority to KR1020090062861A

2009-12-23 Application granted

2009-12-23 Publication of KR100933462B1

Info: Patent citations (1), Cited by (4), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Classifications

- B21H17/02 Material of vegetable origin

View 2 more classifications

Claims (7)

Hide Dependent ^
translated from Korean

Hanji with improved dehydration, including red algae fibers that form curls. The method according to claim 1, Hanji, characterized in that the red algae fiber forming the curl is contained 1 to 50% by weight based on the total weight of hanji. The method according to claim 1, The red algae fiber which formed the said curl is characterized in that the ISO whiteness is 50 ~ 99%. The method according to claim 1, The red algae fiber that forms the curl is Hanji, characterized in that the curl is formed using a kneader or dispenser. The method according to claim 1, The Korean paper is characterized in that the paper or mechanical paper. Hanji production method comprising red algae fibers to improve dehydration by forming curls using kneader or dispenser in the red algae fibers. delete

Description

translated from Korean

Korean paper comprising curled red algae fiber

The present invention relates to Korean paper comprising curled red algae fibers.

Hanji is a paper uniquetc Korea that is made from bast fibers such as mulberry, cedar, and skin. Bastfiber has a fiber length (10mm) that is much longer than that of conifers used as chemical pulp (3mm) or that of hardwoods (1mm). The castle is also excellent and can make tough paper.

Hanji has a softer texture, more flexible folding, toughness and ink staining than ordinary paper. it can express all colors, it is tough in water with its fast absorption, and it has excellent sound insulation and cold weather and warmth according to the season. Even though the characteristics of the paper does not change. In particular, Hanji is known as a paper that lasts for millennia, and the Mugujeong Clown Dami is known to have been created in the 8th century.

Traditional Korean paper is a traditional Korean paper, and the manufacturing method of traditional Korean paper is as follows.

First, raw materials of Korean paper, such as paper mulberry, trichamber and anpi, are harvested in winter. Harvested Hanji raw materials are processed at random. Dakmuji process is the process of steaming Hanji raw material using steam, to peel off the skin containing the bast fiber from the raw material. Peel off the raw material at the end of the shredding process. Peeled skin is called black skin. After washing the skin thoroughly with clear water, remove the black parts of the epidermis with a knife. The skin that has been completely cleared of black parts and dust and impurities is called white skin.

Treat the white skin mercifully. Baekpi can be treated by various medicines. For natural medicines, it is possible to use meat made by burning rye with straw, buckwheat, cotton, soybeans, peppers, and caustic soda as a general chemical. have. Self-treatment refers to the process of boiling enough meat at about 100 ℃ by adding meat or caustic soda to the white skin. Mercy-treated white skin using caustic soda, a general chemical instead of natural meat, is cleaner and easier to process, but it is not seen as a raw material of traditional paper.

Once processed, Hanji raw materials are washed to remove all soluble impurities contained in Hanji raw materials.

The bleaching process is performed on the raw material from which the soluble impurities have been removed. The bleaching process includes sunlight bleaching using sunlight and chemical bleaching using sodium hypochlorite or chlorine dioxide. When chemical bleaching is carried out, the cellulose molecular weight of the raw material of Hanji is significantly reduced, which makes it easy to lose the properties of Hanji, which has long shelf life.

After the bleaching process, the tiling process is performed to remove impurities that have not been sufficiently bleached to complete the Hanji raw material fiber treatment.

A beating step is performed on the Hanji raw material fibers. The confession process is a process of squeezing Hanji raw material fibers with a stick called Dak-Bak, which is an essential and traditional process to increase the strength of Hanji and improve the uniformity of Hanji. Recently, machines such as calviter, which shorten the

length of the Hanji raw material fibers and increase the uniformity, have been used.

Put the Hanji raw material fiber in the paper container after the beating process is finished, and the Hanji is floated with a foot made of bamboo flesh. At this time, the Hanji raw material fiber is mixed with a natural additive called 'dakweed' to make Hanji. It is obtained in the form of juice from the root of a plant called Hwang Chok-gyu, and when used together with raw paper fibers, it improves the strength and uniformity of the paper. Instead of the camphor, PAM (polyacrylamide) or PEO (polyethyleneoxide) may be used. There are two ways to float Hanji, unicycle and twine, and unicycle is known as the traditional method of making Korean paper. Uni-knit can make Hanji with stronger and more uniform than twin-knit. Hanji made of unicycle or twine is drained and dried on a hot iron plate or dried on a wooden board with sunlight to complete Hanji.

When manufacturing hanji using Dac fibers, etc. by the traditional treatment process, it is possible to manufacture a hanji excellent in the strength of tensile strength, rupture strength, theft resistance and the like, and excellent preservability that can be preserved for more than 1000 years. Such Hanji has good affinity with natural phenomena such as light, wind, and moisture, so it is well-winded and absorbs moisture. The use of Korean paper is divided according to its quality and title, such as window papers on the doors, genealogies, Buddhist temples, copy papers used as old seals of ancient books, drawing papers used for drawing dead soldiers and flowers, and greeting cards. There are various kinds such as Taiji used for wedding invitations.

In recent years, traditional Korean paper has been manufactured, including waste paper and other inexpensive materials. For example, various Korean paper using citrus peel, rape powder and hemp has been developed.

However, the traditional method of manufacturing Hanji as described above is very excellent in the preservation of Hanji, but has a disadvantage in that the manufacturing process is difficult and labor costs are high.

In addition, Korean paper has a low basis weight and very low opacity. In order to increase the opacity of such paper, conventionally, it has been used by thickening the paper or adding fillers such as calcium carbonate, clay, talc and titanium dioxide. However, if the paper is made thick, the opacity can be increased, but the price becomes very high. In addition, when the filler is used, it is very difficult to continuously hold the filler in a low basis weight hanji, and even if held once, the filler contained in the hanji may come out and cause contamination by a light impact such as contact. It is very difficult to get improvement effect by being damaged.

In addition, Hanji is suitable for calligraphy using a brush, but has a problem of low smoothness for use for mass printing. Conventionally, in order to increase the smoothness of Hanji, a sheet of paste-coated paper was piled up several times and evenly squeezed with a prosthesis, thereby performing an evaporation process so that the tissue of Hanji was dense and the surface was polished. However, the doping process is uneconomical because it requires a lot of technology and manpower.

Therefore, research for improving the opacity and smoothness of Hanji is required.

Red algae, on the other hand, contain red and purple seaweeds in addition to chlorophyll, which are red or purple, and inhabit relatively deeper water than other algae, are relatively small in size, and have a variety of types of about 4000 species. Red algae have a wider range of habitat than green algae or brown algae and grow from shallow depths to deep water rays. Red algae contain a large number of fibres, called muscle muscles, which are several microns in diameter and have almost constant size in all red algae. In addition, red algae fibers have excellent whiteness and opacity, and have excellent binding ability between red algae fibers. The crystallinity of red algae fibers is similar to cellulose fibers, in particular the thermal properties of bleached red algae fibers are better than cellulose fibers. The red algae include laver, woodworm, ox radish, buckwheat, braid, thorn radish, silk grass, sackcloth, gambling, noodle sprout, stone starfish, stone and Jinuan. The internal gel extract of red algae is used as an additive in food, health supplement food, and agar material.

The inventors have invented Hanji comprising red algae fibers. By manufacturing Hanji comprising red algae fibers, it is possible to produce Hanji with excellent opacity and smoothness.

However, the hanji including the red algae fiber has excellent opacity and smoothness, but the dehydration of the red algae fiber is not very good, and thus the productivity thereof is low. In particular, when manufacturing mechanical hanji, there is a problem in mass production.

In order to improve dehydration of such red algae fibers, a dehydration accelerator composed of a polymer electrolyte may be applied. However, when the dehydration accelerator is added, not only the uniformity of Hanji is impaired, but there is a problem that the environmentally friendly nature of Hanji is impaired by the chemical additives.

To date, there have been few research and development examples applied to Hanji by improving the dehydration of red algae fibers.

Accordingly, an object of the present invention is to provide a Korean paper comprising red algae fiber having excellent opacity and smoothness and improved dehydration.

The inventors of the present invention, while studying how to improve the dehydration of the mixed red algae fiber to improve the opacity and smoothness of the hanji revealed that it can improve the dehydration by forming a curl on the fiber by a mechanical treatment, the red algae that formed the curl Hanji was prepared by mixing the fiber with the raw material fiber, and confirmed that the hanji including the red algae fiber was excellent in dehydration as well as opacity and smoothness, and completed the present invention.

The present invention provides a paper that is excellent in opacity and smoothness, including red algae fiber with improved dehydration.

The present invention relates to Korean paper with improved dehydration properties, including red algae fibers with curls.

In addition, the present invention is characterized by containing 1 to 50% by weight based on the total weight of the red algae fiber forming the curl. When it contains less than 1 weight%, theeffect of the improvement of dehydration etc. is insignificant, and when it exceeds 50 weight%, it is hard to say that it shows the characteristic of Hanji.

In addition, the present invention is characterized in that the ISO whiteness of the red algae fiber formed the curl is 50 ~ 99%. If the whiteness is less than 50%, it is difficult to use as printing paper, and if it exceeds 99%, it is uneconomical because excessive chemicals and costs are required for bleaching red algae fibers.

In addition, the present invention can use a variety of methods and apparatus for the curling process, preferably characterized in that using a kneader or dispenser (Disperser)

In addition, the present invention is not particularly limited to the type of the hanji, preferably characterized in that the hanji is a recording paper or a machine hanji.

The present invention also relates to a method for manufacturing Korean paper comprising red algae fibers having curled red algae fibers to improve dehydration.

In addition, the present invention is characterized in that the curling process of the red algae fiber is using a kneader or a dispenser.

Hereinafter, the present invention will be described in detail.

Hanji according to the invention is characterized in that it comprises 1 to 50% by weight relative to the total weight of the red algae fiber with improved dehydration.

Hanji according to the present invention can be prepared in a conventional paper or a mechanical hanji through the beating process, spinning process, dehydration process and drying process by mixing the Hanji raw material fiber and red algae fiber with improved dehydration. Since the dehydration of the red algae fiber is improved in the step of stepping, it is not necessary to use a foot easily dehydrated, and it is not necessary to select and use a high dehydrating foot to control the low dehydration

of the existing red algae fiber. . It can be manufactured with a paper sheet using uni-knit or twin-knit method, or can be manufactured with a mechanical sheet of paper using a paper machine.

The Hanji raw material fiber is prepared by the traditional method using bast fibers such as mulberry, cedar, bark and hemp as raw materials. In other words, one kind selected from the group consisting of mulberry, cedar, wood, and hemp is produced through raw paper mulberry process, mercy treatment, washing process, bleaching process and tigogi raw material.

The red algae fiber is prepared and used by the methods described in Korean Patent Publication Nos. 10-754890 and 10-0711183. That is, the red algae are immersed in an acidic or alkaline solution for a certain time, washed with water and dehydrated, and the dehydrated red algae are immersed in an extraction solvent for a predetermined time to extract a gel, and the extracted gel is separated and the residue is subjected to several steps Bleached, and collected and fibrized to obtain red algae fibers. The ISO whiteness of the red algae fibers thus prepared is preferably 50 to 99%, more preferably 80 to 99%. The red algae includes at least one selected from the group consisting of laver, wood starfish, ox radish, buckwheat, braid, thorny radish, silk grass, scabbard, gambling, noodle sprout, stone starfish, stone and jinari. The red algae fiber is 1 to 50% by weight, preferably 5 to 30% by weight based on the total weight of Hanji. If the content of red algae fiber exceeds 50% by weight, it is difficult to say Hanji, and less than 1% by weight does not improve the opacity and smoothness.

The red algae fiber had a disadvantage in that the dehydration of the paper was poor due to the short length and narrow width of the fiber. However, the red algae fiber was not formed when the curled and twisted curls were formed through the mechanical treatment of the present invention. Dehydration is better and there is an advantage that the opacity is further improved.

The opacity increases as the basis weight increases. Hanji containing red algae fibers with curls formed according to the present invention having improved dehydration exhibits higher opacity and smoothness than those without red algae fibers. In addition, Hanji containing red algae fibers with curls formed according to the present invention to improve the dehydration is higher opacity even if the basis weight is lower than that of Hanji comprising untreated red algae fibers.

Hanji including red algae fibers with curls formed according to the present invention with improved dehydration appear to have higher opacity and smoothness as the amount of red algae fibers increases.

Hanji containing red algae fibers incorporating curl by mechanical treatment according to the present invention is excellent in opacity and whiteness, so it is suitable as a book paper, a pre-paper, a printing paper for preservation, and can preserve the taste of Hanji as it is excellent in preservation. Therefore, it can be used as a calligraphy paper or high-quality paper.

Hereinafter, preferred examples are provided to aid in understanding the present invention. However, the following examples are merely provided to more easily understand the present invention, and the contents of the present invention are not limited by the examples.

Example 1: Hanji raw fiber manufacturing process

Soaked mulberry in water for about a day to remove the foreign matter, and easy to separate the shell peeled by steam, soaked the skin peeled for 10 hours in water and then peeled the outer skin to prepare a white skin. Soak it in water for about a day and cut it into a suitable length to prevent tangling, and boil it for 6 hours in ashes made of ash, straw, and soybeans.

Then, to remove sugar, ash, etc., other than fiber, it was immersed in flowing water for about half a day or the water was changed 2-3 timesto remove the lye, followed by sunlight for about 5 days, and then decolorized until white color appeared. The daylight bleached sack was pulled out to squeeze out the water, then placed on a flat plate and struck with a bat to release the bundle of fibers and picked out the tee.

Example 2: Red Algae Fiber Extraction Process

Red algae were immersed in an acid solution of pH 2-3 for a certain time, washed with water, and dehydrated. This process removes impurities in the red algae and softens the red algae shell.

The washed and dehydrated red algae were immersed in the extraction solvent to extract the gel component contained in the red algae with the extraction solvent. At this time, the extraction solvent may be water, ethanol, methanol, acetone or ketone. Since the melting point of the gel component included in the red algae is about 60 ℃, the temperature of the extraction solvent is preferably at least 60 ℃.

After the gel extract was removed, a bleaching treatment was performed. Bleaching treatment was performed by ozone treatment, and ozone treatment was repeatedly performed until the red alga became 60 or more in terms of whiteness. Finally, hydrogen peroxide and a reducing agent were added to obtain red algae fibers with a whiteness of 70 or more.

Example 3 Process of Forming Curl on Red Algae Fiber

In order to improve the dehydration of red algae fibers, the red algae fiber stock obtained in Example 2 was concentrated to 25% by weight and fed to a kneader. At this time, if the stock concentration is less than 25% by weight, the concentration is low, the shear force may not be generated sufficiently in the kneader is undesirable, and if the concentration is too high, excessive heat is generated in the stock during the kneading treatment.

Kneading a high concentration of stock is intended to mechanically curl the red algae fibers that are not long in length. In order to form a desired curl, it is preferable to carry out the number of treatments at least once or up to six times in order to adjust the kneading time, and more preferably two to three times. In this example, three kneading treatments were performed, and the bursting strength of the stock increased by 40% and the tensile strength by about 30%.

The process temperature during the kneading treatment is preferably carried out at 60 to 70 ℃. In this example, kneading was carried out three times at 70 ℃ using a kneader of Yamamoto White Horse Co., Ltd., Japan.

White water, which had been recovered during concentration, was added to the kneaded paper stock, diluted again to adjust the concentration to 1% by weight, and completely dissociated with a stirrer of 2300 rpm for 10 minutes.

Example 4 Hanji Manufacturing Process Including Curled Red Algae Fiber

80 parts by weight of the mulberry fibers obtained in Example 1 were put in a paper container, and 20 parts by weight of red algae fibers with curls obtained in Example 3 were added thereto, followed by a conventional method, that is, beating process, extraction process, dehydration process, and drying process. Korean paper was prepared.

Comparative Example 1 Preparation of Hanji Containing Untreated Red Algae Fiber

80 parts by weight of the Doc fiber obtained in Example 1 was put in a paper container, and 20 parts by weight of the red algae fiber of Example 2, which was not subjected to the process of Example 3, were added thereto, thereby preparing a paper containing the conventional method.

Comparative Example 2: Preparation of Korean paper containing only mulberry fiber

100 parts by weight of the mulberry fiber obtained in Example 1 was put in a paper container, and a paper was prepared in a conventional manner.

Experimental Example 1 Measurement of Physical and Optical Properties of Hanji

In order to measure the physical and optical properties of the Hanji and Comparative Examples 1 and 2 according to the invention the following experiment was carried out.

Optical properties of the Hanji prepared in Example 4 and Comparative Examples 1 and 2 were measured after the humidity treatment in a constant temperature and humidity room adjusted to 23 ± 1 ℃, relative humidity 50 ± 2% according to TAPPI standard T402 om-88. Humidified specimens were measured for optical properties such as whiteness (TAPPI T 452 om-98) and opacity (TAPPI T 452 om-96) using Technidyne's Color-Touch based on the TAPPI standard.

The freeness of the stock was measured based on the Canadian Freeness Test method (TAPPI T 227 om-99) to determine the dehydration properties of the red algae fibers before and after mechanical treatment. In addition, in order to measure the dehydration of red algae fibers before and after mechanical treatment, the water retaining degree was measured based on TAPPI USEFUL METHOD UM 256. In order to measure the degree of curl exhibited by red algae fibers before and after mechanical treatment, the fiber length analyzer (MorFi) of TECHPAP was measured. The formula for calculating the curl (%) is described in FIG. 1. Curl (%) represents the overall percentage of fiber shape deviating from the straight state. Equation 1 is a formula for obtaining the curl (%), CL represents the linear distance of the fiber, P means the outer diameter.

$$\text{Curl} = \frac{100 \times (P - 2CL)}{P}$$

$$\text{Curl} = \frac{100 \times (P - 2CL)}{P}$$

The optical properties of Hanji are shown in Table 1 and Yeosu is shown in Table 2.

Whiteness Opacity Example 4 (Korean paper containing curl-forming red algae fiber) 80 85 Comparative Example 1 (Hanji containing untreated red algae fiber) 75 75 Comparative Example 2 (General paper mulberry) 70 65

Conservative Yeosu (mL CSF) curl(%) Example 4 4.9 100 26 Comparative Example 1 6.3 30 14

As shown in Table 1, the opacity and whiteness of the Korean paper containing the red algae fibers subjected to the mechanical treatment according to the present invention (Example 4) are compared to the traditional Korean paper containing red algae fibers (Comparative Example 1) or Korean paper containing only mulberry fiber (compared to it was significantly higher than Example 2). In general, Hanji containing red algae fiber has higher opacity and whiteness than Korean paper containing only mulberry fiber. Hanji treated with the present invention showed better opacity and whiteness than Hanji containing red algae fiber.

In addition, as shown in Table 2, red algae fibers that form curl have less water retention than 20%, and contain less water. It was shown that the dehydration of the paper manufacturing process is excellent.

As described above, the Korean paper comprising red algae fibers formed by curling by mechanical treatment according to the present invention significantly increases the opacity, whiteness, and dehydration of the Korean paper including untreated red algae fibers, thereby increasing the opacity, whiteness, and it seems to have contributed greatly to the improvement of production efficiency.

1 is an explanatory view of a method of measuring curl (%).

2 is a photograph of red algae fibers before curling.

Figure 3 is an enlarged photograph of 100% Korean paper mulberry.

Figure 4 is an enlarged photograph of Hanji made from 20% by weight of red algae fiber and 80% by weight of mulberry fiber without curling.

Figure 5 is an enlarged photograph of Hanji made from 20% by weight of red algae fibers and 80% by weight of mulberry fibers forming curls.

Patent Citations (1)

Publication number	Priority date	Publication date	Assignee	Title
KR20050046601A *	2003-11-13	2005-05-18	유학철	Pulp and paper made from rhodophyta and manufacturing method thereof
Family To Family Citations				

* Cited by examiner, † Cited by third party

Cited By (4)

Publication number	Priority date	Publication date	Assignee	Title
KR101019329B1	2008-07-25	2011-03-07	충남대학교산학협력단	Korean paper comprising red algae fiber
US9074332A2	2013-06-10	2015-07-07	Kimberly-Clark Worldwide, Inc.	Layered tissue structures comprising macroalgae
KR101760213B1	2016-06-23	2017-07-21	이종순	Environment-friendly fiber complex mulching paper for agriculture and preparation method thereof
US11053643B2	2017-02-22	2021-07-06	Kimberly-Clark Worldwide, Inc.	Layered tissue comprising non-wood fibers
Family To Family Citations				

* Cited by examiner, † Cited by third party, ‡ Family to family citation

Similar Documents

Publication	Publication Date	Title
KR101013932B1	2011-03-07	Korean paper comprising red algae fiber
JPS6389795B2	2016-06-22	Treatment method of plant-based materials
CN105544282A	2016-05-04	Papermaking process method utilizing paper mulberry bark as raw material
KR100933462B1	2009-12-23	Korean paper comprising curled red algae fiber
KR100754893B1	2007-09-10	Method for Making Pulp Using Rhodophyta
KR100811196B1	2008-03-17	Method for Preparing Pulp Using Rhodophyta Having Thick Cortex
KR100664885B1	2007-01-09	Korean paper using tangerine peel
CN112779618A	2021-05-11	Heating tobacco cigarette paper and preparation method thereof
CN107237211A	2017-10-10	Work hand writes special half mature rice paper and preparation method thereof
CN107190567A	2017-09-22	Special mature rice paper of traditional Chinese painting and preparation method thereof
CN107779998	2018-03-04	Personage's flower-and-bird painting Special cotton material rice paper and preparation method thereof
KR100925743B1	2009-11-12	Korean paper comprising unbleached red algae fiber
CN113668144B	2022-08-23	Preparation method of opened paper based on wild goose bark fibers
KR100811200B1	2008-03-17	Method for Preparing Pulp Using Rhodophyta Having Thin Cortex
CN107354809A	2017-11-17	Special ultra-clean rice paper of calligraphy and preparation method thereof
CN113605120A	2021-11-05	Method for making calabash vine paper
KR101010978B1	2011-01-26	Method of Manufacturing an opaque paper using Genus Typha L.
KR101360029B1	2014-02-21	A process of preparing shroud for monk by using Korean paper
CN112144313A	2020-12-29	Clean papermaking system and clean papermaking method adopting same
CN106283915B	2018-07-10	A kind of bamboo base tobacco lining paper and preparation method thereof
Song	2017	Evaluation of conservation quality Eastern papers regarding materials and process
KR101468069B1	2015-01-09	Cosmetic Korean paper powder and the method for preparing thereof
KR100481713B1	2005-04-11	A manufacturing method of korean paper
CN107326719A	2017-11-07	Special net skin rice paper of landscape painting and preparation method thereof
KR102293737B1	2021-08-26	anti-bacterial paper using fig and manufacturing method thereof

Priority And Related Applications

Priority Applications (1)

Application	Priority date	Filing date	Title
KR1020090062861A	2009-07-10	2009-07-10	Korean paper comprising curled red algae fiber

Applications Claiming Priority (1)

Application	Filing date	Title
KR1020090062861A	2009-07-10	Korean paper comprising curled red algae fiber

Legal Events

Date	Code	Title	Description
2009-07-10	A201	Request for examination	
2009-07-13	A302	Request for accelerated examination	
2009-09-29	E902	Notification of reason for refusal	
2009-12-07	E701	Decision to grant or registration of patent right	
2009-12-15	GRNT	Written decision to grant	

Concepts

machine-extracted

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Name	Image	Sections	Count	Query match
fiber		title,claims,abstract,description	108	0.000
Rhodophyta		title,claims,abstract,description	91	0.000
dehydration reaction		claims,abstract,description	35	0.000
manufacturing process		claims,description	15	0.000
effects		abstract,description	3	0.000

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심사관 : 나수현

(54) 불균질 이온교환막의 제조 방법

요약

본 발명은 전기식 탈염장치에 구비되어 용존 이온을 제거 또는 농축하는 이온교환막에 관한 것으로, 혼련기에 이온교환수지 50~54 wt% - 고분자결합체 40~50 wt% - 폴리에틸렌글리콜 5~10 wt%의 함량비로 장입한 다음, 130~150℃의 온도범위로 20~40분 동안 반죽하여 혼합물로 제조하고 압출기에 혼합물을 주입하여 0.5~2.0 mm의 두께 범위로 압출하여 평판형상의 쉬트로 성형한 후, 가교기에 쉬트를 침적하여 첨가제가 3.0~5.0 wt%의 함량비로 첨가된 순수를 이용하여 80~100 ℃의 온도범위로 1~3 시간 동안 침적하여 가교시키는 것을 특징으로 하여, 이온교환막의 기구적인 손상 및 누수현상이 발생되지 않아 탈염장치의 분해/조립에 따른 작업공수 및 작업하중이 절감될 뿐만 아니라, 이온교환막의 사용과정에서 유기물에 의한 오염 및 스케일의 형성이 방지됨은 물론 전기적 저항이 감소되어 탈염장치의 유지/보수에 따른 각종 부대비용이 절감되게 한 것이다.

대표도

도 1

색인어

전기식탈염장치, 이온교환막, 폴리에스터, 폴리에틸렌글리콜

명세서

Kimberly Clark EX1002, p. 1982
PGR2026-00078

도면의 간단한 설명

도 1은 일반적인 기술에 따른 전기투석장치의 개략적인 구성도이다.

* 도면 중 주요부분에 대한 부호의 설명 *

10 : 탈염장치 11 : 양극

12 : 음극 13,14 : 양/음이온교환막

15,16 : 스페이서 17,18 : 양/음이온교환수지

20 : 전원공급장치

발명의 상세한 설명

발명의 목적

발명이 속하는 기술 및 그 분야의 종래기술

본 발명은 전기식 탈염장치에 구비되어 용존 이온을 제거 또는 농축하는 이온교환막에 관한 것으로, 특히 이온교환막의 기계적 특성 및 화학적 특성을 동시에 향상시켜 탈염장치의 작동성능 및 신뢰성을 극대화시킬 수 있도록 된 불균질 이온교환막의 제조 방법에 관한 것이다.

일반적으로, 전기식 탈염장치는 물에 용존되어있는 각종 이온성분을 제거 또는 농축하는 정화장치로서, 이러한 전기식 탈염장치는 양극과 음극에 공급되는 직류전원의 전위차를 이용하여 양이온성분과 음이온성분을 분리하여 농축실로 농축하면서 희석실에서 순수를 제조하게 된다.

즉, 도 1에서와 같이, 전기식탈염장치(10)는, 양극(11)과 음극(12)의 사이에 음이온교환막(13)과 양이온교환막(14)이 교대로 적층되며, 이온교환막(13,14)의 사이에 유체의 흐름을 유도하는 스페이서(15,16)가 개재되고, 스페이서(15,16)에 이온교환수지(17,18)이 충진되어 구성된다.

따라서, 전원공급장치(20)에 직류전원을 공급하면, 전기식탈염장치(10)의 양극(11)과 음극(12)의 전위차가 발생하여 양극(11)과 음극(12)의 사이에 전류가 흐르므로, 폐수중의 용존 이온들이 스페이서(15,16)에 의해 흐름이 촉진된 상태에서 양/음이온교환막(13,14)을 통과한다.

이어서, 양/음이온교환막(13,14)을 통과하는 이온성분 중 Na+ 등과 같은 양이온성분은 음극(12)의 방향으로 이동하는 반면, Cl- 등과 같은 음이온성분은 양극 (11)의 방향으로 이동하여 농축실에 농축되므로, 희석실(미도시)에서는 이물질이 제거된 순수가 생산되는 것이다.

한편, 전기식탈염장치(10)에 사용되는 불균질이온교환막(13,14)은 용존이온에 대한 선택 투과성을 지닌 평판 형태로 제조된 것으로서, 이온의 선택투과, 분리탈염, 농축 등의 작용을 나타내어 순수처리, 폐수의 재이용, 당액의 정제 및 연료전지 등과 같은 광범위한 범위에 사용되고 있다.

이때, 양이온교환막(14)은 산성기(예:-SO3-, COO-)를 지니고 있어, 예컨대 양이온(예:H+ , Na+)은 정전기적 인력에 선택적으로 결합하여 전위차 등의 기전력에 의해 막을 통과할 수 있지만, 음이온(예:OH-, Cl-)은 정전기적 반발력에 의해 막을 통과할 수 없는 특징이 있다.

반면에, 음이온교환막(13)은 염기성기(예:NH+)를 지니고 있어, 음이온은 정전기적 인력에 선택적으로 결합하여 전위차 등의 기전력에 의해 막을 통과할 수 있지만, 양이온은 정전기적 반발력에 의해 막을 통과할 수 없는 특징이 있다.

Kimberly Clark EX1002, p. 1983
PGR2026-00078

한편, 이온교환막(13,14)은 분말상태의 이온교환수지와 고분자결합체를 혼합하여 일정온도 및 일정압력하에서 압출성형 및 가압성형 등의 성형방법을 이용하여 제조하는 것으로 비교적 제조가 용이하다. 이때, 고분자결합체로는 폴리에틸렌, 폴리프로필렌, 폴리염화비닐 등을 사용하고 있다.

그런데, 이온교환막(13,14)은 그 기계적 강도가 고분자결합제의 물성 자체에 의존하고 있어 압력을 가해 조립할 경우 파단면이 발생할 우려가 있을 뿐만 아니라, 고분자 결합제로 사용되는 물질들이 대부분 소수성(Hydrophobic)을 가지고 있어 유기물에 의한 오염(Fouling) 및 스케일(Scale)형성에 의한 성능저하에 대한 문제점이 노출되고 있는 실정이다.

그리고, 이온교환막(13,14)의 기계적 물성을 보강하기 위해 직조섬유를 삽입하는 방법을 사용하지만, 이는 멤브레인의 기계적 물성을 향상시키는 데는 도움이 되지만 표면조도가 증가하여 유체가 밀봉되지 않고 누출될 확률이 높고 전기적저항이 크게 증가하여 전류효율을 저하시키는 단점이 있다.

발명이 이루고자 하는 기술적 과제

이에, 본 발명은 상기한 바와 같은 제문제점을 해결하기 위하여 안출된 것으로서, 불균질 이온교환막의 기계적 특성 및 화학적 특성을 동시에 향상시켜 탈염장치의 작동성능 및 신뢰성을 향상시킬 수 있도록 된 불균질 이온교환막의 제조 방법을 제공하는 데에 그 목적이 있다.

상기한 바의 목적을 달성하기 위한 본 발명은, 혼련기에 이온교환수지와 고분자결합체와 폴리에스터 또는 폴리에틸렌글리콜을 첨가하여 일정온도 및 일정압력하에서 성형하되, 폴리에틸렌글리콜이 첨가된 경우 탄산나트륨 또는 황산나트륨이 포함된 순수에서 가교시키는 것을 특징으로 한다.

발명의 구성 및 작용

이하, 본 발명에 따른 실시예들을 상세하게 설명하면 다음과 같다.

먼저, 본 발명에 따른 구성요소 중 장입물을 반죽하여 혼합물로 제조하는 혼련기와, 혼합물을 평판형상의 쉬트로 제조하는 압출기 및, 쉬트를 가교하는 가교기는 공지기술이므로, 자세한 설명을 생략하기로 한다.

[실시예 1]

혼련기에 이온교환수지 50~54 wt% - 고분자결합체 40~50 wt% - 폴리에스더 0.5~3.0 wt%로 장입한 다음, 130~150 ℃의 온도범위로 20~40분 동안 반죽하여 혼합물로 제조한 후, 압출기에 혼합물을 주입하여 0.5~2.0 mm의 두께범위로 압출하여 평판형상의 쉬트로 성형하는 것을 특징으로 한다.

이때, 이온교환수지로는 양이온수지나 음이온수지 등을 분말형태로 제조하여 사용함이 바람직하며, 고분자결합체로는 폴리에틸렌이나 폴리프로필렌이나 폴리염화비닐 등을 사용함이 바람직하다.

또한, 폴리에스터는, 최종제품의 전기적 특성에 영향을 미치지 않으면서도 기계적 강도를 향상시키는 첨가성분으로서, 첨가량이 0.5wt%이하인 경우 강도 향상에 도움을 주지 못하였으며, 첨가량이 3wt%이상인 경우 전기적 저항을 감소시키므로, 그 첨가량을 0.5~3.0 wt%의 중량비로 한정하였다.

또한, 폴리에스터는, 그 절단 크기를 적어도 5cm 이하로 최소화하여 예컨대, 이온교환수지 및 고분자결합체와의 혼합과정에서 용융작업 및 반죽작업이 원활하게 유도되도록함이 바람직하다.

또한, 혼합물 즉, 이온교환수지와 고분자결합체와 폴리에스터의 혼합물을 압출공정을 통해 성형하는 것으로 한정하여 설명하였지만, 가압성형 등과 같은 성형방법으로도 제조할 수 있음은 당연하다.

[실시예 2]

Kimberly Clark EX1002, p. 1984
PGR2026-00078

혼련기에 이온교환수지 50~54 wt% - 고분자결합체 40~50 wt% - 폴리에틸렌글리콜 5~10 wt%의 함량비로 장입한 다음, 130~150℃의 온도범위로 20~40분 동안 반죽하여 혼합물로 제조하고 압출기에 혼합물을 주입하여 0.5~2.0 mm의 두께 범위로 압출하여 평판형상의 쉬트로 성형한 후, 가교기에 쉬트를 침적하여 첨가제가 3.0~5.0 wt%의 함량비로 첨가된 순수를 이용하여 80~100 ℃의 온도범위로 1~3 시간 동안 가교시키는 것을 특징으로 한다.

이때, 이온교환수지로는 양이온수지나 음이온수지 등을 분말형태로 제조하여 사용함이 바람직하며, 고분자결합체로는 폴리에틸렌이나 폴리프로필렌이나 폴리염화비닐 등을 사용함이 바람직하다.

또한, 폴리에틸렌글리콜은, 최종제품의 친수성을 부여하여 오염 및 스케일의 형성을 방지시키는 첨가성분으로, 첨가량이 5wt% 이하인 경우 친수성의 부여에 도움을 주지 못하며, 첨가량이 10wt% 이상인 경우 기계적인 강도를 저하시키므로, 그 첨가량을 5~10 wt%의 범위로 한정하였다.

또한, 첨가제는 순수에 3.0 ~5.0 wt%의 함량비로 첨가된 것으로서 혼합물의 가교과정에서 폴리에틸렌글리콜이 녹는 것을 방지함은 물론 고분자결합체와 폴리에틸렌글리콜을 상호 결합시키는 기능을 수행한다.

물론, 순수에 미량 첨가되는 첨가제로는 탄산나트륨 또는 황산나트륨 중 어느 하나를 선택하여 사용하거나 또는 탄산나트륨과 황산나트륨을 혼합하여 사용할 수도 있다.

[실시예 3]

혼련기에 이온교환수지 50~54wt% - 고분자결합체 40~50wt% - 폴리에스터 0.5~3.0wt% - 폴리에틸렌글리콜 5~10wt%의 함량비로 장입하고 130~150℃의 온도범위로 20~40분 동안 반죽하여 혼합물로 제조한 후, 압출기에 혼합물을 주입하여 0.5~2.0mm의 두께범위로 압출하여 평판형상의 쉬트로 성형하고, 가교기에 쉬트를 침적하여 첨가제가 0.5~2.0wt%의 함량비로 첨가된 순수를 이용하여 80~100℃의 온도범위로 1~3 시간 동안 가교시키는 것을 특징으로 한다.

이때, 이온교환수지의 형태와 고분자결합체의 종류 및 폴리에스터와 폴리에틸렌글리콜의 함량비는 실시예 1, 2와 동일한 조건이므로 자세한 설명은 생략하기로 하고, 다만 폴리에스터와 폴리에틸렌글리콜을 함께 첨가하여 최종제품의 기계적 강도 및 친수성을 동시에 향상시킨 것이다.

발명의 효과

이상에서 설명한 바와 같이 본 발명에 따른 불균질 이온교환막의 제조 방법에 의하면, 이온교환막에 일정량의 폴리에스터 또는 폴리에틸렌글리콜을 첨가하여 기계적인 특성 및 화학적 특성을 동시에 향상시키므로써, 이온교환막의 기구적인 손상이 발생되지 않아 탈염장치의 분해/조립에 따른 작업공수 및 작업하중이 절감될 뿐만 아니라, 유체의 밀봉력이 증대되어 누수현상이 발생되지 않아 주변환경의 오염이 방지되는 효과가 있다.

그리고, 이온교환막의 사용과정에서 유기물에 의한 오염 및 스케일의 형성이 원천적으로 봉쇄되어 이온교환막의 수명이 연장될 뿐만 아니라, 이온교환막의 작동과정에서 전기적 저항의 감소로 인해 전류효율이 증대되어 탈염장치의 작동성능 및 신뢰성이 향상되는 효과가 있다.

(57) 청구의 범위

청구항 1.

분말상태의 이온교환수지와 고분자결합체를 혼합하여 제조하는 공지의 이온교환막에, 0.5~3.0wt%의 폴리에스터를 첨가하고 130~150℃의 온도범위로 20~40분 동안 반죽하여 혼합물로 제조한 후,

상기 혼합물을 0.5~2.0mm의 두께로 압출하여 평판형상의 쉬트로 성형하는 것을 특징으로 하는 불균질 이온교환막의 제조 방법.

Kimberly Clark EX1002, p. 1985
PGR2026-00078

청구항 2.

분말상태의 이온교환수지와 고분자결합체를 혼합하여 제조하는 공지의 이온교환막에, 5～10wt%의 폴리에틸렌글리콜을 첨가하고, 130～150℃의 온도범위로 20～40분 동안 반죽하여 혼합물로 제조한 후,

상기 혼합물을 0.5～2.0mm의 두께범위로 압출하여 평판형상의 쉬트로 성형한 다음,

상기 쉬트를 가교기에 침적한 후 탄산나트륨 또는 황산나트륨 중 어느 하나 또는 이들의 혼합물이 0.5～2.0wt%로 첨가된 순수를 이용하여 80～100℃의 온도범위로 1～3 시간 동안 가교시키는 것을 특징으로 하는 불균질 이온교환막의 제조 방법.

청구항 3.

분말상태의 이온교환수지와 고분자결합체를 혼합하여 제조하는 공지의 이온교환막에, 0.5～3.0wt%의 폴리에스터와 5～10wt%의 폴리에틸렌글리콜을 첨가하고 130～150℃의 온도범위로 20～40분 동안 반죽하여 혼합물로 제조한 후,

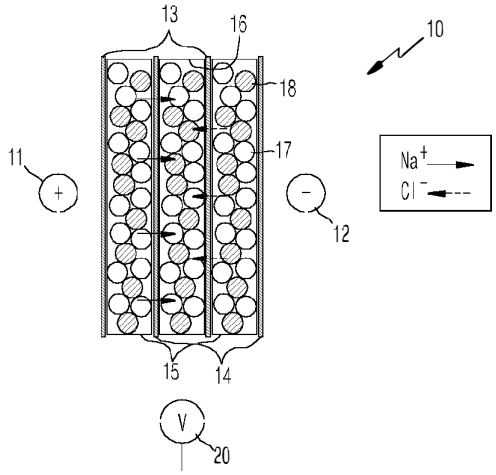
상기 혼합물을 0.5～2.0mm의 두께범위로 압출하여 평판형상의 쉬트로 성형한 다음,

상기 쉬트를 가교기에 침적한 후 탄산나트륨 또는 황산나트륨 중 어느 하나 또는 이들의 혼합물이 0.5～2.0wt%로 첨가된 순수를 이용하여 80～100℃의 온도범위로 1～3 시간 동안 가교시키는 것을 특징으로 하는 불균질 이온교환막의 제조 방법.

청구항 4.
삭제

도면

도면1



Kimberly Clark EX1002, p. 1986
PGR2026-00078

Manufacturing method of heterogeneous ion exchange membrane

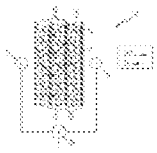
Abstract

translated from Korean

BACKGROUND OF THE INVENTION 1. Field of the Invention The present invention relates to an ion exchange membrane provided in an electric desalination apparatus for removing or concentrating dissolved ions. The kneader is used in an ion exchange resin 50 to 54 wt%-a polymer binder 46 to 50 wt%-polyethylene glycol 5 to 10 wt% After charging to a ratio, it was kneaded for 20 to 40 minutes at a temperature range of 130 to 150 °C to prepare a mixture, injecting the mixture into an extruder, extruded to a thickness range of 0.5 to 2.0 mm to form a flat sheet, crosslinking The sheet is deposited on the sheet, and crosslinked by depositing for 1 to 3 hours at a temperature range of 80 to 100 ° C. using pure water to which an additive is added at a content ratio of 3.0 to 5.0 wt%. Since leakage does not occur, not only work man-hours and work loads are reduced due to the decomposition / assembly of the desalination unit, but also organic contamination and scale formation during the use of the ion exchange membrane are prevented. Doemeun will not of course be a reduction in the electrical resistance of the various forces cost effective maintenance / repair of the desalination apparatus.

Electric desalination unit, ion exchange membrane, polyester, polyethylene glycol

Images (1)



KR100547592B1

South Korea

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Other languages: Korean

Inventor: 한상필, 이철기

Worldwide applications

2003 KR

Application KR1020030024719A events

2003-04-18 Application filed by 한국원자력연구원
2003-04-18 Priority to KR1020030024719A
2004-10-27 Publication of KR20040090772A
2006-01-31 Application granted
2006-01-31 Publication of KR100547592B1

Info: Cited by (3), Legal events, Similar documents, Priority and Related Applications

External links: Espacenet, Global Dossier, Discuss

Classifications

- C08J5/2218 Synthetic macromolecular compounds

View 6 more classifications

Claims (4)

Hide Dependent ^

translated from Korean

To a known ion exchange membrane prepared by mixing a powdered ion exchange resin and a polymer binder, 0.5 to 3.0 wt% of polyester is added and kneaded for 20 to 40 minutes at a temperature range of 130 to 150 ° C. to prepare a mixture. after, A method for producing a heterogeneous ion exchange membrane, wherein the mixture is extruded to a thickness of 0.5 to 2.0 mm to form a flat sheet. To a known ion exchange membrane prepared by mixing a powdered ion exchange resin and a polymer binder, 5 to 10 wt% of polyethylene glycol is added, and kneaded for 20 to 40 minutes at a temperature range of 130 to 150 ° C. to prepare a mixture. after, The mixture was extruded into a thickness range of 0.5 to 2.0 mm to form a sheet-like sheet. After depositing the sheet in the crosslinker, any one of sodium carbonate or sodium sulfate or a mixture thereof is crosslinked for 1 to 3 hours in a temperature range of 80 to 100 ° C using pure water added at 0.5 to 2.0 wt%. Method for producing heterogeneous ion exchange membrane. 0.5-3.0 wt% of polyester and 5-10 wt% of polyethylene glycol are added to a known ion exchange membrane prepared by mixing a powder-type ion exchange resin and a polymer binder, and the temperature is in the range of 20 to 40 with a temperature range of 130 to 150 ° C. Knead for minutes to make a mixture, The mixture was extruded into a thickness range of 0.5 to 2.0 mm to form a sheet-like sheet. After depositing the sheet in the crosslinker, any one of sodium carbonate or sodium sulfate or a mixture thereof is crosslinked for 1 to 3 hours in a temperature range of 80 to 100 ° C using pure water added at 0.5 to 2.0 wt%. Method for producing heterogeneous ion exchange membrane. delete

Description

translated from Korean

Method for making the heterogeneous ion exchange membrane

1 is a schematic configuration diagram of an electrodialysis apparatus according to a general technique.

Explanation of symbols on the main parts of the drawings

10 desalting apparatus 11 anode

12: cathode 13,14: positive / negative ion exchange membrane

15, 16 spacer 17,18 positive / negative ion exchange resin

20 power supply

The present invention relates to an ion exchange membrane provided in the electric desalination apparatus to remove or concentrate dissolved ions, and in particular, to improve the mechanical and chemical properties of the ion exchange membrane at the same time, thereby making it possible to maximize the operating performance and reliability of the desalination apparatus. A method for producing an ion exchange membrane.

In general, an electric desalting apparatus is a purifying apparatus for removing or concentrating various ionic components dissolved in water. The electric desalting apparatus separates a cation component and an anion component by using a potential difference of a DC power supplied to a positive electrode and a negative electrode. Pure water is produced in the dilution chamber while concentrating in the concentration chamber.

That is, as shown in FIG. 1, in the electric desalination apparatus 10, the anion exchange membrane 13 and the cation exchange membrane 14 are alternately stacked between the anode 11 and the cathode 12, and the ion exchange membrane 13, The spacers 15 and 16 which guide the flow of the fluid are interposed therebetween, and the ion exchangeresins 17 and 18 are filled in the spacers 15 and 16.

Therefore, when DC power is supplied to the power supply device 20, a potential difference between the positive electrode 11 and the negative electrode 12 of the electric desalination device 10 is generated, and a current is generated between the positive electrode 11 and the negative electrode 12. As it flows, dissolved ions in the wastewater pass through the positive / anion exchange membranes 13 and 14 in a state where the flow is promoted by the spacers 15 and 16.

Subsequently, of the ionic components passing through the positive / anion exchange membranes 13 and 14, a cation component such as Na + moves in the direction of the cathode 12, while an anion component such as Cl - moves in the direction of the positive electrode 11. Since it is concentrated in a concentration chamber, in the dilution chamber (not shown), pure water from which foreign substances have been removed is produced.

On the other hand, the heterogeneous ion exchange membranes 13 and 14 used in the electric desalination apparatus 10 are manufactured in the form of a flat plate having selective permeability to dissolved ions, and exhibit the effects of selective permeation, separation desalination, and concentration of ions. It is used in a wide range of fields such as pure water treatment, reuse of waste water, purification of sugar solutions and fuel cells.

At this time, the cation exchange membrane 14 has an acidic group (eg, -SO3-, COO-). For example, cations (eg, H + and Na +) selectively bind to electrostatic attraction and pass through the membrane by electromotive force such as a potential difference. However, anions (eg, OH-, Cl-) cannot be passed through the membrane by electrostatic repulsion.

On the other hand, the anion exchange membrane 13 has a basic group (eg NH +), and the anion may selectively bind to electrostatic attraction and pass through the membrane by electromotive force such as a potential difference, but the cation may be blocked by the electrostatic repulsive force. There is a characteristic that cannot pass.

On the other hand, the ion exchange membrane (13,14) is relatively easy to manufacture by mixing the ion exchange resin and the polymer binder in a powder state by using a molding method such as extrusion molding and pressure molding under a constant temperature and a certain pressure. In this case, polyethylene, polypropylene, polyvinyl chloride, or the like is used as the polymer binder.

However, since the mechanical strength of the ion exchange membranes 13 and 14 depends on the physical properties of the polymer binder itself, there is a risk of fracture surface when assembled under pressure, and most of the materials used as the polymer binder are hydrophobic. As a result, there is a problem of deterioration of performance due to fouling and scale formation by organic materials.

In addition, the method of inserting the woven fiber to reinforce the mechanical properties of the ion exchange membrane (13,14) is used, but this helps to improve the mechanical properties of the membrane, but the surface roughness is increased to leak the fluid without sealing There is a disadvantage in that the probability is high and the electrical resistance is greatly increased to lower the current efficiency.

Accordingly, the present invention has been made to solve the problems described above, the heterogeneous ion exchange membrane to improve the mechanical and chemical properties of the heterogeneous ion exchange membrane at the same time to improve the operating performance and reliability of the desalination apparatus Its purpose is to provide a process for the preparation of.

The present invention for achieving the above object, the kneading machine is added to the ion exchange resin, a polymer binder and polyester or polyethylene glycol by molding at a constant temperature and a constant pressure, when the polyethylene glycol is added sodium carbonate or sodium sulfate Crosslinked in the purified pure water.

Hereinafter, the embodiments according to the present invention will be described in detail.

First, a kneader for kneading the contents of the component according to the present invention to prepare a mixture, an extruder for producing the mixture into a flat sheet, and a crosslinking group for crosslinking the sheet are well known technologies, and thus, detailed descriptions thereof will be omitted.

Example 1

50 to 54 wt% of an ion exchange resin-40 to 50 wt% of a polymer binder-0.5 to 3.0 wt% of polyester, and then kneaded for 20to 40 minutes at a temperature range of 130 to 150 ℃ to prepare a mixture. Thereafter, the mixture is injected into the extruder and extruded into a thickness range of 0.5 to 2.0 mm to form a flat sheet.

In this case, the ion exchange resin is preferably prepared by using a cationic resin or an anion resin in powder form, and the polymer binder is preferably polyethylene, polypropylene, polyvinyl chloride, or the like.

In addition, polyester is an additive component that improves the mechanical strength without affecting the electrical properties of the final product, it does not help to improve the strength when the addition amount is less than 0.5wt%, the electrical resistance when the addition amount is more than 3wt% In order to reduce the amount, the addition amount was limited to a weight ratio of 0.5 to 3.0 wt%.

In addition, the polyester, it is preferable to minimize the cut size to at least 5cm or less to facilitate the melting and kneading operation, for example in the mixing process with the ion exchange resin and the polymer binder.

In addition, the mixture, i.e., the mixture of the ion exchange resin, the polymer binder and the polyester, was described as being limited to molding through an extrusion process, but it can be manufactured by a molding method such as pressure molding.

Example 2

50 to 54 wt% of the ion exchange resin-40 to 50 wt% of the polymer binder-5 to 10 wt% of polyethylene glycol, charged into the kneader, and then kneaded for 20 to 40 minutes in a temperature range of 130 to 150 ℃ to obtain a mixture. Afterpreparing and injecting the mixture into an extruder and extruding it into a thickness range of 0.5 to 2.0 mm to form a flat sheet, the sheet was deposited on a crosslinker and 80% using pure water to which an additive was added at a content ratio of 3.0 to 5.0 wt%. It is characterized by crosslinking for 1 to 3 hours in the temperature range of ~ 100 °C.

In this case, the ion exchange resin is preferably prepared by using a cationic resin or an anion resin in powder form, and the polymer binder is preferably polyethylene, polypropylene, polyvinyl chloride, or the like.

In addition, polyethylene glycol is an additive component that imparts hydrophilicity of the final product to prevent contamination and formation of scales, and when the added amount is 5 wt% or less, it does not help to impart hydrophilicity, and when the added amount is 10 wt% or more, the mechanical strength is increased. Since it lowers, the addition amount was limited to the range of 5-10 wt%.

In addition, the additive is added to the pure water in a content ratio of 3.0 to 5.0 wt% to prevent the polyethylene glycol from melting during the crosslinking of the mixture as well as to perform the function of mutually bonding the polymer binder and polyethylene glycol.

Of course, as an additive added in a small amount to the pure water, either sodium carbonate or sodium sulfate may be selected or used in combination with sodium carbonate and sodium sulfate.

Example 3

50 to 54 wt% of ion exchange resin-40 to 50 wt% of polymer binder-0.5 to 3.0 wt% of polyester-5 to 10 wt% of polyethylene glycol, charged and kneaded for 20 to 40 minutes at a temperature range of 130 to 150 After the mixture was prepared into a mixture, the mixture was injected into an extruder, extruded into a thickness range of 0.5 to 2.0 mm, formed into a flat sheet, and the sheet was deposited into a crosslinker to add additives at a content ratio of 0.5 to 2.0 wt%, it is characterized by crosslinking for 1 to 3 hours in the temperature range of 80 ~ 100 ℃ using.

At this time, since the form of the ion exchange resin and the type of the polymer binder and the content ratio of the polyester and polyethylene glycol are the same conditions as in Examples 1 and 2, the detailed description thereof will be omitted. The mechanical strength and hydrophilicity of the product are improved at the same time.

As described above, according to the method for producing a heterogeneous ion exchange membrane according to the present invention, by adding a predetermined amount of polyester or polyethylene glycol to the ion exchange membrane to improve mechanical and chemical properties simultaneously, mechanical damage to the ion exchange membrane Since this does not occur, the labor and work load due to disassembly / assembly of the desalination apparatus is not only reduced, but the sealing force of the fluid is increased, so that leakage does not occur, thereby preventing pollution of the surrounding environment.

In addition, contamination of organic matter and formation of scale during the use of the ion exchange membrane are essentially blocked to prolong the life of the ion exchange membrane, and the current efficiency is increased due to the decrease in the electrical resistance during the operation of the ion exchange membrane, thereby providing a desalination apparatus. The operation performance and reliability of the effect is improved.

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Publication number	Priority date	Publication date	Assignee	Title
KR20200095238A	2019-01-31	2020-08-10	주식회사 이노멤텍	Heterogeneous membrane and its manufacturing method
US11053643B2	2017-02-22	2021-07-06	Kimberly-Clark Worldwide, Inc.	Layered tissue comprising non-wood fibers
KR20230072892A	2021-11-18	2023-05-25	주식회사 에코비트	Cation exchange membrane for ultrapure water with improved conductivity by containing graphene and electo deionization device comprising the same

Family To Family Citations

* Cited by examiner, † Cited by third party, ‡ Family to family citation

Similar Documents

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CN101195508B	2011-08-31	Method and apparatus for preventing scaling in electrodeionization units
EP1617482B1	2005-06-22	Electrochemically assisted ion exchange
Xu	2005	Ion exchange membranes: State of their development and perspective
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US20080029395A1	2008-02-07	Multi-functional filtration and ultra-pure water generator
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KR20150007070A	2015-01-20	Capacitive deionization unit cell and preparation method thereof
CN212198606U	2020-12-22	One-way cation mixed exchange type water purification system and water purifier
KR20120100079A	2012-09-12	Membrane having carbon polyaniline

Priority And Related Applications

Priority Applications (1)

Application	Priority date	Filing date	Title
KR1020030024719A	2003-04-18	2003-04-18	Manufacturing method of heterogeneous ion exchange membrane

Applications Claiming Priority (1)

Application	Filing date	Title
KR1020030024719A	2003-04-18	Manufacturing method of heterogeneous ion exchange membrane

Legal Events

Date	Code	Title	Description
2003-04-18	A201	Request for examination	
2005-06-23	E902	Notification of reason for refusal	
2006-01-04	E701	Decision to grant or registration of patent right	
2006-01-23	GRNT	Written decision to grant	
2013-01-21	FPAY	Annual fee payment	Payment date: 20130121 Year of fee payment: 8
2014-01-02	FPAY	Annual fee payment	Payment date: 20140102 Year of fee payment: 9
2015-01-08	FPAY	Annual fee payment	Payment date: 20150108 Year of fee payment: 10
2017-12-01	FPAY	Annual fee payment	Payment date: 20171201 Year of fee payment: 13
2018-12-26	FPAY	Annual fee payment	Payment date: 20181226 Year of fee payment: 14
2019-11-14	FPAY	Annual fee payment	Payment date: 20191114 Year of fee payment: 15

Concepts

machine-extracted

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Name	Image	Sections	Count	Query match
ion exchange membrane		title,claims,abstract,description	27	0.000
manufacturing process		title,claims,description	7	0.000
mixture		claims,abstract,description	23	0.000
polymer binder		claims,abstract,description	15	0.000
polymer binding agent		claims,abstract,description	15	0.000
Polyethylene glycol		claims,abstract,description	13	0.000
ion exchange resin		claims,abstract,description	13	0.000

⊗ ion-exchange polymer	claims,abstract,description	13	0.000
⊗ polyethylene glycol	claims,abstract,description	13	0.000
⊗ water	claims,abstract,description	11	0.000
⊗ polyester	claims,abstract,description	10	0.000
⊗ deposition	claims,abstract	3	0.000
⊗ sodium carbonate	claims,description	10	0.000
⊗ mixing	claims,description	5	0.000
⊗ na2so4	claims,description	5	0.000
⊗ sodium carbonate	claims,description	5	0.000
⊗ sodium carbonate	claims,description	5	0.000
⊗ sodium sulfate	claims,description	5	0.000
⊗ sodium sulphate	claims,description	5	0.000
⊗ Cross linker	claims,description	4	0.000
⊗ desalination reaction	abstract,description	13	0.000
⊗ additive	abstract,description	7	0.000
⊗ additive	abstract,description	6	0.000
⊗ cross linking	abstract,description	6	0.000
⊗ ions	abstract,description	5	0.000
⊗ biosynthetic process	abstract,description	4	0.000
⊗ formation reaction	abstract,description	4	0.000
⊗ contamination	abstract,description	3	0.000
⊗ decomposition reaction	abstract	1	0.000

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(19) 대한민국특허청(KR)
(12) 공개특허공보(A)

(11) 공개번호 10-2011-0060510
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(54) 신축성이 향상된 대나무 섬유 부직포를 이용한 화장품용 시트 마스크

(57) 요 약

본 발명은 대나무 섬유 부직포를 이용한 시트 마스크에 관한 것으로, 대나무 섬유와 PLA 섬유 또는 PET 섬유를 혼섬함으로써 대나무 소재 고유의 부드러움은 유지하면서 PLA 섬유 또는 PET 섬유로 신축성을 향상시켜 굴곡이 많은 부위에도 밀착이 잘되는 대나무 섬유 부직포를 이용한 시트 마스크에 관한 것이다.

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특허청구의 범위

청구항 1

대나무 섬유와 폴리락틱산(Polylactic Acid, PLA) 섬유 또는 폴리에틸렌 테레프탈레이트(polyethylen terephthalate, PET) 섬유를 혼섬하여 제조한 대나무 섬유 부직포.

청구항 2

제 1항에 있어서, 상기 대나무 섬유는 50~90중량%, PLA섬유 또는 PET 섬유는 50~10중량%로 혼섬되는 것을 특징으로 하는 대나무 섬유 부직포.

청구항 3

제 1항에 있어서, 30~100g/m^2의 중량을 갖는 것을 특징으로 하는 대나무 섬유 부직포.

청구항 4

제 1항 내지 제 3항 중 어느 한 항의 부직포에 미용액을 담지한 시트 마스크.

청구항 5

1) 대나무 섬유와 폴리락틱산(Polylactic Acid, PLA) 섬유 또는 폴리에틸렌 테레프탈레이트(polyethylen terephthalate, PET) 섬유를 균일하게 혼섬하는 단계;

2) 균일하게 혼섬된 섬유를 타면기에 넣어 풀어헤치고 불순물을 제거하여 랩(솜 형태)을 만드는 단계;

3) 뭉쳐진 랩을 풀어헤쳐 시트의 형태로 펼치는 카딩 공정 단계;

4) 시트화된 섬유를 겹쳐 쌓아 웹을 만들고 고압의 수류를 이용하여 웹화된 섬유를 서로 결합시키고 건조하는 단계;를 포함하는 대나무 섬유 부직포의 제조방법.

청구항 6

제 5항에 있어서, 상기 대나무 섬유는 50~90중량%, PLA 섬유 또는 PET 섬유는 50~10중량%로 혼섬되는 것을 특징으로 하는 대나무 섬유 부직포의 제조방법.

청구항 7

제 5항에 있어서, 상기 건조 단계에서 건조 온도가 80~140℃인 것을 특징으로 하는 대나무 섬유 부직포의 제조방법.

명 세 서

발명의 상세한 설명

기 술 분 야

[0001] 본 발명은 대나무 섬유 부직포를 이용한 시트 마스크에 관한 것으로, 대나무 섬유와 PLA 섬유 또는 PET 섬유를 혼섬함으로써 대나무 소재 고유의 부드러움은 유지하면서 PLA 섬유 또는 PET 섬유로 신축성을 향상시켜 굴곡이 많은 부위에도 밀착이 잘되는 대나무 섬유 부직포를 이용한 시트 마스크에 관한 것이다.

배 경 기 술

[0002] 일반적으로 화장료를 함침한 시트 마스크의 부직포로는 코튼을 주성분으로 한 부직포가 사용되고 있었다. 코튼은 흡수성이 높아서 화장료를 함침하는데 적절하기 때문이다. 그러나 코튼제 부직포는 신축성이 떨어져서 굴곡이 많은 안면 부위에 밀착시키기 어려운 단점이 있다.

[0003] 코튼 부직포와 마찬가지로 천연 섬유들을 활용한 부직포의 개발은 다양하게 진행되고 있는데, 그 중에서 대표적

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인 천연섬유가 대나무 섬유이다. 대나무 섬유는 순식물성 섬유소재로서 독특한 단면구조에 의한 높은 흡수성 및 방습성을 지니며, 영구적인 소취성 및 항균성을 갖고, 뛰어난 촉감으로 피부에 접촉시 부드러운 접촉느낌을 줄 뿐 아니라 피부안정성도 뛰어나다. 따라서, 다양한 방식으로 제조된 대나무 섬유는 화장품용 시트 마스크(한국공개특허공보 제2006-001890호)나 기저귀 등의 생활용품과 같이 여러 방면에서 활용되고 있다. 하지만 대나무 섬유만으로 제조된 부직포는 신축성이 떨어져서 굴곡이 많은 부위에 밀착시키기가 힘든 단점이 있다.

[0004] 한편, 일반적으로 부직포는 실의 개념을 포함하지 않아 직조되지 않고 포형상을 갖는 원단을 지칭하며, 사용되는 용도분야는 가정용, 산업용 등의 광범위한 분야에 적용되고 있다.

[0005] 본래 본 발명과 연관된 화장품용 시트 마스크의 부직포 제조공정을 살펴보면 결합방식에 있어 열적, 화학적 결합방식을 사용하고 있는 것이 특징이다. 대표적으로 한국등록특허공보 제10-0755958호에서는 대나무 섬유와 PP 소재를 혼합하여 니들펀칭공정과 접착제를 사용하는 공정으로 하는 1차 결합공정을 진행한 후, 2차적으로 열융착시키는 공정과 물 분사를 진행하는 결합공정으로 부직포를 제조하는 등의 공정이 복잡한 특징이 있다. 특히, 종래 제조방식에서의 접착제 사용은 인체에 유해하며, 이는 마스크팩, 물티슈, 기저귀 등의 위생용 제품에 사용할 경우 사용자의 위생에 막대한 영향을 줄 소지가 있다. 접착제의 사용은 사용 후 폐기시에도 환경오염을 발생시키는 원인으로 작용하며, 석유를 원료로 하는 PET 등의 합성섬유는 또한 사용 후 폐기시의 썩지 않아 환경오염을 유발하며 소각시 유해물질이 나와 대기오염의 원인으로 작용할 수 있다.

발명의 내용

해결 하고자하는 과제

[0006] 이에, 본 발명자는 대나무 섬유 자체의 부드러운 질감은 유지하면서 신축성을 증대시켜 굴곡이 많은 부위에도 밀착이 잘 되는 시트 마스크용 부직포를 제조하기 위해 연구를 거듭한 결과, PLA 섬유 또는 PET 섬유를 대나무 섬유에 혼섬하면 신축성을 향상시킬 수 있음을 발견하고 본 발명을 완성하였다.

[0007] 따라서, 본 발명의 목적은 신축성이 향상되고 제조시 접착제가 필요하지 않아 인체에 무해한 대나무 섬유 부직포 및 이의 제조방법을 제공하는 것이다.

과제 해결수단

[0008] 상기 목적을 달성하기 위하여, 본 발명에서는 대나무 섬유와 PLA 섬유 또는 PET 섬유를 혼섬하여 제조한 대나무 섬유 부직포 및 이의 제조방법을 제공한다.

효 과

[0009] 본 발명으로 제조된 부직포는 대나무 소재의 독특한 부드러운 질감 및 다양한 장점은 그대로 살리면서 굴곡진 부위에 밀착이 잘되도록 신축성이 매우 뛰어나다. 화장품용 시트 마스크로서 활용시에 부드러운 착용감과 밀착감이 우수할 뿐만 아니라, 제조공정에서 접착제가 필요하지 않기 때문에 인체에 무해하여 시트 마스크 소재로 매우 적합하다. 또한, 물티슈, 클렌징패드, 가정용 와이퍼 등의 ■용 또는 위생 제품으로서의 폭넓은 활용도 가능하다.

발명의 실시를 위한 구체적인 내용

[0010] 본 발명에서는 대나무 섬유와 폴리락틱산(Polylactic Acid, PLA) 섬유 또는 폴리에틸렌 테레프탈레이트(polyethylen terephthalate, PET) 섬유를 혼섬하여 제조한 대나무 섬유 부직포 및 이의 제조방법을 제공한다.

[0011] 이하, 본 발명을 보다 상세히 설명한다.

[0012] 본 발명의 대나무 섬유는 순식물성 섬유 소재로서 독특한 단면구조에 의한 높은 흡수성 및 방습성을 지니며, 영구적인 소취성 및 항균성을 갖고, 뛰어난 촉감으로 피부에 접촉시 부드러운 접촉 느낌을 줄 뿐 아니라 피부안정

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성도 뛰어나다.

[0013] 부직포는 고유의 섬유 배열에 의한 횡방향 처짐이 발생하지만, 폴리락틱산(Polylactic Acid, PLA) 섬유와 폴리에틸렌 테레프탈레이트(polyethylen terephthalate, PET) 섬유는 횡방향 신율의 반발탄성을 보유하고 있어 대나무 섬유와 혼섬하여 사용할 경우 부직포의 신축성을 향상시킬 수 있다. 이렇게 제조된 부직포는 신축성을 갖게 되어 굴곡진 부위에도 잘 밀착할 수 있는 장점을 갖게 된다.

[0014] 본 발명의 폴리락틱산(Polylactic Acid Fiber, PLA) 섬유는 생분해성으로 환경 오염을 발생시키지 않아 친환경적이며, 대나무 섬유와 혼섬할 경우에는 신축성이 향상됨과 동시에 생분해가 가능하여 친환경적인 소재인 대나무 섬유의 본래 장점을 극대화시킬 수 있다는 장점을 갖는다.

[0015] 본 발명의 폴리에틸렌 테레프탈레이트(Polyethylen terephthalate, PET) 섬유는 기존의 다른 섬유들보다 신축성이 뛰어난 특징을 가지고 있어 다른 섬유들과 혼섬시 신축성을 크게 향상시킬 수 있다는 장점을 갖는다.

[0016] 본 발명에서는 부직포 총 중량에 대하여 원사 혼섬비를 대나무 섬유는 50~90중량%, PLA 섬유 또는 PET 섬유는 50~10중량%로 혼섬한다. 이때, PLA 섬유 또는 PET 섬유의 함량이 50중량%를 초과하면 대나무 섬유 특유의 부드러운 질감이 사라지고, 10중량% 미만이면 원하는 만큼의 신축성이 생기지 않는다.

[0017] 본 발명의 부직포는 30~100g/m^2의 중량을 갖는 것을 특징으로 한다. 상기 중량 범위를 벗어나는 부직포는 시트 마스크로 화장액을 침적시켜 사용하기 어렵기 때문이다.

[0018] 본 발명은 상기 부직포에 미용액을 담지한 시트 마스크를 제공한다.

[0019] 본 발명의 부직포는

[0020] 1) 대나무 섬유와 PLA섬유 또는 PET 섬유를 균일하게 혼섬하는 단계;

[0021] 2) 균일하게 혼섬된 섬유를 타면기에 넣어 풀어헤치고 불순물을 제거하여 랩(솜 형태)을 만드는 단계;

[0022] 3) 뭉쳐진 랩을 풀어헤쳐 시트의 형태로 펼치는 카딩 공정 단계;

[0023] 4) 시트화된 섬유를 겹쳐 쌓아 웹을 만들고 고압의 수류를 이용하여 웹화된 섬유를 서로 결합시키고 건조하는 단계;로 만들어지는 것을 특징으로 한다. 이렇게 제조된 부직포는 케미칼 또는 열적 결합 방식이 아닌 소재의 고유한 성질을 그대로 보유할 수 있도록 순수 유체 결합 방식을 이용함으로써 인체나 환경에 무해한 특징이 있다. 또한, 대나무 섬유와 PLA 섬유를 순수 유체 결합 방식으로 결합시킬 경우, 폐기시 소각방식이 아닌 매립 방식을 통해 생분해시킬 수 있어 환경오염의 원인을 차단할 수 있어 친환경적이다.

[0024] 상기 PLA섬유와 PET섬유는 물과 접촉시 열에 민감하게 반응하기 때문에 PLA 와 PET 혼섬비 및 생산 속도에 따라 건조시 건조 온도를 80~140℃로 적절히 조절하는 것을 특징으로 한다. 즉, PLA 또는 PET 섬유의 혼섬비가 10중량%인 경우에는 생산속도가 빠르고 PLA 또는 PET 섬유량이 적기 때문에 적용온도는 140℃로 처리하며, PLA 또는 PET 섬유가 50중량% 사용될 때에는 80℃의 건조 온도를 적용한다.

[0025] 이하, 본 발명의 이해를 돕기 위한 바람직한 실시예를 제시한다. 그러나 하기 실시예는 본 발명을 보다 쉽게 이해하기 위하여 제시되는 것으로 본 발명이 하기의 실시예에 한정되는 것은 아니다.

[0026] [제조예] 부직포의 제조

[0027] 비교예 1 및 실시예 1~4는 하기 공정을 통하여 제조되었다. 여기서 사용된 대나무 섬유는 섬도 1.5데니어, 섬유장 40㎜이고, PLA섬유는 섬유섬도 1.5데니어, 섬유장 38㎜인 것을 사용하여 하기 표 1의 혼율대로 각각의 섬유를 혼섬하여 부직포를 제조하였다. 또한, PET섬유는 섬유섬도 1.5데니어, 섬유장 38mm 인 것을 사용하여 상기 대나무 섬유와 혼섬하였다.

[0028] <제조 과정>

[0029] 1) 혼면(Blending) 공정: 대나무 섬유와 PLA 섬유 또는 PET 섬유를 표 1의 비율로 원사를 넣어 혼합한다.

[0030] 2) 타면(Opening) 공정: 상기 혼면 공정에서 공급되는 원면을 타면기에 넣어 풀어 헤치고 불순물을 제거하여 랩(솜 형태)을 취하도록 한다.

[0031] 3) 소면(Carding) 공정: 상기 타면 공정에서 뭉쳐져 있는 랩을 빗질하여 완전히 헤쳐서 잡물이나 짧은 섬유를

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제거하고 섬유를 한 올씩 분리하여 가지런히 평행이 되게 한 다음, 기계방향 및 크로스 방향으로 평면시트를 만들어 적층상태를 이루도록 한다.

[0032] 4) 접합(Bonding) 및 건조 공정: 상기 소면 공정에서 만들어진 웹을 고압의 수류를 이용하여 순수하게 물만을 사용하여 웹상의 섬유를 결합시켜 일체화된 부직포를 형성하고 건조한다.

[0033] [시험예 1]

[0034] 상기 비교예 1 및 실시예 1~4을 이용하여 대나무 섬유 및 PLA섬유와의 혼섬비와 부직포 중량에 따른 부직포의 물성을 테스트하였다.

[0035] 후도(Thickness)는 후도계(Thickness gauage)를 이용하여 측정하였고 부직포당 3회 측정하여 평균값을 나타내었다.

[0036] 각각의 부직포에서 MD방향 5cm, CD방향 5cm의 시료를 잘라 인스트론 기기를 이용, 인장속도 200mm/min를 적용하여 MD방향 및 CD 방향으로 인장강도 및 신도를 측정하였다. 여기서, MD방향이라 함은 기계방향(machine direction)을 지칭하는 뜻으로 기계의 진행방향을 의미하고, CD방향이라 함은 횡-기계방향(cross-machine direction)을 지칭하는 뜻으로 기계의 진행방향과 직교방향을 의미한다.

표 1

[0037]

구분		비교예1	실시예1	실시예2	실시예3	실시예4
혼율		대나무 섬유 100중량%	대나무 섬유 70중량% + PLA 30중량%			대나무 섬유 70중량% + PET 30중량%
중량(GSM)		70	75.1	70.2	65.4	70.0
후도(mm)		0.45	0.48	0.45	0.42	0.45
인장강도	MD	18.4	19.5	19.1	18.0	19.3
(Kgf/5cm)	CD	3.23	3.27	3.42	3.58	3.49
신도(%)	MD	21.7	31.7	29.1	26.4	30.8
	CD	98.7	131.0	115.2	96.8	129.5

[0038] 상기 표 1을 보면, 대나무 섬유 100중량%로 이루어진 70GSM 중량의 원단(비교예 1)은 대나무 섬유 70중량% 및 PLA 30중량%를 혼섬하여 제조된 65GSM 중량의 부직포(실시예 3)과 유사한 물성을 나타냈다. 또한, 대나무 섬유 70중량% 및 PLA 30중량%를 혼섬하여 제조된 70GSM 및 75GSM 부직포(실시예 1~2)는 신도가 유의하게 증가하였고, 대나무 섬유 70중량% 및 PET 30중량%를 혼섬하여 제조된 70GSM 부직포(실시예 4)에서도 유사하게 신도가 증가하는 것을 확인할 수 있었다.

[0039] [실시예 5] 시트 마스크 제조

[0040] 하기 표 2에 기재된 조성으로 에멀젼을 제조하였다.

표 2

[0041]

구분	원료명	함량(중량%)
유성성분	하이드로제네이티드 폴리데센	8.0
	디메치콘	0.5
	글리세릴스테아레이트SE/ 피이지-100스테아레이트	0.8
	폴리글리세릴-3 메틸글루코스디스테아레이트	1.0

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수성성분	정제수	잔량
	디소듐 이디티에이	0.02
	글리세린	5.0
	부틸렌글리콜	10.0
	방부제	0.25
	트리에탄올아민	0.05
	카보머	0.05
	향	적량

[0042] <에멀젼의 제조방법>

[0043] (1) 유성성분을 70~75℃로 가열하여 균일하게 혼합하였다.

[0044] (2) 수성성분을 70~75℃로 가열하여 균일하게 용해 및 혼합하였다.

[0045] (3) 70~75℃를 유지한 상태로 상기 (2)에 상기(1)을 교반하면서 서서히 투입한 후에 냉각하여 수중유형 에멀젼을 얻었다.

[0046] 상기 실시예 2에서 제조한 부직포를 얼굴 형태로 성형, 재단한 다음 표 2의조성으로 제조한 에멀젼 25g에 함침시켜 시트 마스크를 제조하였다.

[0047] [비교예 2]

[0048] 시판되고 있는 레이온 부직포를 얼굴 형태로 성형, 재단한 다음 상기 표 2의조성으로 제조한 에멀젼 25g에 함침시켜 비교예 2의 시트 마스크를 제조하였다.

[0049] [비교예 3]

[0050] 상기 비교예 1에서 제조한 대나무 부직포를 얼굴 형태로 성형, 재단한 다음 상기 표 2의 조성으로 제조한 에멀젼 25g에 함침시켜 비교예 3의 시트 마스크를 제조하였다.

[0051] [시험예 2]

[0052] 상기 비교예 2~3와 실시예 5에서 제조한 시트 마스크의 사용 중 밀착감, 부드러움 및 전체적인 만족도를 평가하기 위하여 25명의 시험 대상자들을 선정하였고, 이들에게 비교예 2~3와 실시예 5에서 제조한 마스크를 사용하게 한 후 설문조사를 실시하였다. 설문조사는 각각의 마스크를 사용해보고 밀착감, 부드러움 및 시트마스크로서의 전체적인 만족도 항목에 대해서 가장 선호하는 시트 마스크 형태를 선택하게 하였으며, 그 결과는 하기 표 3에 나타내었다.

표 3

[0053]

구분	사용중 밀착감(명)	사용중 부드러움(명)	전체적인 만족도(명)
비교예 2의 시트마스크	8	2	4
비교예 3의 시트마스크	1	14	5
실시예 5의 시트마스크	16	9	16

[0054] 상기 표 3의 결과에서 알 수 있듯이, 비교예 2의 일반 레이온 부직포의 경우보다 대나무 섬유로 제조된 비교예 3 및 실시예 5의 시트 마스크에서 사용 중 부드러움에 대한 만족도가 높았다. 또한, 대나무 섬유로만 만들어진 비교예 3에 비해서 대나무 섬유와 PLA섬유의 혼섬으로 제조된 실시예 5의 밀착감에 대한 만족도가 훨씬 월등함을 알 수 있으며, 시트 마스크로서의 만족도 또한 본 발명에 따른 부직포를 이용한 시트 마스크에서 가장 뛰어

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남을 알 수 있었다.

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Sheet mask using nonwoven fabric of bamboo fiber having high elasticity

Abstract

PURPOSE: A non-woven fabric of bamboo fiber is provided to improve elasticity and to ensure harmless benefit to human body. CONSTITUTION: A method for fabricating a non-woven fabric of bamboo fiber comprises: a step of blending polylactic acid(PLA) or polyethyleneterephthalate(PET) fiber; a step of removing foreign materials and preparing a wrap(cotton type); a step of carding the lump wrap to unfold in a sheet form; and a step of overlapping the sheeted fibers to make a web, binding the web fibers and drying. The non-woven fabric contains 50-90 weight% of bamboo fiber, 50-10 weight% of PLA or PET fiber. The non-woven fabric has the weight of 30-100g/m^2. A sheet mask is prepared by dipping the non-woven fabric in a skin care solution.

Classifications

- D04H1/425 Cellulose series

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Find Prior Art Similar

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Claims (7)

Hide Dependent
translated from Korean

Bamboo fiber nonwoven fabric made of a mixture of bamboo fibers, polylactic acid (PLA) fibers or polyethylene terephthalate (PET) fibers. The bamboo fiber nonwoven fabric of claim 1, wherein the bamboo fiber is 50 to 90% by weight, the PLA fiber or the PET fiber is mixed to 50 to 10% by weight. The bamboo fiber nonwoven fabric of claim 1 having a weight of 30-100 g / m ^{2} . The sheet mask which supported the cosmetic liquid on the nonwoven fabric of any one of Claims 1-3. 1) uniformly mixing the bamboo fibers with Polylactic Acid (PLA) fibers or polyethylene terephthalate (PET) fibers; 2) forming a wrap (cotton form) by loosening the uniformly mixed fibers into a masking machine and removing the impurities; 3) a carding process step of unpacking the lumps to spread out in the form of a sheet; 4) stacking the sheeted fibers to form a web and bonding the webbed fibers with each other using a high pressure water flow and dry; manufacturing method of a bamboo fiber nonwoven fabric comprising a. The method of claim 5, wherein the bamboo fiber is 50 to 90% by weight, PLA fiber or PET fiber is 50 to 10% by weight mixed fiber manufacturing method of the nonwoven fabric. The method of claim 5, wherein the drying step is a drying temperature of 80 ~ 140 ℃ in the drying step.

Description

translated from Korean

Sheet mask using nonwoven fabric of bamboo fiber having high elasticity}

The present invention relates to a sheet mask using a bamboo fiber nonwoven fabric, by blending the bamboo fiber and PLA fiber or PET fiber, while maintaining the softness inherent in the bamboo material to improve the elasticity with PLA fiber or PET fiber to adhere to a lot of bending The present invention relates to a sheet mask using a bamboo fiber nonwoven fabric.

In general, a nonwoven fabric mainly composed of cotton has been used as a nonwoven fabric of a sheet mask impregnated with cosmetics. Cotton is highly absorbent and is suitable for impregnating cosmetics. However, cotton non-woven fabric has a disadvantage in that it is difficult to adhere to a lot of curved face due to the lack of elasticity.

Like cotton nonwoven fabrics, the development of nonwoven fabrics using natural fibers is progressing in various ways. Among them, representative natural fibers are bamboo fibers. Bamboo fiber is a pure vegetable fiber material, which has high absorbency and moisture resistance due to its unique cross-sectional structure, permanent deodorant and antimicrobial properties, and gives excellent touch stability as well as excellent skin stability. Therefore, the bamboo fiber produced in various ways is utilized in many ways, such as a cosmetic sheet mask (Korean Patent Publication No. 2006-001890) and household goods such as diapers. However, the nonwoven fabric made of only bamboo fiber has a disadvantage in that it is difficult to adhere to a lot of curved areas due to its lack of elasticity.

On the other hand, in general, non-woven fabric does not include the concept of yarn refers to the fabric having a form without being woven, the field of use is applied to a wide range of fields, such as home, industrial.

Looking at the nonwoven fabric manufacturing process of the sheet mask for cosmetics originally associated with the present invention is characterized in that the thermal and chemical bonding method in the bonding method. Representatively, in Korean Patent Publication No. 10-0755958, after mixing the bamboo fiber and the PP material, the needle bonding process and the adhesive bonding process are performed. The process, such as manufacturing a non-woven fabric as a bonding process to proceed is a complex feature. In particular, the use of the adhesive in the conventional manufacturing method is harmful to the human body, which may have a significant impact on the hygiene of the user when used in hygiene products such as mask packs, wet wipes, diapers. The use of adhesive acts as a cause of environmental pollution even after disposal. Synthetic fiber such as PET, which is petroleum-based raw material, also causes environmental pollution because it does not decay when discarded after use. Can act as a source of contamination.

Accordingly, the present inventors conducted a study to manufacture a non-woven fabric for the sheet mask that is well adhered even to a large portion of the bending by maintaining the soft texture of the bamboo fiber itself, PLA PLA or PET fibers to the bamboo fiber The present invention has been completed by discovering that

intermixing can improve elasticity.

Accordingly, it is an object of the present invention to provide a bamboo fiber nonwoven fabric and a method for producing the same, which is improved in elasticity and does not require an adhesive when manufactured.

In order to achieve the above object, the present invention provides a bamboo fiber nonwoven fabric prepared by mixing the fiber and the PLA fiber or PET fiber and a manufacturing method thereof.

The nonwoven fabric produced by the present invention has excellent elasticity so that the soft texture and various advantages of the bamboo material are kept intact while being well adhered to the curved portion. When used as a sheet mask for cosmetics, it is not only excellent in a soft fit and adhesion, but is also harmless to a human body because it does not require an adhesive in a manufacturing process, and thus is suitable as a sheet mask material. It is also possible to use a wide range of cosmetic or hygiene products such as wet wipes, cleansing pads and household wipers.

The present invention provides a bamboo fiber nonwoven fabric prepared by mixing a bamboo fiber and a polylactic acid (PLA) fiber or polyethylene terephthalate (PET) fiber, and a method of manufacturing the same.

Hereinafter, the present invention will be described in more detail.

Bamboo fiber of the present invention is a pure vegetable fiber material, has a high absorption and moisture resistance by a unique cross-sectional structure, has a permanent deodorant and antibacterial properties, excellent touch and excellent skin stability as well as skin contact. .

Nonwoven fabrics have transverse sagging due to their inherent fiber arrangement, but polylactic acid (PLA) fibers and polyethylene terephthalate (PET) fibers have repulsive elasticity with transverse elongation. When used in combination, the elasticity of the nonwoven fabric can be improved. The nonwoven fabric thus prepared has elasticity and thus has an advantage of being able to adhere well to curved portions.

The polylactic acid fiber (PLA) fiber of the present invention is biodegradable and eco-friendly because it does not cause environmental pollution, and when mixed with bamboo fiber, elasticity is improved and biodegradation is possible. It has the advantage that it can maximize the original advantage.

Polyethylene terephthalate (PET) fiber of the present invention has an excellent elasticity characteristics compared to other conventional fibers and has the advantage of greatly improving the elasticity when mixed with other fibers.

In the present invention, with respect to the total weight of the nonwoven fabric, the yarn blending ratio is blended with 50 to 90% by weight of bamboo fiber, 50 to 10% by weight of PLA fiber or PET fiber. At this time, when the content of the PLA fiber or PET fiber exceeds 50% by weight, the soft texture unique to the bamboo fiber disappears, and less than 10% by weight does not produce as much stretch as desired.

Nonwoven fabric of the present invention is characterized by having a weight of 30 ~ 100g / m^2 . This is because nonwoven fabric outside the weight range is difficult to use by depositing a cosmetic liquid with a sheet mask.

The present invention provides a sheet mask carrying a cosmetic liquid on the nonwoven fabric.

Nonwoven fabric of the present invention

1) uniformly mixing the bamboo fibers and PLA fibers or PET fibers;

2) forming a wrap (cotton form) by loosening the uniformly mixed fibers into a masking machine and removing the impurities;

3) a carding process step of unpacking the lumps to spread out in the form of a sheet;

4) stacking the sheeted fibers to form a web and bonding the webbed fibers to each other and drying using high pressure water flow; characterized in that it is made of. The nonwoven fabric thus prepared has a characteristic that is harmless to the human body or the environment by using a pure fluid bonding method to retain the inherent properties of the material as it is not a chemical or thermal bonding method. In addition, when the bamboo fiber and PLA fiber is combined in a pure fluid bonding method, it can be biodegraded through landfill rather than incineration when discarded, it is environmentally friendly to block the cause of environmental pollution.

The PLA fibers and PET fibers are sensitive to heat when contacted with water, so that the drying temperature during drying according to PLA and PET blending ratio and production rate is properly adjusted to 80 ~ 140 ℃. In other words, when the blending ratio of PLA or PET fiber is 10% by weight, the application speed is 140 ° C because the production speed is fast and the amount of PLA or PET fiber is low, and the drying temperature of 80 ° C when 50% by weight of PLA or PET fiber is used. Apply.

Hereinafter, preferred examples for aiding in understanding the present invention are presented. However, the following examples are presented to more easily understand the present invention, and the present invention is not limited to the following examples.

[Production Example] Production of Nonwoven Fabric

Comparative Example 1 and Examples 1 to 4 were prepared through the following process. Bamboo fiber used here is 1.5 denier, fiber length 40mm, PLA fiber is 1.5 denier fiber, fiber length 38mm by using a blend of each fiber according to the mixing ratio of the following Table 1 to prepare a nonwoven fabric. In addition, PET fibers were mixed with the bamboo fibers using a fiber fineness of 1.5 denier and a fiber length of 38 mm.

<Production process>

1) Blending (Blending) process: Bamboo fibers and PLA fibers or PET fibers are mixed in the yarn in the ratio of Table 1.

2) Opening process: The raw cotton supplied in the blending process is put into the other cotton machine to loosen, remove impurities, and take a wrap (cotton form).

3) Carding process: Comb the lumps in the other surface process and comb through them completely to remove any miscellaneous goods or short fibers, and to separate the fibers one by one so that they are aligned in parallel and then flat sheets in the machine direction and cross direction. To make a lamination state.

4) Bonding and drying process: The web made in the carding process is pure water using only high pressure water flow to combine the fibers on the web to form an integrated nonwoven fabric and dry.

[Test Example 1]

The physical properties of the nonwoven fabric according to the blending ratio and the nonwoven fabric weight of the bamboo fiber and PLA fiber using the Comparative Example 1 and Examples 1 to 4 were tested.

Thickness was measured using a thickness gauge, and the average value was measured three times per nonwoven fabric.

Tensile strength and elongation were measured in MD and CD directions by applying a tensile speed of 200 mm / min using an Instron machine by cutting samples of 5 cm in MD and 5 cm in CD from each nonwoven fabric. Here, the MD direction refers to the machine direction (machine direction) means the direction of the machine, the

CD direction refers to the cross-machine direction (machine direction) means the direction of the machine And orthogonal direction.

division Comparative Example 1 Example 1 Example 2 Example 3 Example 4 Mixing 100% of bamboo fiber 70% by weight of bamboo fiber
30 wt% PLA 70% of bamboo fiber
+ 30% PET Weight (GSM) 70 75.1 70.2 65.4 70.0 Thickness (mm) 0.45 0.48 0.45 0.42 0.45 The tensile strength
(Kgf / 5cm) MD 18.4 19.5 19.1 18.0 19.3 CD 3.23 3.27 3.42 3.58 3.49 Shrink (%) MD 21.7 31.7 29.1 26.4 30.8 CD 98.7 131.9 115.2 96.8 129.5

Referring to Table 1, the 70GSM weight fabric (Comparative Example 1) made of 100% by weight of bamboo fiber has similar properties to the 65GSM weight nonwoven fabric (Example 3) prepared by mixing 70% by weight of bamboo fiber and 30% by weight of PLA. Indicated. In addition, 70GSM and 75GSM nonwoven fabric (Examples 1 to 2) prepared by mixing 70% by weight of bamboo fiber and 30% by weight of PLA increased elongation significantly, and prepared by mixing 70% by weight of bamboo fiber and 30% by weight of PET fiber. It was also confirmed that the elongation was similarly increased in the 70GSM nonwoven fabric (Example 4).

Example 5 Sheet Mask Preparation

An emulsion was prepared with the composition shown in Table 2 below.

division Raw material name Content (% by weight) Oily ingredients Hydrogenated Polydecene 8.0 Dimethicone 0.5 Glyceryl Stearate SE / Fiji-100 Stearate 0.8 Polyglyceryl-3 Methylglucose distearate 1.0 Aqueous component Purified water Balance Disodium ID 0.02 glycerin 5.0 Butylene glycol 10.0 antiseptic 0.25 Triethanolamine 0.05 Carbomer 0.05 Incense Quantity

<Method for preparing emulsion>

(1) The oily component was heated to 70 to 75 ° C. and uniformly mixed.

(2) The aqueous component was heated to 70 to 75 ° C. to uniformly dissolve and mix.

(3) The above (2) was slowly added while stirring (1) while maintaining 70-75 degreeC, and it cooled, and obtained the oil-in-water emulsion.

The nonwoven fabric prepared in Example 2 was molded and cut into a face shape and then impregnated into 25 g of the emulsion prepared in the composition of Table 2 to prepare a sheet mask.

Comparative Example 2

A commercially available rayon nonwoven fabric was molded and cut into a face shape and then impregnated into 25 g of the emulsion prepared in the composition of Table 2 to prepare a sheet mask of Comparative Example 2.

Comparative Example 3

The bamboo nonwoven fabric prepared in Comparative Example 1 was molded and cut into a face shape and then impregnated into 25 g of the emulsion prepared in the composition of Table 2 to prepare a sheet mask of Comparative Example 3.

[Test Example 2]

Twenty-five test subjects were selected to evaluate the adhesion, softness and overall satisfaction of the sheet masks prepared in Comparative Examples 2 to 3 and Example 5, which were prepared in Comparative Examples 2 to 3 and Example 5 The survey was conducted after the mask was used. The survey allowed each of the masks to be used and to select the most preferred sheet mask type for overall satisfaction as a fit, softness and sheet mask, and the results are shown in Table 3 below.

division Adhesion during use (person) Softness in use (person) Overall satisfaction (persons) Sheet Mask of Comparative Example 2 8 2 4 Sheet Mask of Comparative Example 3 One 14 5 Sheet mask of Example 5 16 9 16

As can be seen from the results of Table 3, the sheet mask of Comparative Example 3 and Example 5 made of bamboo fibers than the general rayon nonwoven fabric of Comparative Example 2 had a higher satisfaction with the softness during use. In addition, it can be seen that the satisfaction of the adhesion of Example 5, which is made of a mixed fiber of bamboo fiber and PLA fiber, is much superior to Comparative Example 3 made of only bamboo fiber. It was found to be the best in the sheet mask.

Patent Citations (3)

Publication number	Priority date	Publication date	Assignee	Title
KR200600018890A *	2005-12-06	2006-01-06	김영태	Mask Pack Using Bamboo Fiber
KR20090058374A *	2007-12-04	2009-06-09	현대자동차주식회사	Preparation method of poly lactic acid/natural fiber composites
JP2009197362A *	2008-02-22	2009-09-03	Unitika Textiles Ltd	Bamboo fiber sheet and method for producing the same
Family To Family Citations				

* Cited by examiner, † Cited by third party

Cited By (13)

Publication number	Priority date	Publication date	Assignee	Title
WO2013041986A3 *	2011-09-21	2013-05-23	Kimberly-Clark Worldwide, Inc.	Tissue product comprising bamboo
KR101695569B1 *	2016-06-02	2016-12-29	(주)퓸크론	Manufacturing method of sheet for cosmetic mask
CN107299421A *	2017-07-24	2017-10-27	绵阳师范学院	A kind of novel and multifunctional bamboo fibre silk-dressing machine
CN108796819A *	2018-05-31	2018-11-13	合肥洁客天颐布制品有限公司	A kind of non-woven fabrics and preparation method thereof of high-hydroscopicity energy
CN109112720A *	2018-10-19	2019-01-01	江苏鑫轮纳米生物科技有限公司	A kind of preparation method of collagen primary colors bamboo fibre watch box towel

CN110644107A *	2019-08-30	2020-01-03	际华三五四二纺织有限公司	Blended high-count functional fabric and production process thereof
CN112709003A *	2020-12-21	2021-04-27	宁波保税区锦鸿化工科技有限公司	Non-woven fabric and preparation method thereof
US11083643B2	2017-02-22	2021-07-06	Kimberly-Clark Worldwide, Inc.	Layered tissue comprising non-wood fibers
KR102418316B1 *	2021-09-14	2022-07-08	주식회사 엠브이온니아	Antibacterial Sheet and Manufacturing Method Thereof
KR20220099687A *	2021-01-07	2022-07-14	서상천	Manufacturing method of biodegradable nonwoven fabric for mask
WO2023083731A1 *	2021-11-13	2023-05-19	Coin Consulting GmbH	Moist wipe with biodegradable composite substrate
Family To Family Citations				
KR20190131671A	2018-05-17	2019-11-27	(주)코니도	Method for Caring Skin by layering and kit for the method
KR102278638B1	2020-12-14	2021-07-16	주식회사 엘라포스메딕	Maskpack with improved moisture content

* Cited by examiner, † Cited by third party, ‡ Family to family citation

Similar Documents

Publication	Publication Date	Title
KR101587796B1	2016-01-25	Sheet mask using nonwoven fabric of bamboo fiber having high elasticity
RU2605095C2	2016-12-20	Absorbing products containing polyorganosiloxane polymers with conditioning effect
CN105143542B	2018-09-21	The supatex fabric for the short bast fiber individually charged and the product being produced from it
EP1614790B1	2008-10-08	An absorbent personal care product for cosmetic and/or dermatological applications comprising at least one absorbent sheet
CA2921537C	2021-03-30	Entangled substrate of short individualized bast fibers
EP2132376B1	2012-10-17	Antibacterial and deodorant fiber, fiber formed article, and fiber product
KR101976155B1	2019-05-07	Fibrous Nonwoven Fabric For Mask Pack
WO1991001801A1	1991-02-21	Microcapsule, treatment liquid containing microcapsules, and textile structure having microcapsules stuck thereto
CN101906697A	2010-12-08	The knitted fabric of excellent contact cool feeling and with the contact cool feeling intimate apparel of its formation
KR20150082792A	2015-07-16	Mesh derived from natural fiber and hydrogel mask using the same
WO1993016670A1	1993-09-02	A surface covering material for an absorptive product
EP2042185A1	2009-04-01	Method for removing water-insoluble substances from substrate surfaces
CN108385275A	2018-08-10	A kind of weak acid non-woven cloth
CN113089316A	2021-07-09	Lysimachia christinae Hance fiber antibacterial textile fabric and preparation method thereof
CN108149369B	2021-02-26	Woven or knitted fabric containing rayon for sheet-type mask
CN101570935B	2011-04-27	Modification method for preparing highly-hydrophilic real silk fiber spunlace non-woven material
CN101453972A	2009-06-10	Sweat absorbent sheet and disposable diaper
WO2015002555A1	2015-01-08	Biodegradable, combustible or noncombustible nonwoven, process of manufacture and use
KR20180062027A	2018-06-08	2-layer Nonwoven Sheet With Moisture And Water Repellent Function And Mask Pack Using That
KR102250875B1	2021-05-12	Maskpack with improved skin adhesion and manufacturing method thereof
KR101712023B1	2017-03-14	Mask pack using Korean paper layered Red ginseng and the preparation thereof
TW201245538A	2012-11-16	Color fastness-modified fiber and fiber forming body constructed by the same
KR20110068525A	2011-06-08	Meltblown non-woven fabric of ultrafine fiber with good hydroscopicity and the sheet mask for cosmetics using the same
JP2002069848A	2002-03-08	Fiber treating agent, method for treating fiber and textile product
Khalid et al.	2022	Development of Skin Care Sheet Masks

Priority And Related Applications

Priority Applications (1)

Application	Priority date	Filing date	Title

KR102009011711 0A	2009-11-30	2009-11-30	Sheet mask using nonwoven fabric of bamboo fiber having high elasticity

Applications Claiming Priority (1)

Application	Filing date	Title
KR102009011711 0A	2009-11-30	Sheet mask using nonwoven fabric of bamboo fiber having high elasticity

Legal Events

Date	Code	Title	Description
2014-09-02	A201	Request for examination	
2015-08-18	E902	Notification of reason for refusal	
2016-01-14	E701	Decision to grant or registration of patent right	
2016-01-18	GRNT	Written decision to grant	
2019-01-02	FPAY	Annual fee payment	Payment date: 20190102 Year of fee payment: 4
2020-01-02	FPAY	Annual fee payment	Payment date: 20200102 Year of fee payment: 5

Concepts

machine-extracted

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Name	Image	Sections	Count	Query match
fiber		title,claims,abstract,description	114	0.000
nonwoven fabric		title,claims,abstract,description	51	0.000
Bambusa arundinacea		title,claims,abstract,description	49	0.000
Bambusa tulda		title,claims,abstract,description	49	0.000
Phyllostachys viridis		title,claims,abstract,description	49	0.000
bamboo		title,claims,abstract,description	49	0.000
Bambusa tulda		title	1	0.000
Bambuseae		claims,abstract,description	48	0.000
polyethylene terephthalate		claims,abstract,description	32	0.000
polyethylene terephthalate		claims,abstract,description	32	0.000
polylactic acid		claims,abstract,description	31	0.000
poly(lactic acid) polymer		claims,abstract,description	26	0.000
mixing		claims,abstract,description	19	0.000
Cotton		claims,abstract,description	10	0.000
drying		claims,abstract,description	9	0.000
carding		claims,abstract,description	5	0.000
manufacturing process		claims,description	15	0.000
method		claims,description	13	0.000
cosmetic		claims,description	9	0.000
mixture		claims,description	8	0.000
water		claims,description	6	0.000
polyethylene terephthalate		claims,description	5	0.000
impurity		claims,description	3	0.000
liquid		claims,description	3	0.000

masking	claims,description	2	0.000
material	abstract,description	6	0.000
Skin	abstract,description	4	0.000
dipping method	abstract	1	0.000

Show all concepts from the description section

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(54) **Title**: SOFT TISSUE COMPRISING NON-WOOD FIBERS

(57) **Abstract**: The present invention provides soft, durable and bulky tissue products comprising non-wood fibers and more particularly hesperaloe fiber. The inventors have discovered that high yield hesperaloe pulp fiber, when incorporated in amounts of at least about 5 percent by weight of the tissue product, produces products having a GMT less than about 1000 g/3" and a GM Slope less than about 7.0 kg. At the foregoing tensile strengths and modulus the tissue products of the present invention are also generally soft, such as having a Stiffness Index less than about 10.0, and more preferably less than about 9.0, such as from about 7.0 to about 9.0.

SOFT TISSUE COMPRISING NON-WOOD FIBERS

BACKGROUND OF THE DISCLOSURE

Tissue products, such as facial tissues, paper towels, bath tissues, napkins, and other similar products, are designed to include several important properties. For example, the products should have good bulk, a soft feel, and should have good strength and durability. Unfortunately, however, when steps are taken to increase one property of the product, other characteristics of the product are often adversely affected.

To achieve the optimum product properties, tissue products are typically formed, at least in part, from pulps containing wood fibers and often a blend of hardwood and softwood fibers to achieve the desired properties. Typically when attempting to optimize surface softness, as is often the case with tissue products, the papermaker will select the fiber furnish based in part on the coarseness of pulp fibers. Pulps having fibers with low coarseness are desirable because tissue paper made from fibers having a low coarseness can be made softer than similar tissue paper made from fibers having a high coarseness. To optimize surface softness even further, premium tissue products usually comprise layered structures where the low coarseness fibers are directed to the outside layer of the tissue sheet with the inner layer of the sheet comprising longer, coarser fibers.

Unfortunately, the need for softness is balanced by the need for durability. Durability in tissue products can be defined in terms of tensile strength, tensile energy absorption (TEA), burst strength and tear strength. Typically tear, burst and TEA will show a positive correlation with tensile strength while tensile strength, and thus durability, and softness are inversely related. Thus the paper maker is continuously challenged with the need to balance the need for softness with a need for durability. Unfortunately, tissue paper durability generally decreases as the fiber length is reduced. Therefore, simply reducing the pulp fiber length can result in an undesirable trade-off between product surface softness and product durability.

Besides durability long fibers also play an important role in overall tissue product softness. While surface softness in tissue products is an important attribute, a second element in the overall softness of a tissue sheet is stiffness. Stiffness can be measured from the tensile slope of stress – strain tensile curve. The lower the slope the lower the stiffness and the better overall softness the product will display. Stiffness and tensile strength are positively correlated, however at a given tensile strength shorter fibers will display a greater stiffness than long fibers. While not wishing to be bound by theory, it is believed that this behavior is due to the higher number of hydrogen bonds required to produce a product of a given tensile strength with short fibers than with long fibers. Thus, easily

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collapsible, low coarseness long fibers, such as those provided by northern softwood kraft (NSWK) fibers typically supply the best combination of durability and softness in tissue products when those fibers are used in combination with hardwood Kraft fibers such as Eucalyptus hardwood Kraft fibers. While Northern Softwood Kraft Fibers have a higher coarseness than Eucalyptus fibers their small cell wall thickness relative to lumen diameter combined with their long length makes them the ideal candidate for optimizing durability and softness in tissue.

Unfortunately supply of NSWK is under significant pressure both economically and environmentally. As such, prices of NSWK have escalated significantly creating a need to find alternatives to optimize softness and strength in tissue products. Alternatives, however, are limited. For example, southern softwood kraft (SSWK) may only be used in limited amounts in the manufacture of tissue products because its high coarseness results in stiffer, harsher feeling products than NSWK. Thus, there remains a need for an alternative to NSWK for the manufacture of premium tissue products, which must be both soft and strong.

SUMMARY OF THE DISCLOSURE

The present inventors have successfully used hesperaloe fibers to produce a tissue having satisfactory softness, strength and bulk. To produce the instant tissue products the inventors have successfully moderated the changes in strength and stiffness typically associated with substituting conventional wood papermaking fibers, such as NSWK, with hesperaloe fibers. Not only have the inventors succeeded in moderating changes to strength and stiffness they have done so without negatively effecting bulk. As such, the tissue products of the present invention have properties comparable to or better than those produced using conventional wood papermaking fibers, and more particularly softwood fibers, and still more particularly NSWK fibers. Accordingly, in certain preferred embodiments, the invention provides tissue products in which hesperaloe fibers replace at least about 50 percent of the NSWK, more preferably at least about 75 percent and still more preferably all NSWK without negatively effecting the tissue products strength, stiffness and bulk.

In other embodiments the present invention provides tissue products comprising a multi-layered tissue web where one or more of the layers comprise a blend of hesperaloe fibers and NSWK fibers and/or Southern Softwood Kraft (SSWK) fibers. Blending hesperaloe fibers with NSWK fibers and/or SSWK fibers may improve the physical properties of the tissue product, such as increased softness and durability while reducing the cost of manufacture. In particularly preferred embodiments the multi-layered tissue structure comprises two outer layers and a middle layer, where the outer layers are substantially free from hesperaloe fiber and the middle layer consists essentially of hesperaloe fiber.

In yet other embodiments the present invention provides a tissue product comprising from about 20 to about 50 weight percent hesperaloe fiber and substantially free from long average fiber length kraft fibers, such as NSWK and SSWK, the tissue product having a sheet bulk greater than about 10 cc/g, a GMT from about 500 to about 750 g/3", a Stiffness Index less than about 8.0 and a Durability Index greater than about 30.

In still other embodiments the present invention provides a tissue product comprising at least about 20 weight percent hesperaloe fiber, the tissue product having a GMT from about 400 to about 1,000 g/3", a Stiffness Index less than about 10 and more preferably less than about 8.0, and a sheet bulk greater than about 10 cc/g.

In another embodiment the present invention provides a tissue product comprising at least one through-air dried tissue web, the web comprising at least about 20 weight percent hesperaloe fiber, the tissue product having a GMT from about 500 to about 750 g/3", a Stiffness Index less than about 8.0 and a Durability Index greater than about 30.

In yet another embodiment the present invention provides a tissue product comprising from about 20 to about 50 weight percent hesperaloe fiber, the tissue product having a sheet bulk greater than about 10 cc/g, a GMT from about 500 to about 750 g/3", a Stiffness Index less than about 8.0 and a Durability Index greater than about 30.

In other embodiments the present invention provides a tissue product comprising from about 20 to about 50 weight percent hesperaloe fiber and substantially free from NSWK, the tissue product having a basis weight from about 20 to about 50 gsm, a GMT from about 500 to about 750 g/3", a Stiffness Index less than about 8.0 and a Durability Index greater than about 32.

In still other embodiments the present invention provides a product comprising at least one multi-layered through-air dried tissue web comprising a first and a second layer, the first layer being substantially free from high yield hesperaloe pulp fibers and the second layer consisting essentially of high yield hesperaloe pulp fibers, the tissue product having a Durability Index greater than about 28.0 and a Stiffness Index less than about 10.0, wherein the tissue product comprises from about 20 to about 50 weight percent high yield hesperaloe pulp fibers.

In yet other embodiments the present invention provides a single-ply through-air dried tissue product comprising at least about 20 weight percent high yield hesperaloe pulp fibers, the tissue product having a basis weight from about 30 to about 60 gsm, a sheet bulk greater than about 10 cc/g and a Stiffness Index less than about 10.

DEFINITIONS

As used herein, a "tissue product" generally refers to various paper products, such as facial tissue, bath tissue, paper towels, napkins, and the like. Normally, the basis weight of a tissue product of the present invention is less than about 80 grams per square meter (gsm), in some embodiments less than about 60 gsm, and in some embodiments from about 10 to about 60 gsm and more preferably from about 20 to about 50 gsm.

As used herein, the term "layer" refers to a plurality of strata of fibers, chemical treatments, or the like within a ply.

As used herein, the terms "layered tissue web," "multi-layered tissue web," "multi-layered web," and "multi-layered paper sheet," generally refer to sheets of paper prepared from two or more layers of aqueous papermaking furnish which are preferably comprised of different fiber types. The layers are preferably formed from the deposition of separate streams of dilute fiber slurries, upon one or more endless foraminous screens. If the individual layers are initially formed on separate foraminous screens, the layers are subsequently combined (while wet) to form a layered composite web.

The term "ply" refers to a discrete product element. Individual plies may be arranged in juxtaposition to each other. The term may refer to a plurality of web-like components such as in a multi-ply facial tissue, bath tissue, paper towel, wipe, or napkin.

As used herein, the term "basis weight" generally refers to the bone dry weight per unit area of a tissue and is generally expressed as grams per square meter (gsm). Basis weight is measured using TAPPI test method T-220.

As used herein, the term "Burst Index" refers to the dry burst peak load (typically having units of grams) at a relative geometric mean tensile strength (typically having units of grams per three inches) as defined by the equation:

$$Burst\ Index = \frac{Dry\ Burst\ Peak\ Load\ (g)}{GMT\ (g/3")}\ x\ 10$$

While Burst Index may vary tissue products prepared according to the present disclosure generally have a Burst Index greater than about 8.0, more preferably greater than about 8.5 and still more preferably greater than about 9.0.

As used herein, the term "TEA Index" refers the geometric mean tensile energy absorption (typically expressed in g•cm/cm^2) at a given geometric mean tensile strength (typically having units of grams per three inches) as defined by the equation:

$$TEA\ Index = \frac{GM\ TEA\ (\mathrm{g \bullet cm/cm2})}{GMT\ (g/3")}\ x\ 1{,}000$$

While the TEA Index may vary tissue products prepared according to the present disclosure generally have a TEA Index greater than about 9.0, more preferably greater than about 9.5 and still more preferably greater than about 10.0.

As used herein, the term "Tear Index" refers to the GM Tear Strength (typically expressed in grams) at a relative geometric mean tensile strength (typically having units of grams per three inches) as defined by the equation:

$$Tear\ Index = \frac{GM\ Tear\ (g)}{GMT(g/3")}\ x\ 1{,}000$$

While the Tear Index may vary tissue products prepared according to the present disclosure generally have a Tear Index greater than about 12.0, more preferably greater than about 12.5 and still more preferably greater than about 13.0.

As used herein, the term "Durability Index" refers to the sum of the Tear Index, the Burst Index, and the TEA Index and is an indication of the durability of the product at a given tensile strength.

$$Durability\ Index = Tear\ Index + Burst\ Index + TEA\ Index$$

While the Durability Index may vary tissue products prepared according to the present disclosure generally have a Durability Index value greater than about 28, more preferably greater than about 30 and still more preferably greater than about 32.

As used herein, the term "caliper" is the representative thickness of a single sheet (caliper of tissue products comprising two or more plies is the thickness of a single sheet of tissue product comprising all plies) measured in accordance with TAPPI test method T402 using an EMVECO 200-A Microgage automated micrometer (EMVECO, Inc., Newberg, OR). The micrometer has an anvil diameter of 2.22 inches (56.4 mm) and an anvil pressure of 132 grams per square inch (per 6.45 square centimeters) (2.0 kPa).

As used herein, the term "sheet bulk" refers to the quotient of the caliper (μm) divided by the bone dry basis weight (gsm). The resulting sheet bulk is expressed in cubic centimeters per gram (cc/g). Tissue products prepared according to the present invention generally have a sheet bulk greater than about 10 cc/g, more preferably greater than about 11 cc/g and still more preferably greater than about 12 cc/g.

As used herein, the term "fiber length" refers to the length weighted average length of fibers determined utilizing a Kajaani fiber analyzer model No. FS-100 available from Kajaani Oy Electronics, Kajaani, Finland. According to the test procedure, a pulp sample is treated with a macerating liquid to ensure that no fiber bundles or shives are present. Each pulp sample is disintegrated into hot water and diluted to an approximately 0.001 percent solution. Individual test samples are drawn in approximately 50 to 100 ml portions from the dilute solution when tested using the standard Kajaani fiber analysis test procedure. The weighted average fiber length may be expressed by the following equation:

$$\sum_{x_i=0}^{k} (x_i \times n_i)/n$$

where k = maximum fiber length

x_i = fiber length

n_i = number of fibers having length x_i

n = total number of fibers measured.

As used herein, the term "hesperaloe fiber" refers to a fiber derived from a plant of the genus *Hesperaloe* of the family Asparagaceae including, for example, *Hesperaloe funifera*. The fibers are generally processed into a pulp for use in the manufacture of tissue products according to the present invention. Preferably the pulping process is a high yield pulping process. The high yield hesperaloe pulp fibers generally have a lignin content, measured as Klason lignin, from about 10 to about 15 weight percent. The terms "hesperaloe fiber" and "high yield hesperaloe pulp fiber" may be used interchangeably herein when referring to non-wood fibers incorporated into tissue products, one skilled in the art will appreciate however that when incorporating non-wood fibers into tissue products it is preferred that the fibers be processed, such as by high yield pulping.

As used herein, the term "slope" refers to slope of the line resulting from plotting tensile versus stretch and is an output of the MTS TestWorks™ in the course of determining the tensile strength as described in the Test Methods section herein. Slope is reported in the units of grams (g) per unit of sample width (inches) and is measured as the gradient of the least-squares line fitted to the load-corrected strain points falling between a specimen-generated force of 70 to 157 grams (0.687 to 1.540 N) divided by the specimen width. Slopes are generally reported herein as having units of grams per 3 inch sample width or g/3".

As used herein, the term "geometric mean slope" (GM Slope) generally refers to the square root of the product of machine direction slope and cross-machine direction slope. GM Slop generally is expressed in units of kg.

As used herein, the terms "geometric mean tensile" and "GMT" refer to the square root of the product of the machine direction tensile strength and the cross-machine direction tensile strength of the web. While the GMT may vary tissue products prepared according to the present disclosure generally have a GMT greater than about 400 g/3", more preferably greater than about 500 g/3" and still more preferably greater than about 600 g/3".

As used herein, the term "Stiffness Index" refers to the quotient of the geometric mean tensile slope, defined as the square root of the product of the MD and CD slopes (typically having units of kg), divided by the geometric mean tensile strength (typically having units of grams per three inches).

$$Stiffness\ Index = \frac{\sqrt{MD\ Tensile\ Slope\ (kg) x\ CD\ Tensile\ Slope(kg)}}{GMT\ (g/3")}\ x\ 1{,}000$$

While the Stiffness Index may vary tissue products prepared according to the present disclosure generally have a Stiffness Index less than about 10.0, more preferably less than about 9.0 and still more preferably less than about 8.0.

DETAILED DESCRIPTION OF THE DISLOSURE

Generally the skilled tissue maker is concerned with balancing various tissue properties such as bulk, softness, stiffness and strength. For example, the tissue maker often desires to increase bulk without stiffening the tissue product or reducing softness, while at the same time maintaining a given tensile strength. Previous attempts to manufacture tissue using hesperaloe fibers have not successfully balanced these important tissue properties resulting in reduced bulk with dramatic increases in tensile and stiffness. Despite the failings of the prior art, the present inventors have now succeeded in moderating the changes in strength and stiffness without negatively effecting bulk when manufacturing a tissue product comprising hesperaloe fibers, as illustrated in Table 1, below.

TABLE 1

Example	Furnish	Delta Bulk	Delta GMT	Delta GM Slope
US 5,320,710	50% *H. Funifera* 50% NSWK	-20%	192%	65%
Inventive	40% *H. Funifera* 60% EHWK	2%	1%	8%

Not only were previous attempts to balance bulk, strength, stiffness and softness unsuccessful, the resulting tissue products were not suitable for use as premium bath tissue because

the strengths and modulus were excessively high. For example, when compared to Northern® Bathroom Tissue the inventive code of US 5,320,710 had 11 percent lower bulk, 23 percent greater modulus and 148 percent greater stiffness (measured as the modulus divided by the tensile strength). The present inventors have overcome these failings to provide a tissue product that is comparable or better than commercially available bath tissue products. For example, when compared to a current version of Northern® Bathroom Tissue, products of the present invention have comparable bulks, 31 percent lower modulus and 13 percent lower stiffness.

Without being bound by any particular theory, the high degree of strength and stiffness observed previously in tissue products may be attributed in-part to the morphology of hesperaloe fiber when prepared by chemical pulping, which has a relatively long fiber length, high aspect ratio and high ratio of fiber length to cell wall thickness. A comparison of fiber morphology, as reported in the literature for, hesperaloe kraft pulp fibers, conventional NSWK and SSWK is provided in Table 2, below.

TABLE 2

Fiber	Fiber Length (mm)	Average Fiber Width (μm)	Cell Wall Thickness (μm)	Aspect Ratio	Fiber Length : Cell Wall Thickness
H. Funifera kraft pulp	3.4	16.5	3.5	206	971
NSWK	3.5	36	6	97	583
SSWK	4.0	43	7	93	571

Despite the foregoing properties of hesperaloe kraft pulp fibers and the tendency of such pulps to produce overly strong and stiff tissue products, the present inventors have discovered that hesperaloe fibers processed by high yield pulping means, such as mechanical pulping, may be a suitable replacement for high fiber length wood fibers without decreasing bulk, significantly altering tensile, increasing stiffness or reducing softness. Processing of hesperaloe fibers by high yield pulping means generally yields a fiber having a slightly shorter fiber length and higher coarseness compared to hesperaloe chemical pulp fibers.

Not only have the present inventors discovered that high yield hesperaloe pulp fibers are a suitable replacement for high fiber length wood fibers, such as NSWK, but also that the resulting tissue products have physical properties comparable to or better than those produced using NSWK fibers. Accordingly, in certain embodiments, hesperaloe fibers may replace at least about 50 percent of the NSWK in the tissue product, more preferably at least about 75 percent and still more preferably all NSWK without negatively effecting the tissue products softness and durability.

Thus, in one embodiment the present invention provides a tissue product comprising at least about 5 percent, by weight of the tissue product, high yield hesperaloe pulp fiber, the tissue product having a GMT less than about 1000 g/3" and a GM Slope less than about 7.0 kg. In still other embodiments the present disclosure provides a tissue product having a GMT from about 400 to about 1,000 g/3" and more preferably from about 500 to about 800 g/3", a GM Slope less than about 7.0 kg, such as from about 4.5 to about 7.0 kg, and comprising from about 5 to about 50 percent, by weight of the tissue product, high yield hesperaloe pulp fiber. At the foregoing tensile strengths and modulus the tissue products of the present invention are also generally soft, such as having a Stiffness Index less than about 10.0, and more preferably less than about 9.0, such as from about 7.0 to about 9.0.

The improved properties are further illustrated in the table below which compares the change in various tissue product properties relative to comparable tissue products comprising NSWK. All tissues shown in Table 3 are single-ply products having a basis weight of about 35 grams per square meter (gsm) and comprising either 40 weight percent NSWK or hesperaloe and 60 weight percent EHWK, based upon the total weight of the tissue product. Surprisingly hesperaloe provides comparable levels of durability without stiffening or dramatically increasing tensile strength.

TABLE 3

	NSWK	High Yield Hesperaloe Fiber	Delta (%)
GMT (g/3")	627	635	1.3
Sheet Bulk (cc/g)	11	11.2	1.8
Tear Index	14.04	14.96	6.6
TEA Index	9.09	9.45	4.0
Burst Index	9.38	8.27	-11.8
Durability Index	32.5	32.7	0.6
Stiffness Index	7.66	8.2	6.9

Accordingly, in certain embodiments the present invention provides tissue products that are not only soft, but also highly durable at relatively modest tensile strengths. As such the tissue products generally have a GMT less than about 1000 g/3", such as from about 400 to about 1,000 g/3", and more preferably from about 500 to about 800 g/3", but still have a Durability Index greater than about 25, such as from about 25 to about 35, and more preferably from about 30 to about 35.

In other embodiments the tissue products have a Stiffness Index less than about 10.0 and a Durability Index greater than about 30, such as from about 30 to about 35. In one particularly preferred embodiment the tissue product comprises a through-air dried web comprising less than about 5 weight percent NSWK, and from about 10 to about 40 weight percent hesperaloe fiber, the tissue product a Durability Index from about 30 to about 35 and Stiffness Index from about 8.0 to about 10.0.

In a particularly preferred embodiment the tissue product comprises a multi-layered through-air dried web wherein hesperaloe fiber is selectively disposed in only one of the layers such that the hesperaloe fiber is not brought into contact with the user's skin in-use. For example, in one embodiment the tissue web may comprise a two layered web wherein the first layer consists essentially of hardwood kraft pulp fibers and is substantially free of hesperaloe and the second layer comprises hesperaloe, wherein the hesperaloe comprises at least about 50 percent by weight of the second layer, such as from about 50 to about 100 percent by weight of the second layer. It should be understood that, when referring to a layer that is substantially free of hesperaloe fibers, negligible amounts of the fiber may be present therein, however, such small amounts often arise from the hesperaloe fibers applied to an adjacent layer, and do not typically substantially affect the softness or other physical characteristics of the web.

The tissue webs may be incorporated into tissue products that may be either single- or multi-ply, where one or more of the plies may be formed by a multi-layered tissue web having hesperaloe fibers selectively incorporated in one of its layers. In one embodiment the tissue product is constructed such that the hesperaloe fibers are not brought into contact with the user's skin in-use. For example, the tissue product may comprise two multi-layered through-air dried webs wherein each web comprises a first fibrous layer substantially free from hesperaloe fibers and a second fibrous layer comprising hesperaloe fibers. The webs are plied together such that the outer surface of the tissue product is formed from the first fibrous layer of each web and the second fibrous layer comprising the hesperaloe fibers is not brought into contact with the user's skin in-use.

Generally hesperaloe fibers useful in the present invention are derived from non-woody plants in the genus Hesperaloe in the family Agavaceae. Suitable species within the genus Hesperaloe include, for example *H. funifera*, *H. nocturna*, *H. parviflova*, and *H. changii*, as well as combinations thereof.

In certain embodiments the hesperaloe fibers are processed by a high yield pulping process, such as mechanically treating the fibers. High yield pulping processes include, for example, mechanical pulp (MP), refiner mechanical pulp (RMP), pressurized refiner mechanical pulp (PRMP), thermomechanical pulp (TMP), high temperature TMP (HT-TMP) RTS-TMP, thermopulp, groundwood pulp (GW), stone groundwood pulp (SGW), pressure groundwood pulp (PGW), super pressure groundwood pulp (PGW-S), thermo groundwood pulp (TGW), thermo stone groundwood pulp (TSGW) or any modifications and combinations thereof. Processing of hesperaloe fibers using a high yield pulping process generally results in a pulp having a yield of at least about 85 percent, more preferably at least about 90 percent and still more preferably at least about 95 percent.

The high yield pulping process may comprise heating the hesperaloe fiber above ambient temperatures, such as from about to 100 to about 200°C and more preferably from about 120 to about 190°C while subjecting the fiber to mechanical forces. In other embodiments a caustic or oxidizing agent may be introduced to the process to facilitate fiber separation. For example, in one embodiment a 3-8 percent solution of NaOH may be added to the fiber during mechanical treatment. Although a caustic or oxidizing agent may be added during processing, it is generally preferred that the hesperaloe fiber is not pretreated with a chemical agent prior to processing. For example, high yield hesperaloe pulps are generally prepared without pretreatment of the fiber with an aqueous solution of sodium sulfite or the like, which is commonly employed in the manufacture of chemi-mechanical wood pulps.

Generally the high yield pulping process removes from about 1 to about 3 weight percent of the lignin from the hesperaloe fiber. As such high yield hesperaloe pulp useful in the present invention generally has a lignin content less than about 15 weight percent, preferably less than about 13 weight percent and still more preferably less than about 11 weight percent, such as from about 10 to about 15 weight percent.

In a particularly preferred embodiment hesperaloe fibers are utilized in the tissue web as a replacement for high fiber length wood fibers such as softwood fibers and more specifically NSWK or Southern softwood kraft (SSWK). In one particular embodiment the hesperaloe fibers are substituted for NSWK such that the total amount of NSWK, by weight of the tissue product, is less than about 10 percent and more preferably less than about 5 percent. In other embodiments it may be desirable to replace all of the NSWK with hesperaloe fibers such that the tissue product is substantially free from NSWK. In other embodiments hesperaloe fibers may be blended with SSWK fibers such that the total amount of SSWK, by weight of the tissue product, is less than about 10 percent and more preferably less than about 5 percent.

If desired, various chemical compositions may be applied to one or more layers of the multi-layered tissue web to further enhance softness and/or reduce the generation of lint or slough. For example, in some embodiments, a wet strength agent can be utilized, to further increase the strength of the tissue product. As used herein, a “wet strength agent” is any material that, when added to pulp fibers can provide a resulting web or sheet with a wet geometric tensile strength to dry geometric tensile strength ratio in excess of about 0.1. Typically these materials are termed either “permanent” wet strength agents or “temporary” wet strength agents. As is well known in the art, temporary and permanent wet strength agents may also sometimes function as dry strength agents to enhance the strength of the tissue product when dry.

Wet strength agents may be applied in various amounts, depending on the desired characteristics of the web. For instance, in some embodiments, the total amount of wet strength agents added can be between about 1 to about 60 pounds per ton (lbs/T), in some embodiments, between about 5 to about 30 lbs/T, and in some embodiments, between about 7 to about 13 lbs/T of the dry weight of fibrous material. The wet strength agents can be incorporated into any layer of the multi-layered tissue web.

A chemical debonder can also be applied to soften the web. Specifically, a chemical debonder can reduce the amount of hydrogen bonds within one or more layers of the web, which results in a softer product. Depending on the desired characteristics of the resulting tissue product, the debonder can be utilized in varying amounts. For example, in some embodiments, the debonder can be applied in an amount between about 1 to about 30 lbs/T, in some embodiments between about 3 to about 20 lbs/T, and in some embodiments, between about 6 to about 15 lbs/T of the dry weight of fibrous material. The debonder can be incorporated into any layer of the multi-layered tissue web.

Any material capable of enhancing the soft feel of a web by disrupting hydrogen bonding can generally be used as a debonder in the present invention. In particular, as stated above, it is typically desired that the debonder possess a cationic charge for forming an electrostatic bond with anionic groups present on the pulp. Some examples of suitable cationic debonders can include, but are not limited to, quaternary ammonium compounds, imidazolinium compounds, bis-imidazolinium compounds, diquaternary ammonium compounds, polyquaternary ammonium compounds, ester-functional quaternary ammonium compounds (e.g., quaternized fatty acid trialkanolamine ester salts), phospholipid derivatives, polydimethylsiloxanes and related cationic and non-ionic silicone compounds, fatty and carboxylic acid derivatives, mono and polysaccharide derivatives, polyhydroxy hydrocarbons, etc. For instance, some suitable debonders are described in US Patent Nos. 5,716,498, 5,730,839, 6,211,139, 5,543,067, and WO/0021918, all of which are incorporated herein in a manner consistent with the present disclosure.

Still other suitable debonders are disclosed in US Patent Nos. 5,529,665 and 5,558,873, both of which are incorporated herein in a manner consistent with the present disclosure. In particular, US Patent No. 5,529,665 discloses the use of various cationic silicone compositions as softening agents.

Tissue webs useful in forming tissue products of the present invention can generally be formed by any of a variety of papermaking processes known in the art. For example, a papermaking process of the present disclosure can utilize adhesive creping, wet creping, double creping, embossing, wet-pressing, air pressing, through-air drying, creped through-air drying, uncreped

through-air drying, as well as other steps in forming the paper web. Examples of papermaking processes and techniques useful in forming tissue webs according to the present invention include, for example, those disclosed in US Patent Nos. 5,048,589, 5,399,412, 5,129,988 and 5,494,554 all of which are incorporated herein in a manner consistent with the present disclosure. In one embodiment the tissue web is formed by through-air drying and be either creped or uncreped. When forming multi-ply tissue products, the separate plies can be made from the same process or from different processes as desired.

TEST METHODS

Sheet Bulk

Sheet Bulk is calculated as the quotient of the dry sheet caliper (µm) divided by the basis weight (gsm). Dry sheet caliper is the measurement of the thickness of a single tissue sheet measured in accordance with TAPPI test methods T402 and T411 om-89. The micrometer used for carrying out T411 om-89 is an Emveco 200-A Tissue Caliper Tester (Emveco, Inc., Newberg, OR). The micrometer has a load of 2 kilo-Pascals, a pressure foot area of 2500 square millimeters, a pressure foot diameter of 56.42 millimeters, a dwell time of 3 seconds and a lowering rate of 0.8 millimeters per second.

Tear

Tear testing was carried out in accordance with TAPPI test method T-414 "Internal Tearing Resistance of Paper (Elmendorf-type method)" using a falling pendulum instrument such as Lorentzen & Wettre Model SE 009. Tear strength is directional and MD and CD tear are measured independently.

More particularly, a rectangular test specimen of the sample to be tested is cut out of the tissue product or tissue basesheet such that the test specimen measures 63 mm ± 0.15 mm (2.5 inches ± 0.006") in the direction to be tested (such as the MD or CD direction) and between 73 and 114 millimeters (2.9 and 4.6 inches) in the other direction. The specimen edges must be cut parallel and perpendicular to the testing direction (not skewed). Any suitable cutting device, capable of the proscribed precision and accuracy, can be used. The test specimen should be taken from areas of the sample that are free of folds, wrinkles, crimp lines, perforations or any other distortions that would make the test specimen abnormal from the rest of the material.

The number of plies or sheets to test is determined based on the number of plies or sheets required for the test results to fall between 20 to 80 percent on the linear range scale of the tear tester and more preferably between 20 to 60 percent of the linear range scale of the tear tester. The sample preferably should be cut no closer than 6 mm (0.25 inch) from the edge of the material from which the

specimens will be cut. When testing requires more than one sheet or ply the sheets are placed facing in the same direction.

The test specimen is then placed between the clamps of the falling pendulum apparatus with the edge of the specimen aligned with the front edge of the clamp. The clamps are closed and a 20-millimeter slit is cut into the leading edge of the specimen usually by a cutting knife attached to the instrument. For example, on the Lorentzen & Wettre Model SE 009 the slit is created by pushing down on the cutting knife lever until it reaches its stop. The slit should be clean with no tears or nicks as this slit will serve to start the tear during the subsequent test.

The pendulum is released and the tear value, which is the force required to completely tear the test specimen, is recorded. The test is repeated a total of ten times for each sample and the average of the ten readings reported as the tear strength. Tear strength is reported in units of grams of force (gf). The average tear value is the tear strength for the direction (MD or CD) tested. The "geometric mean tear strength" is the square root of the product of the average MD tear strength and the average CD tear strength. The Lorentzen & Wettre Model SE 009 has a setting for the number of plies tested. Some testers may need to have the reported tear strength multiplied by a factor to give a per ply tear strength. For basesheets intended to be multiple ply products, the tear results are reported as the tear of the multiple ply product and not the single-ply basesheet. This is done by multiplying the single-ply basesheet tear value by the number of plies in the finished product. Similarly, multiple ply finished product data for tear is presented as the tear strength for the finished product sheet and not the individual plies. A variety of means can be used to calculate but in general will be done by inputting the number of sheets to be tested rather than number of plies to be tested into the measuring device. For example, two sheets would be two 1-ply sheets for 1-ply product and two 2-ply sheets (4-plies) for 2-ply products.

Tensile

Tensile testing was done in accordance with TAPPI test method T-576 "Tensile properties of towel and tissue products (using constant rate of elongation)" wherein the testing is conducted on a tensile testing machine maintaining a constant rate of elongation and the width of each specimen tested is 3 inches. More specifically, samples for dry tensile strength testing were prepared by cutting a 3 inches ± 0.05 inches (76.2 mm ± 1.3 mm) wide strip in either the machine direction (MD) or cross-machine direction (CD) orientation using a JDC Precision Sample Cutter (Thwing-Albert Instrument Company, Philadelphia, PA, Model No. JDC 3-10, Serial No. 37333) or equivalent. The instrument used for measuring tensile strengths was an MTS Systems Sintech 11S, Serial No. 6233. The data acquisition software was an MTS TestWorks® for Windows Ver. 3.10 (MTS Systems Corp., Research

Triangle Park, NC). The load cell was selected from either a 50 Newton or 100 Newton maximum, depending on the strength of the sample being tested, such that the majority of peak load values fall between 10 to 90 percent of the load cell's full scale value. The gauge length between jaws was 4 ± 0.04 inches (101.6 ± 1 mm) for facial tissue and towels and 2 ± 0.02 inches (50.8 ± 0.5 mm) for bath tissue. The crosshead speed was 10 ± 0.4 inches/min (254 ± 1 mm/min), and the break sensitivity was set at 65 percent. The sample was placed in the jaws of the instrument, centered both vertically and horizontally. The test was then started and ended when the specimen broke. The peak load was recorded as either the "MD tensile strength" or the "CD tensile strength" of the specimen depending on direction of the sample being tested. Ten representative specimens were tested for each product or sheet and the arithmetic average of all individual specimen tests was recorded as the appropriate MD or CD tensile strength the product or sheet in units of grams of force per 3 inches of sample. The geometric mean tensile (GMT) strength was calculated and is expressed as grams-force per 3 inches of sample width. Tensile energy absorbed (TEA) and slope are also calculated by the tensile tester. TEA is reported in units of gm cm/cm^2. Slope is recorded in units of kg. Both TEA and Slope are directional dependent and thus MD and CD directions are measured independently. Geometric mean TEA and geometric mean slope are defined as the square root of the product of the representative MD and CD values for the given property.

Multi-ply products were tested as multi-ply products and results represent the tensile strength of the total product. For example, a 2-ply product was tested as a 2-ply product and recorded as such. A basesheet intended to be used for a two ply product was tested as two plies and the tensile recorded as such. Alternatively, a single ply may be tested and the result multiplied by the number of plies in the final product to get the tensile strength.

Burst Strength

Burst strength herein is a measure of the ability of a fibrous structure to absorb energy, when subjected to deformation normal to the plane of the fibrous structure. Burst strength may be measured in general accordance with ASTM D-6548 with the exception that the testing is done on a Constant-Rate-of-Extension (MTS Systems Corporation, Eden Prairie, MN) tensile tester with a computer-based data acquisition and frame control system, where the load cell is positioned above the specimen clamp such that the penetration member is lowered into the test specimen causing it to rupture. The arrangement of the load cell and the specimen is opposite that illustrated in FIG. 1 of ASTM D-6548. The penetration assembly consists of a semi spherical anodized aluminum penetration member having a diameter of 1.588 ± 0.005 cm affixed to an adjustable rod having a ball end socket. The test specimen is secured in a specimen clamp consisting of upper and lower concentric rings of aluminum

between which the sample is held firmly by mechanical clamping during testing. The specimen clamping rings has an internal diameter of 8.89 ± 0.03 cm.

The tensile tester is set up such that the crosshead speed is 15.2 cm/min, the probe separation is 104 mm, the break sensitivity is 60 percent and the slack compensation is 10 gf and the instrument is calibrated according to the manufacturer's instructions.

Samples are conditioned under TAPPI conditions and cut into 127 x 127 mm ± 5 mm squares. For each test a total of 3 sheets of product are combined. The sheets are stacked on top of one another in a manner such that the machine direction of the sheets is aligned. Where samples comprise multiple plies, the plies are not separated for testing. In each instance the test sample comprises three sheets of product. For example, if the product is a 2-ply tissue product, three sheets of product, totaling six plies are tested. If the product is a single-ply tissue product, then three sheets of product totaling three plies are tested.

Prior to testing the height of the probe is adjusted as necessary by inserting the burst fixture into the bottom of the tensile tester and lowering the probe until it was positioned approximately 12.7 mm above the alignment plate. The length of the probe is then adjusted until it rests in the recessed area of the alignment plate when lowered.

It is recommended to use a load cell in which the majority of the peak load results fall between 10 and 90 percent of the capacity of the load cell. To determine the most appropriate load cell for testing, samples are initially tested to determine peak load. If peak load is < 450 gf a 10 Newton load cell is used, if peak load is > 450 gf a 50 Newton load cell is used.

Once the apparatus is set-up and a load cell selected, samples are tested by inserting the sample into the specimen clamp and clamping the test sample in place. The test sequence is then activated, causing the penetration assembly to be lowered at the rate and distance specified above. Upon rupture of the test specimen by the penetration assembly the measured resistance to penetration force is displayed and recorded. The specimen clamp is then released to remove the sample and ready the apparatus for the next test.

The peak load (gf) and energy to peak (g-cm) are recorded and the process repeated for all remaining specimens. A minimum of five specimens are tested per sample and the peak load average of five tests is reported as the Dry Burst Strength.

EXAMPLES

Example 1

Single-ply uncreped through-air dried (UCTAD) tissue web were made generally in accordance with US Patent No. 5,607,551. The tissue webs and resulting tissue products were formed from various fiber furnishes including, Eucalyptus Hardwood Kraft (EHWK) pulp, NSWK pulp, and high yield hesperaloe pulp (HYH).

The EHWK furnish was prepared by dispersing about 120 pounds (oven dry basis) EHWK pulp in a pulper for 30 minutes at a consistency of about 3 percent. The fiber was then transferred to a machine chest and diluted to a consistency of 1 percent. In certain instances starch (Redibond 2038 A) was added to the EHWK machine chest as indicated in Table 4.

The NSWK furnish was prepared by dispersing about 50 pounds (oven dry basis) of NSWK pulp in a pulper for 30 minutes at a consistency of about 3 percent. The fiber was then transferred to a machine chest and diluted to a consistency of 1 percent. In certain instances starch (Redibond 2038 A) was added to the NSWK machine chest as indicated in Table 4.

The HYH was prepared by dispersing about 50 pounds (oven dry basis) HYH pulp in a pulper for 30 minutes at a consistency of about 3 percent. The fiber was then transferred to a machine chest and diluted to a consistency of 1 percent. HYH was produced by processing *H. Funifera* using a three stage non-wood pulping process commercially available from Taizen America (Macon, GA). The hesperaloe was not refined. The hesperaloe had an average fiber length of about 1.85 mm and a fiber coarseness of about 5.47 mg/100 m.

TABLE 4

Sample	Furnish Layering	Redibond 2038 A (kg/ton)/Layer	Refining (min)
Control 1	EHWK/NSWK/EHWK	3/All	1
Control 2	EHWK/NSWK/EHWK	3/All	1
Inventive 1	EHWK/Hesperaloe/EHWK	0	-
Inventive 2	EHWK/Hesperaloe/EHWK	6/EWHK	-

The stock solutions were pumped to a 3-layer headbox after dilution to 0.75 percent consistency to form a three layered tissue web. EHWK fibers were disposed on the two outer layers and either NSWK or HYH was disposed in the middle layer. The relative weight percentage of the layers was 30% / 40% / 30%. The formed web was non-compressively dewatered and rush transferred to a transfer fabric traveling at a speed about 28 percent slower than the forming fabric. The transfer vacuum at the transfer to the TAD fabric was maintained at approximately 6 inches of mercury vacuum to control molding to a constant level. The web was then transferred to a T-1205-2 TAD fabric

(commercially available from Voith Fabrics, Appleton, WI and previously disclosed in US Patent No. 8,500,955, the contents of which are incorporated herein in a manner consistent with the present disclosure). The web was then dried and wound into a parent roll. The parent rolls were then converted into 1-ply bath tissue rolls. Calendering was done with a steel-on-rubber setup. The rubber roll using in the converting process had a hardness of 40 P&J. The rolls were converted to a diameter of about 117 mm with Kershaw firmness target of about 6 mm and a target roll weight of about 400 grams. Samples were produced as described in Table 5, below.

TABLE 5

Sample	Basis Weight (gsm)	Target GMT (g/3")	Plies	EHWK (wt%)	NSWK (wt%)	Hesperaloe (wt%)
Control 1	31.0	650	1	60	40	-
Control 2	31.2	900	1	60	40	-
Inventive 1	31.3	650	1	60	-	40
Inventive 2	31.9	900	1	60	-	40

The effect of hesperaloe fibers on various tissue properties, including tensile, durability and softness, is summarized in the tables below.

TABLE 6

Sample	Basis Weight (gsm)	Sheet Bulk (cc/g)	GMT (g/3")	GM TEA (g•cm/cm^2)	GM Slope (kg)	GM Tear (g)	Dry Burst (g)
Control 1	31.0	11.0	627	5.7	4.8	8.8	588
Control 2	31.2	12.0	883	8.6	5.4	12.9	764
Inventive 1	31.3	11.2	635	6.0	5.2	9.5	525
Inventive 2	31.9	11.5	920	9.7	6.2	13.3	736

TABLE 7

Sample	Tear Index	TEA Index	Burst Index
Control 1	14.04	9.09	9.38
Control 2	14.6	9.74	8.65
Inventive 1	14.96	9.45	8.27
Inventive 2	14.46	10.54	8.00

TABLE 8

Sample	Stiffness Index	Delta Stiffness Index (%)	Durability Index	Delta Durability
Control 1	7.66	-	32.50	-
Control 2	6.11	-	33.00	-
Inventive 1	8.19	7	32.68	1
Inventive 2	6.74	10	33.00	0

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Example 2

Additional single-ply uncreped through-air dried (UCTAD) tissue web were made generally in accordance with US Patent No. 5,607,551 at differing basis weights and tensile strengths compared to the tissue products of Example 1. The tissue webs and resulting tissue products were formed from various fiber furnishes including, Eucalyptus Hardwood Kraft (EHWK) pulp, NSWK pulp, and hesperaloe pulp. Fiber furnishes were prepared as described in Example 1 and the following samples were prepared.

TABLE 9

Sample	Furnish	Redibond 2038 A (kg/ton)	Refining (min)
Control 3	EHWK/NSWK/EHWK	0	-
Control 4	EHWK/NSWK/EHWK	2	-
Inventive 3	EHWK/Hesperaloe/EHWK	4	-
Inventive 4	EHWK/Hesperaloe/EHWK	0	2

The stock solutions were pumped to a 3-layer headbox after dilution to 0.75 percent consistency to form a three layered tissue web. EHWK fibers were disposed on the two outer layers and either NSWK or HYH was disposed in the middle layer. The relative weight percentage of the layers was 30% / 40% / 30%. The formed web was non-compressively dewatered and rush transferred to a transfer fabric traveling at a speed about 28 percent slower than the forming fabric. The transfer vacuum at the transfer to the TAD fabric was maintained at approximately 6 inches of mercury vacuum to control molding to a constant level. The web was then transferred to a either T-1205-2 or T2407-13 (commercially available from Voith Fabrics, Appleton, WI and previously disclosed in US Patent No. 8,702,905, the contents of which are incorporated herein in a manner consistent with the present disclosure) TAD fabric. The web was then dried and wound into a parent roll. The parent rolls were then converted into 1-ply bath tissue rolls. Calendering was done with a steel-on-rubber setup. The rubber roll using in the converting process had a hardness of 40 P&J. The rolls were converted to a diameter of about 117 mm with Kershaw firmness target of about 6 mm and a target roll weight of about 400 grams. Samples were produced as described in Table 10, below.

TABLE 10

Sample	Vacuum (Inches of Hg)	TAD Fabric	EHWK (wt%)	NSWK (wt%)	Hesperaloe (wt%)
Control 3	9	T-1205-2	60	40	-
Control 4	9	T2407-13	60	40	-
Inventive 3	9	T-1205-2	60	-	40
Inventive 4	9	T2407-13	60	-	40

TABLE 11

Sample	GMT	Basis Weight (gsm)	Bulk (cc/g)	CD Stretch (%)	GM Slope (kg)	Stiffness Index	GM Stretch (%)	GM TEA (g•cm/cm^2)	TEA Index
Control 3	441	26.9	15.3	8.7	4.08	9.25	11.3	4.58	10.39
Control 4	492	27.9	15.5	8.5	4.57	9.30	11.3	4.96	10.09
Inventive 3	459	27.3	17.2	9.3	3.85	8.38	11.9	5.03	10.95
Inventive 4	460	25.8	16.6	9.5	4.21	9.16	11.7	5.06	11.01

While tissue webs, and tissue products comprising the same, have been described in detail with respect to the specific embodiments thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing, may readily conceive of alterations to, variations of, and equivalents to these embodiments. Accordingly, the scope of the present invention should be assessed as that of the appended claims and any equivalents thereto and the foregoing embodiments:

In a first embodiment the present invention provides a tissue product comprising at least about 20 weight percent high yield hesperaloe pulp fibers, the tissue product having a GMT from about 400 to about 1,000 g/3", a Stiffness Index less than about 10 and a sheet bulk greater than about 10 cc/g.

In a second embodiment the present invention provides the tissue product of the first embodiment having a Burst Index greater than about 8.0.

In a third embodiment the present invention provides the tissue product of the first or the second embodiments having a TEA Index greater than about 8.0.

In a fourth embodiment the present invention provides the tissue product of any one of the first through the third embodiments having a Durability Index greater than about 28.

In a fifth embodiment the present invention provides the tissue product of any one of the first through the fourth embodiments wherein the GM Slope is less than about 6.0 kg.

In a sixth embodiment the present invention provides the tissue product of any one of the first through the fifth embodiments having a GMT from about 700 to about 1,000 g/3 and still more preferably from about 750 to about 900 g/3".

In a seventh embodiment the present invention provides the tissue product of any one of the first through the sixth embodiments wherein the tissue product is substantially free from softwood kraft pulp fibers.

In an eighth embodiment the present invention provides the tissue product of any one of the first through the seventh embodiments comprising from about 25 to about 50 weight percent high yield hesperaloe pulp fibers.

In a ninth embodiment the present invention provides the tissue product of any one of the first through the eighth embodiments wherein the high yield hesperaloe pulp fibers have a lignin content from about 10 to about 15 weight percent.

In a tenth embodiment the present invention provides the tissue product of any one of the first through the ninth embodiments wherein the tissue product is substantially free from NSWK fibers.

In a eleventh embodiment the present invention provides a tissue product comprising at least one multi-layered through-air dried tissue web comprising a first and a second layer, the first layer being substantially free from high yield hesperaloe pulp fibers and the second layer consisting essentially of high yield hesperaloe pulp fibers, the tissue product having a Durability Index greater than about 28.0, such as from about 28.0 to about 32.0 and more preferably from about 29.0 to about 31.0, and a Stiffness Index less than about 10.0.

WHAT IS CLAIMED IS:

1. A tissue product comprising at least about 20 weight percent high yield hesperaloe pulp fibers, the tissue product having a GMT from about 400 to about 1,000 g/3" and a Stiffness Index less than about 10.0.

2. The tissue product of claim 1 having a sheet bulk greater than about 10 cc/g.

3. The tissue product of claim 1 having a Burst Index greater than about 8.0.

4. The tissue product of claim 1 having a TEA Index greater than about 8.0.

5. The tissue product of claim 1 having a Durability Index greater than about 28.

6. The tissue product of claim 1 having a GM Slope less than about 6.0 kg.

7. The tissue product of claim 1 having a basis weight from about 30 to about 60 gsm and a sheet bulk from about 10 to about 15 cc/g.

8. The tissue product of claim 1 wherein the tissue product is substantially free from softwood kraft pulp fibers.

9. The tissue product of claim 1 wherein the tissue product comprises from about 25 to about 50 weight percent high yield hesperaloe pulp fibers.

10. The tissue product of claim 1 wherein the high yield hesperaloe pulp fibers have a lignin content from about 10 to about 15 weight percent.

11. The tissue product of claim 1 wherein the tissue product comprises two plies and each ply is a through-air dried tissue web.

12. A tissue product comprising at least one multi-layered through-air dried tissue web comprising a first and a second layer, the first layer being substantially free from high yield hesperaloe pulp fibers and the second layer consisting essentially of high yield hesperaloe pulp fibers, the tissue product having a Durability Index greater than about 28.0 and a Stiffness Index less than about 10.0, wherein the tissue product comprises from about 20 to about 50 weight percent high yield hesperaloe pulp fibers.

13. The tissue product of claim 12 having a Burst Index greater than about 8.0.

14. The tissue product of claim 12 having a TEA Index greater than about 8.0.

15. The tissue product of claim 12 having a GM Slope less than about 6.0 kg.

16. The tissue product of claim 12 having a basis weight from about 30 to about 60 gsm and a sheet bulk from about 10 to about 15 cc/g.

17. The tissue product of claim 12 wherein the tissue product is substantially free from softwood kraft pulp fibers.

18. The tissue product of claim 12 wherein the high yield hesperaloe pulp fibers have a lignin content from about 10 to about 15 weight percent.

19. A single-ply through-air dried tissue product comprising at least about 20 weight percent high yield hesperaloe pulp fibers, the tissue product having a basis weight from about 30 to about 60 gsm, a sheet bulk greater than about 10 cc/g and a Stiffness Index less than about 10.

20. The single-ply through-air dried tissue product of claim 19 having a GM Slope less than about 6.0 kg.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/033168

A. CLASSIFICATION OF SUBJECT MATTER

A47K 10/16(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A47K 10/16; D21H 27/38; D21H 11/12; D21H 27/00; B65H 18/28; D21H 27/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: tissue, hesperaloe, geometric mean tensile, stiffness index, durability, basis weight, and bulk

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014-0284010 A1 (KIMBERLY-CLARK WORLDWIDE, INC.) 25 September 2014 See paragraphs [0014], [0020], [0022], [0027], [0077], [0081], [0089] and claims 1, 10-12.	1-20
Y	US 5320710 A (REEVES et al.) 14 June 1994 See column 2, lines 61-68; claims 1-2, 7 and figure 2.	1-20
A	US 2013-0199741 A1 (STAGE et al.) 08 August 2013 See paragraph [0030] and claims 1-2, 7-8, 11, 17.	1-20
A	US 2004-0140076 A1 (HERMANS et al.) 22 July 2004 See paragraphs [0063], [0164] and claims 1-2.	1-20
A	US 2013-0068868 A1 (HERMANS et al.) 21 March 2013 See claims 1-3, 10, 14.	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 February 2016 (26.02.2016)	**26 February 2016 (26.02.2016)**

Name and mailing address of the ISA/KR
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2015/033168

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2015/033168

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		WO 2013-041989 A3	13/06/2013

(19) 대한민국특허청(KR)
(12) 공개특허공보(A)

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전체 청구항 수 : 총 7 항

(54) 대나무 펄프로 제작된 화장지와 그 제조방법

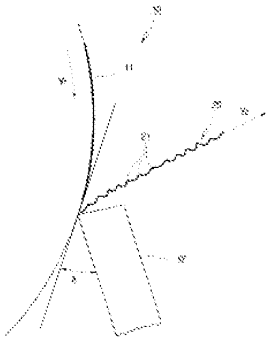
(57) 요 약

본 발명은 대나무 펄프를 이용하여 제조하는 화장지와 그 화장지 제조방법에 관한 것이다. 더욱 상세히 설명하자면, 섬유질이지만 섬유장이 긴 침엽수 펄프와 다소 단 섬유장인 활엽수를 혼합하지 않고 대나무 펄프만을 이용하여 질 좋고 부드러운 화장지를 제조할 수 있는 대나무 펄프로 제작된 화장지와 그 제조방법에 관한 것이다.

따라서 본 발명에 따라 대나무 펄프를 이용하여 화장지를 제조하게 되면, 침엽수와 활엽수 펄프를 서로 혼합할 필요가 없기에 화장지 제조비용이 절감된다.

또한 본 발명은 침엽수와 활엽수 펄프를 혼합하지 않아서, 그 제조비용이 적고, 첨가제의 투입량이 적어 공정이 간단하고, 활용가능성이 높다.

대 표 도 - 도2



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특허청구의 범위

청구항 1

화장지 제조방법에 있어서,

제1단계: 제작된 대나무 펄프를 해리시키고, 제진하며 고해시키는 단계와;

제2단계: 일반 화장지, 화장용 화장지, 냅킨용 화장지의 특성에 따라 첨가제를 투입하여 혼합하는 단계와;

제3단계: 정선기를 거치며 응집된 부분을 균일하게 분산시키는 정선의 단계와;

제4단계: 이동되는 망위에 상기 펄프를 펼쳐 물을 빼며 시트화시키는 초지공정의 단계와;

제5단계: 양키 건조기(10)를 이용하여 고온의 롤(11) 표면에서 건조시키며, 독터 블레이드(12)를 상기 롤(11)에 밀착시켜 화장지(20)에 잔주름(21)을 만들어 주는 건조의 공정과;

제6단계: 화장지의 두께를 일정하게 유지시키는 캘린더링, 인쇄와 엠보싱 및 절취선 작업의 공정과 재단과, 포장의 공정들을; 거치며 화장지를 제조하는 것을 특징으로 하는 대나무 펄프로 화장지를 생산하는 제조방법.

청구항 2

제1항에 있어서,

상기 2단계에서 일반 화장지의 첨가제는,

투입된 대나무 펄프의 중량에 비한 0.1-5 중량부의 습강제와, 0.1-5 중량부의 흡수제와, 0.01-2 중량부의 유연제와, 정착을 위해 투입되는 0.01-5 중량부의 보류제가 투입되는 것을 특징으로 하는 대나무 펄프로 제작된 화장지와 그 제조방법.

청구항 3

제1항에 있어서,

상기 2단계에서 화장용 화장지의 첨가제는,

투입된 대나무 펄프의 중량에 비한 0.1-5 중량부의 습강제와, 0.01-5 중량부의 건조강도 증강제와, 0.1-3 중량부의 흡수제와, 0.01-2 중량부의 유연제와, 정착을 위해 투입되는 0.01-5 중량부의 보류제가 투입되는 것을 특징으로 하는 대나무 펄프로 제작된 화장지와 그 제조방법.

청구항 4

제1항에 있어서,

상기 2단계에서 냅킨용 화장지의 첨가제는,

투입된 대나무 펄프의 중량에 비한 0.1-5 중량부의 습강제와, 0.01-6 중량부의 건조강도 증강제와, 0.1-2 중량부의 흡수제와, 0.01-2 중량부의 유연제와, 정착을 위해 투입되는 0.01-5 중량부의 보류제가 투입되는 것을 특징으로 하는 대나무 펄프로 제작된 화장지와 그 제조방법.

청구항 5

제1항에 있어서,

상기 제5단계의 고온의 롤(11)은,

30-150℃의 온도로 가온된 상태인 것을 특징으로 하는 대나무 펄프로 화장지를 생산하는 제조방법.

청구항 6

제1항에 있어서,

상기 제5단계의 독터 블레이드(12)는,

그 밀착 각도를 조절하여 화장지에 형성되는 잔주름(21)의 크기를 차별화시키는 것을 특징으로 하는 대나무 펄

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프로 화장지를 생산하는 제조방법.

청구항 7

펄프로 제작되는 화장지에 있어서,

상기 제1항 내지 제6항 중 어느 한 항의 제조방법을 통해 제작된 것을 특징으로 하는 대나무 펄프로 제작된 화장지.

명 세 서

발명의 상세한 설명

기 술 분 야

<1> 본 발명은 대나무 펄프를 이용하여 제조하는 화장지와 그 화장지 제조방법에 관한 것이다. 더욱 상세히 설명하자면, 섬유질이지만 섬유장이 긴 침엽수 펄프와 다소 단 섬유장인 활엽수를 혼합하지 않고 대나무 펄프만을 이용하여 질 좋고 부드러운 화장지를 제조할 수 있는 대나무 펄프로 제작된 화장지와 그 제조방법에 관한 것이다.

배 경 기 술

<2> 일반적으로 화장지는 그 부드러움을 유지하면서도 수분흡수율이 높고, 비록 물에 젖었다 할지라도 찢어지는 현상을 방지하기 위해서 섬유장이 긴 침엽수 펄프와 섬유장이 작은 활엽수를 혼합하여 제작하여야만 한다. 섬유장이 긴 침엽수가 화장지로 제작되었을 경우에 화장지가 쉽게 찢어지는 것을 막고, 섬유장이 작지만 부드러운 활엽수 펄프가 부드러움을 유지해야만 하기에 그러하다.

<3> 결국 화장지라는 용도 특성상 일반 인쇄필기용지로 사용되는 백상지뿐만 아니라 산업용지와는 매우 다른 성질이 요구되었었다. 종이 제조에 들어가는 원료의 펄프의 처리뿐만 아니라 사용되는 첨가제의 종류 및 양에 있어서도 큰 차이를 나타낸다. 화장지는 보통 두루마리 화장지, 미용화장지, 냅킨, 키친타월, 화장실용 종이타월 등으로 나누어지며, 산업용으로 기계 또는 기계부품을 닦기 위한 수단으로 사용되는 와이프도 포함될 수 있다. 두루마리 화장지의 경우는 부드러운 성질과 흡수성, 그리고 물 풀림성이 매우 중요하다. 미용화장지의 경우에는 부드러운 성질과 흡수성이 좋아야 하지만 두루마리 화장지보다 물에 대한 저항성이 높아야 한다. 냅킨, 키친타월, 화장실용 종이타월 등은 기타 화장지보다 흡수성은 양호하되 물에 대한 높은 저항성을 필요로 한다. 와이프는 대개 부직포 형태로 만들어지며 매우 높은 습강도를 필요로 한다.

<4> 제조 공정 측면에서 보면 비록 일부 다른 단위 공정이 포함되기는 하지만 대부분의 공정이 다른 제지공정과 매우 유사하다. 하지만 그 중의 일부 공정은 동일한 공정이 적용된다고 하더라도 다른 조건을 적용해야 화장지에 요구되는 특성들을 만족시켜 줄 수 있다.

발명의 내용

해결 하고자하는 과제

<5> 본 발명은 대나무 펄프를 이용하여 제조하는 화장지와 그 화장지 제조방법에 관한 것으로, 비록 섬유질이지만 섬유장이 긴 침엽수 펄프와 다소 단 섬유장인 활엽수를 혼합하지 않고 대나무 펄프만을 이용하여 질 좋고 부드러운 화장지를 제조할 수 있는 대나무 펄프로 제작된 화장지와 그 제조방법을 제공하고자 한다.

<6>

과제 해결수단

<7> 본 발명은 화장지 제조방법에 있어서, 제1단계: 제작된 대나무 펄프를 해리시키고, 제진하며 고해시키는 단계와; 제2단계: 일반 화장지, 화장용 화장지, 냅킨용 화장지의 특성에 따라 첨가제를 투입하여 혼합하는 단계와; 제3단계: 정선기를 거치며 응집된 부분을 균일하게 분산시키는 정선의 단계와; 제4단계: 이동되는 망위에 상기 펄프를 펼쳐 물을 빼며 시트화시키는 초지공정의 계와; 제5단계: 양키 건조기(10)를 이용하여 고온의 롤(11) 표면에서 건조시키며, 독터 블레이드(12)를 상기 롤(11)에 밀착시켜 화장지(20)에 잔주름(21)을 만들어 주는 건조의 공정과; 제6단계: 화장지의 두께를 일정하게 유지시키는 캘린더링, 인쇄와 엠보싱 및 절취선 작업의 공

정과 재단과, 포장의 공정들을; 거치며 화장지를 제조하는 대나무 펄프로 화장지를 생산하는 제조방법이다.

<8> 본 발명에 따라 상기 2단계의 일반 화장지의 첨가제는, 투입된 대나무 펄프의 중량에 비한 0.1-5 중량부의 습강제와, 0.1-5 중량부의 흡수제와, 0.01-2 중량부의 유연제와, 정착을 위해 투입되는 0.01-5 중량부의 보류제가 투입되고; 화장용 화장지의 첨가제는, 투입된 대나무 펄프의 중량에 비한 0.1-5 중량부의 습강제와, 0.01-5 중량부의 건조강도 증강제와, 0.1-3 중량부의 흡수제와, 0.01-2 중량부의 유연제와, 정착을 위해 투입되는 0.01-5 중량부의 보류제가 투입되며; 냅킨용 화장지의 첨가제는, 투입된 대나무 펄프의 중량에 비한 0.1-5 중량부의 습강제와, 0.01-6 중량부의 건조강도 증강제와, 0.1-2 중량부의 흡수제와, 0.01-2 중량부의 유연제와, 정착을 위해 투입되는 0.01-5 중량부의 보류제가 투입되고; 상기 제5단계의 고온의 롤(11)은, 30-150℃의 온도로 가온된 상태이며; 상기 제5단계의 독터 블레이드(12)는, 그 밀착 각도를 조절하여 화장지에 형성되는 잔주름(21)의 크기를 차별화시키는 대나무 펄프로 화장지를 생산하는 제조방법이다.

<9> 또한 본 발명은 펄프로 제작되는 화장지에 있어서, 전술된 상기 모든 기술적 사항을 통한 제조방법을 통해 제작된 대나무 펄프로 제작된 화장지이다.

효 과

<10> 본 발명에 따라 대나무 펄프를 이용하여 화장지를 제조하게 되면, 침엽수와 활엽수 펄프를 서로 혼합할 필요가 없기에 화장지 제조비용이 절감된다.

<11> 또한 본 발명은 침엽수와 활엽수 펄프를 혼합하지 않아서, 그 제조비용이 적고, 첨가제의 투입량이 적어 공정이 간단하고, 활용가능성이 높다.

발명의 실시를 위한 구체적인 내용

<12> 본 발명은 화장지 제조방법에 있어서, 제1단계: 제작된 대나무 펄프를 해리시키고, 제진하며 고해시키는 단계를 거친다. 즉, 일반적인 대나무를 통해서 제조된 대나무 펄프를 이용하여 펄프를 해리(Disintegration, repulping)하고, 제진(Cleaning)하며 고해(refining)하는 단계를 거치는데, 이때 사용되는 대나무 펄프는 본 발명의 출원인이 대한민국 특허청에 그 특허등록을 받은 등록 제10-547491호와 10-547492호의 제조방법을 통해서 제조된 대나무 펄프를 사용함이 가장 바람직하다. 본 발명의 대나무 펄프는 해리의 과정에서 펄퍼(PULPER)를 이용하여 시트상으로 제공된 펄프를 섬유 상태로 해리시키는 것이다. 이 해리란 풀어 헤치는 공정으로 펄프를 가공하는 데에는 없어서는 안되는 공정이다. 또한 이렇게 해리된 대나무 펄프는 제진과 고해의 과정을 거치는데, 제진의 공정에서 제진기를 통해 이물질과 불순물을 제거하는 것이다. 사실상 목재 등을 통해서 섬유질을 생산하는 펄프 제조공정을 통해, 이미 불순물이 말끔히 제거된 상태이지만, 오랜 저장기간이나 운송이나 운반의 과정속에서 포함될 수 있는 불순물을 바로 이 제진기가 제거하는 것이다. 여기서 본 발명에서는 특별히 물의 첨가량을 한정하고 있지 않다. 이는 펄프를 가공하는 과정에서는 어떠한 상품을 제조하기 위해서도 반드시 투입되는 것이 물이기도 하지만, 설치된 화장지 제조장치나 시스템에 따라서 그 투입량을 달리하기에 그러하다.

<13> 물론 상기 고해의 공정은 refining 이라고도 칭하는데, 펄프 자체로는 섬유간 결합이 매우 약하기 때문에 펄프의 섬유화(fibrillation)를 일으키는 공정이다. 이 공정은 펄프를 잘게 갈아주는 공정을 말하는 것으로, 덩어리화된 펄프도 갈아주고, 일정한 형태가 모두 풀어주어 갈아주는 것이다.

<14> 다음으로 본 발명은 제2단계: 일반 화장지, 화장용 화장지, 냅킨용 화장지의 특성에 따라 첨가제(Addition of additives)를 투입하여 혼합하는 단계를 거친다. 사실상 화장지라고 하는 것은 그 사용의 형태인 용도에 따라 다양한 형태로 제작이 가능하다. 즉, 일반 화장지, 화장을 위해 사용되는 화장용 화장지, 냅킨용 화장지 등이 있고, 이를 더욱 발전시켜서 제작할 수 있는 것이 바로 타올과 부직포의 종류도 크게 봐서는 화장지의 일종일 것이다. 즉, 모두 섬유질을 갖춘 펄프로 제작을 완성하는 것이다. 본 발명에서는 이러한 많은 제조품 중에서 상기 일반화장지, 화장용 화장지, 냅킨용 화장지만을 특정하여 제조하는데, 이들도 역시 그 특성이 있기에 제조하는 방식에 차이가 있다. 특별한 공정상의 차이점은 보이지 않으나 그 투입되는 첨가물과 약간의 조건에서 차이가 있는 것이다. 본 발명과 같은 각종의 화장지 제조방법에서는 이렇게 고해된 펄프에 첨가제를 투입함으로 차별이 나는 화장지들을 선별해서 제조할 수가 있다.

<15> 다음으로 제3단계: 정선기를 거치며 응집된 부분을 균일하게 분산시키는 정선(Screening)의 단계를 거친다. 즉, 펄프에 첨가제가 투입되고 나면, 정선기를 통해서 응집된 부분을 균일하게 분산시키는 것이다. 상기 2단계를 거치며 첨가제가 펄프에 투입되고 나면, 응집되는 부분이 발생된다. 첨가제가 용이하게 혼합되어 화합을 이

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루어지는 것이 바람직하나, 그 상황에 따라서 첨가제가 일부 펄프와 응집되어 그 분포됨에 있어서 균일함을 유지하지 못하는 현상이 발생되는 것이다. 이때에는 덩어리진 응집물이 이곳저곳에서 생성되는데, 이를 고루게 펼치고 분쇄시켜서 첨가제가 고루 풀리게 유도하는 공정이 바로 이 정선(Screening)의 공정인 것이다.

<16> 다음으로 제4단계: 이동되는 망위에 상기 펄프를 펼쳐 물을 빼며 시트화시키는 초지공정(sheet forming)의 단계를 거친다. 이렇게 정선의 과정을 거친 펄프는 화장지를 직접 생산하기 위해서 시트화된 형태로 제작을 해야만 한다. 이 시트화 형태를 위해서는 넓은 표면적을 가진 공간에 펄프를 일정량씩 펼치는 공정이 필요한데, 정선된 펄프의 경우 다량의 수분을 함유하고 있어 이러한 작업이 어렵다. 따라서 수분이 다량 포함된 펄프를 망위에 고르게 펼치는 작업을 수행하게 된다. 바로 이러한 작업이 초지공정의 단계이다. 이때 사용되는 망의 하단으로는 다량의 수분이 빠지고, 고르게 펼쳐지게 된다. 이때 망을 하나로 설치되는 방식이 있고, 2개가 설치되는 방식이 사용가능한데, 이는 공지된 사항이기에 선택적으로 사용이 가능하다.

<17> 다음으로 제5단계: 양키 건조기(10)를 이용하여 고온의 롤(11) 표면에서 건조시키며, 독터 블레이드(12)를 상기 롤(11)에 밀착시켜 화장지(20)에 잔주름(21)을 만들어 주는 건조(Drying)의 공정이 진행된다. 즉, 도시된 양키건조기로 상기 펄프를 이송시키고, 이를 건조(Drying)시키는 것이다. 이때 사용되는 방식이 고온의 롤의 외부에 펄프를 감아 그 고온을 이용하여 펄프를 건조시키는 방식이다. 이미 시트의 형태로 곱게 펼쳐진 펄프를 양키건조기의 롤의 표면으로 감아 회전시키게 되면, 상기 롤은 이미 고온으로 상승된 상태이기에 축축히 젖어 있던 펄프를 건조시키게 된다. 물론 이 양키 건조기의 롤 일측에는 도시된 것처럼 독터 브레이드가 밀착된 상태를 유지하고 있다. 밀착된 롤에는 펄프가 부착되어 회전하고 있는 상태이며, 상기 브레이드는 상기 펄프를 밀어주는 방향으로 부착되어 있는 것이다. 따라서 상기 브레이드에 부딪친 상기 펄프는 벗겨지는 과정을 거치는 것이다. 이때 상기 펄프의 경우 건조되어 그 롤에 밀착된 상태이기에 상기 독터 브레이드의 미는 작용에 따라 자연스럽게 잔주름을 형성하게 되는데, 이 잔주름이 후일 화장지로 변화된 상태에서 부드러움을 간직할 수 있게 하는 여건을 마련한다. 이때 형성시키는 잔주름의 크기는 상기 브레이드와 롤의 각도를 통해서 얼마든지 변경이 가능한데, 도시된 도면에서 독터 브레이드(docter blade)와 롤의 밀착도 즉, 그 각도인 A가 크면 클수록 밀착된 상태를 유지하기에 그 잔주름(Creping)의 크기도 작게 형성된다. 물론 이와는 반대로 상기 각도의 크기를 작게하면 그 잔주름의 크기를 키우는 것이다. 여기서 부드러운 성질이 중요시되는 두루마리 화장지나 미용화장지의 경우에는 dry creping을 하며, 냅킨 등은 wet creping을 실시한다.

<18> 다음으로 제6단계: 화장지의 두께를 일정하게 유지시키는 캘린더링, 인쇄와 엠보싱(Embossing) 및 절취선 작업의 공정과 재단과, 포장의 공정들을 거치며 본 발명의 화장지는 완성이 된다. 즉, 잔주름이 형성된 상태에서 일측으로 배출된 사실상 펄프가 아닌 화장지는 그 특성에 따라 캘린더링 공정을 거치는 것이다. 이 캘린더링 공정은 일반적인 제지의 공정에서 사용되는 공정으로 종이와 화장지 등의 판지의 두께를 균일하게 유지시키기 위한 공정을 말하는 것이다. 그러나 본 발명은 화장지 제조공정이다. 종래 지류의 제조방법에서 사용되는 것처럼 이 캘린더링 공정을 무리하게 할 필요가 없다. 그 표면의 평활도를 높이기 위한 작업을 주력해서 시도할 것이 아니기 때문이다. 화장지의 경우 그 인쇄도를 높힐 필요가 없고, 그 특성상 수분의 흡착력이 높기에 많은 량의 염료를 사용한 인쇄는 번지는 효과를 가져올 소지가 많다. 따라서 본 발명의 캘린더링(Calendering) 공정은 부드럽고, 2겹 3겹으로 겹칠 수 있게 하기 위해 얇게 하는 캘린더링(Calendering) 공정이 더욱 부가되어야만 한다. 물론 이를 위해서 투입되는 펄프의 량을 최소화시키고, 상부에서 하부로 밀착시키는 공정은 적게한다. 2개의 롤 사이를 통과시키며 그 표면을 압착하여 평활도를 높이는 공정을 수행하는 것을 자제하고, 투입량의 비를 조절함으로 두께를 적게하는 것이다. 이때 롤을 사용한 두께 축소의 캘린더링 공정이 사용가능한데, 이때의 롤은 그 표면이 거친 롤을 사용하여 평활도 보다는 두께 조절용으로 사용되어야 한다.

<19> 그렇다면 본 발명에서 사용되는 상기 2단계에서 일반 화장지의 첨가제를 의 구성과 그 특성을 살펴본다.

<20> 즉, 본 발명은 전술된 것처럼 일반 화장지와 화장용 화장지 및 냅킨용 화장지가 생산될 수 있다. 이들의 첨가제(Addition of additives)는 모두 일부는 공통되고 일부는 다를 소지가 있는데, 특히 그 투입되는 투입량의 조건이 상이하다. 그 용도에 맞는 재질로 변화시켜야만 하기에 그러하다. 따라서 이들을 설명함에 있어서 상기의 순서에 따라 상세히 설명한다.

<21> 먼저 일반 화장지의 경우, 투입된 대나무 펄프의 중량에 비한 0.1-5 중량부의 습강제와, 0.1-5 중량부의 흡수제와, 0.01-2 중량부의 유연제와, 정착을 위해 투입되는 0.01-5 중량부의 보류제가 투입되는 것이 바람직하다. 상기 습강제는 영구적인 습강제(폴리아미드폴리아민 에피클로로하이드린: polyamidepolyamine epichlorohydrin)와 일시적이 습강제가 사용이 가능한데, 영구적인 습강제로는 PAE(polyamidepolyamine epichlorohydrin) 수지가 사용되며, 일시적인 습강제로는 dialdehyde starch, glyoxal 등이 사용된다. 이들 습

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강제는 자체적으로 화학적인 가교결합을 형성하며, 일부는 섬유와도 결합을 형성한다. 이들이 습강제로서 작용하는 기작(mechanism)은 가교결합한 수지(cross-linked resin)가 섬유간 결합부위(fiber bonding site)를 도포하여 줌으로써 소수성 표면(hydrophobic surface)을 형성하는 것이다. 즉, 이러한 습강제를 화장지에 침투시킴으로서 습도에 강한 내구성을 발휘하게 된다. 일부 화장지의 경우 투입되는 습강제의 미비로 인하여 수분에 의해 쉽게 찢어지거나 흐트러질 우려가 있는데, 이 습강제를 투입함으로 찢어지는 현상을 방지시킨다. 물론 상기 습강제의 경우 일반적인 화장지에 투입되는 양이 가장 적을 소지가 있고, 냅킨 화장지에 투입되는 습강제가 가장 많을 소지가 있지만 이는 펄프의 재질의 특성에 따라서 차이가 있다. 본 발명에서는 상기 투입량을 유지시키는 것이 가장 질 좋은 각종의 화장지를 생산할 수 있었기에 이 투입비율을 준수한다.

<22> 다음으로 사용되는 첨가물(Addition of additives)은 0.1-5 중량부의 흡수제이다. 흡수제는 특히 흡수성이 요구되는 경우에 사용되는데, 주로 계면활성제를 이용하여 종이의 소수성 부위를 덮어줌으로써 친수성 부위를 늘리는 원리가 적용되며, 계면활성제의 사용은 수분 흡수를 증가시킬 수 있는 반면 섬유간 결합을 저해하기 때문에 벌크를 증가시켜주고, 총 흡수량도 증가시켜주는 결과를 얻을 수 있다. 본 발명에서는 일반적인 화장지에 그 흡수제의 투입량이 가장 높고, 다음으로 화장용 화장지, 냅킨용 화장지의 순서로 이루어진다. 일반적인 화장지의 흡수량이 가장 높게 필요하게 때문이다. 나아가 상기 기재된 내용 중에 벌크라는 용어가 있는데, 이 벌크란 섬유처럼 부풀어 오르는 성질을 높여준 것이다. 이 벌크성이 높다면 수분과 접촉되는 그 표면적을 크게 하기에 흡수력이 높아야만하는 일반 화장지는 이 벌크성을 가장 크게 한다.

<23> 다음의 구성물은 유연제이다. 유연제로는 quaternary imidazolines(쿼터 이미디졸린) 또는 dialkyldimethyl quaternary amine(디알킬디메틸 쿼터 아민)이 주로 사용하며, glycol도 사용될 수 있다. 유연제는 섬유 사이에 반류해 있는 물분자의 표면장력을 감소시켜주며, 물이 증발됨에 따라 얻어지는 결합 면적이 감소되어 섬유간 결합을 감소시키기 때문에 보다 벌크하고 강도가 떨어지지만 부드러운 촉감이 현저히 개선되는 효과를 얻을 수 있다. 또한 이들 유연제가 지니고 있는 알킬기는 기름같이 매끄러운 촉감을 주어 벌키하면서도 부드러운 감을 제공해준다.

<24> 사실상 본 발명에서는 그 특허청구범위를 작성함에 있어서 이 염료의 투입을 기재하지 않고 있다. 이유는 대부분 하얀색의 염료를 투입하기도 하지만, 타 색상의 염료를 투입하는 경우가 있기 때문이다. 물론 펄프의 표백과정을 완벽하게 거친 화장지의 경우 염료를 전혀 투입하지 않는 경우도 있다. 또한 그 나타내기 위한 색상과 그 색도에 따라서 염료의 종류와 량은 얼마든지 변동가능하기 때문이다. 또한 화장지와 타월의 경우 직접염료(direct dyes)와 양이온성 직접염료(cationic direct dyes)가 일반적으로 사용된다.

<25> 투입되는 마지막 구성요소로는 보류제가 사용되는데, 약 0.01-5 중량부의 보류제가 투입된다. 화장지 제조 시 사용되는 대부분의 첨가제들은 자체적으로 섬유와 결합하는 능력이 없기 때문에 보류제의 사용을 필요로 한다. 보류 시스템은 single polymer, dual polyner 및 micro particle system으로 나누어진다. 보류제로서 저분자량 고전하 밀도 양이온성 고분자인 알람(alum), PAC는 지료에 패치를 형성하여 보류를 개선하기 위한 목적으로 사용된다. 고분자량 고분자는 콜로이드 성분 또는 미세분 사이의 브리지 기작(bridging mechanism)을 통하여 응집시키고 이들이 섬유에 부착되도록 해준다. 이 경우 일반적인 전단력에는 잘 견딜 수 있으나 펄프에서 발생되는 높은 전단력에 대하여 견디지 못한다. 따라서 고분자량과 저분자량 고분자를 함께 사용하면 이러한 문제의 해결이 가능하다. 벤토나이트, 실리카, 유기 마이크로 파티클 등을 이용하는 마이크로 파티클도 사용이 가능하기는 하지만 화장지의 경우 가격이 비싸기 때문에 잘 사용되지 않는다. 보류제 사용 시 주의해야 할 사항은 양호한 지필도(formation)를 얻을 수 있도록 하는 것이며, 일과 보류도(first pass retention)가 높을 경우 일반적으로 지필도가 악화된다는 사실을 기억해야 한다. 보류제로 사용되는 합성 양이온성 고분자로는 polyacrylamide(폴리아크릴아마이드), polyDadMac(폴리데드막: polydiallyldimethylammonium chloride), polyamines(폴리아민) 및 polyethylenimine(폴리에틸렌아민) 등이 있다.

<26> 그리고 이때 pH 조절은 반드시 필요하나, 청구범위에 생략한 이유는 너무나 당연한 것이고, 그 조절의 범위 역시 갖추어진 화장지 제조장치나 시스템에 따라 변수가 많아 특정하기 힘들었다. 이 pH 조절은 타월 및 화장지 제조 시 화학 첨가제들의 효율을 최적화하기 위한 수단으로 사용된다. 예를 들면 PAE 습강제의 경우에는 pH 7.0-8.0에서 가장 좋은 효율을 나타낸다. 또한 양키 건조기 도포제도 지료와 접착/탈착용 오링 스프레이의 pH의 영향을 받을 수 있다. pH의 조절 방법은 유입되는 pH의 산도에 따라 달라진다. 일반적으로 사용하는 산으로는 황산(sulfuric acid), 알람(alum) 또는 탄산(CO_2)이 있다. 염기로는 가성소오다(소디움 하이드록사이드: sodium hydroxide), 액상 소다회(liquid soda ash)가 사용된다.

<27> 상기의 일반적인 화장지와는 달리 상기 2단계에서 화장용 화장지의 첨가제는, 투입된 대나무 펄프의 중량에 비

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한 0.1-5 중량부의 습강제와, 0.01-5 중량부의 건조강도 증강제(dry strength agent)와, 0.1-3 중량부의 흡수제와, 0.01-2 중량부의 유연제와, 정착을 위해 투입되는 0.01-5 중량부의 보류제가 투입된다. 그리고 냅킨용 화장지의 첨가제는, 투입된 대나무 펄프의 중량에 비한 0.1-5 중량부의 습강제와, 0.01-6 중량부의 건조강도 증강제와, 0.1-2 중량부의 흡수제와, 0.01-2 중량부의 유연제와, 정착을 위해 투입되는 0.01-5 중량부의 보류제가 투입된다.

<28> 이 투입 구성요소와 그 투입량은 전술된 일반적인 화장지와 다소 차이가 있다. 이들은 모두 각각의 제조되는 화장지의 용도에 따라 차별화 둔 것이다. 아무튼 전술된 일반적인 화장지 제조방법에서 투입되는 구성요소의 전부는 화장용 화장지와 냅킨용 화장지에도 모두 투입된다. 단 상기 화장용 화장지와 냅킨용 화장지에만 투입되는 구성요소가 하나 더 있는데, 이 구성요소가 바로 건조 강도 증강제이다.

<29> 즉, 일반 화장지나 타월의 경우에는 고해(refining)만으로도 충분한 강도를 얻을 수 있기 때문에 건조강도 증강제를 필요로 하지 않는다. 그러나 가끔 벌크(bulk)를 유지하기 위하여 고해를 하지 않을 경우에는 강도 개선을 위하여 사용한다. 건조강도 증강제로는 양이온성 전분(cationic starch), CMC(카부시메틸: carboxymethyl cellulose), polyacrylamide(폴리아크릴아마이드), guar gum(구아검) 등이 사용된다.

<30> 한편 본 발명에서 사용되는 상기 양키 건조기에서 롤이 특별한 온도를 유지하면 건조시켜야만 하는데, 상기 제5단계의 고온의 롤(11)은, 30-150℃의 온도이다. 이 온도를 유지함이 건조의 속도와 그 수분의 포함비율에 적당하고, 제조되는 생산량을 적절히 유지시킬 수 있다.

<31> 또한 상기 제5단계의 독터 블레이드(12)는, 그 밀착 각도를 조절하여 화장지에 형성되는 잔주름(21)의 크기를 차별화시키는 것이 바람직한데, 이에 대한 설명은 이미 한 상태이기에 여기서는 생략한다.

<32> 본 발명은 대나무 펄프를 이용하여 제작하는 화장지에만 그 특징이 있는 것이 아니다. 그 제조방법을 통해서 제조된 화장지에도 특징이 있다. 다시 말해서 펄프로 제작되는 화장지에 있어서, 전술된 모든 제조방법을 통해 제작된 대나무 펄프로 제작된 화장지에도 큰 특징이 있는 것이다.

도면의 간단한 설명

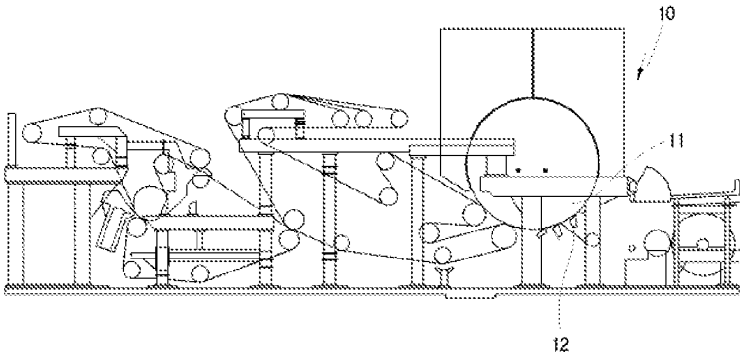
<33> 도 1은 본 발명의 화장지를 생산하는 시스템을 전체 도시한 도면,

<34> 도 2는 본 발명의 양키 건조기를 도시한 측면도이다.

<35> **<도시된 도면의 주요 부호에 대한 간단한 설명>**

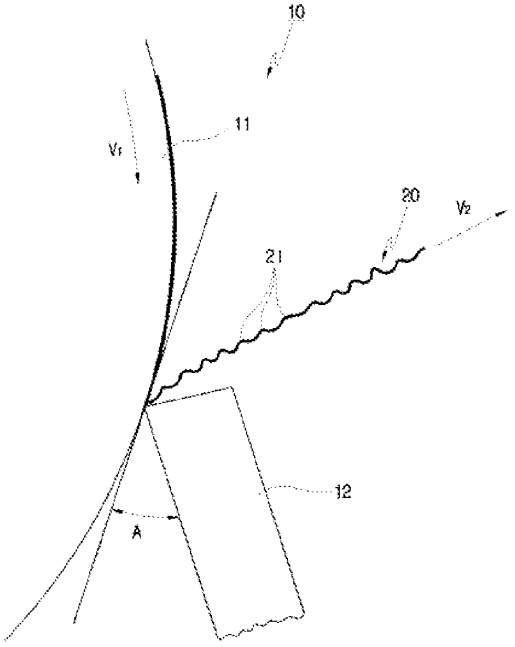
도면

도면1



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도면2



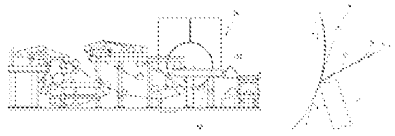
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The product method and tissue from bamboo pulp

Abstract

A tissue made of bamboo pump and a manufacturing method thereof are provided to reduce manufacturing cost and offer a simple process without mixing pulp of needle-leaf tree and pulp of a broadleaf tree. A method for manufacturing a tissue comprises the following steps of: dissociating, dusting, and beating bamboo pulp; mixing the pump with an additive according to property of the tissue; dispersing the cohered pulp uniformly; making the pulp with a sheet shape on a moving net after flowing out water; drying the pulp on a roll(11) with high temperature by using a drier(10); making fine wrinkles(21) on the tissue(20) after adhering a doctor blade(12) on the roll; and performing a calendaring, printing, embossing, cutting, wrapping processes.

Images (2)



Classifications

- A47K10/16 Paper towels; Toilet paper; Holders therefor

View 4 more classifications

KR20090036284A

South Korea

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Other languages: Korean

Inventor: 이경학

Worldwide applications

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Application KR1020070101369A events

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External links: Espacenet, Global Dossier, Discuss

Claims (7)

Hide Dependent ⌄

translated from Korean

In the toilet paper manufacturing method, First step: dissociating, dumping and beating the manufactured bamboo pulp, A second step: adding and mixing additives according to the characteristics of the general toilet paper, the toilet paper, and the napkin toilet paper; The third step: the step of the line to uniformly distribute the aggregated portion through the selector; A fourth step: a step of papermaking process of spreading the pulp on the moving network to draw water; The fifth step is drying using the Yankee dryer 10 to dry on the surface of the hot roll 11, and the doctor blade 12 is adhered to the roll 11 to make fine wrinkles 21 on the toilet paper 20. Process of; Step 6: calendaring, printing, embossing, and perforating to keep the thickness of the toilet paper constant; Process for producing toilet paper with bamboo pulp, characterized in that the manufacturing of toilet paper through. The method of claim 1, In the second step, the additive of the general toilet paper, 0.1-5 parts by weight of the humectant, 0.1-5 parts by weight of the absorbent, 0.01-2 parts by weight of the softener, and 0.01-5 parts by weight of the retention agent introduced for fixing are added to the weight of the bamboo pulp added. Toilet paper made from bamboo pulp and its manufacturing method. The method of claim 1, The additive of the toilet paper in the second step, 0.1-5 parts by weight of the humectant, 0.01-5 parts by weight of the dry strength enhancer, 0.1-3 parts by weight of the absorbent, 0.01-2 parts by weight of the softener, 0.01-5 parts by weight of the bamboo pulp Toilet paper made of bamboo pulp, characterized in that the weight part of the retention agent is added and its manufacturing method. The method of claim 1, In the second step, the additive of the toilet paper for napkin, 0.1-5 parts by weight of humectant, 0.01-5 parts by weight of dry strength enhancer, 0.1-2 parts by weight of absorbent, 0.01-2 parts by weight of softener, and 0.01-5 parts that are added for fixing Toilet paper made of bamboo pulp, characterized in that the weight part of the retention agent is added and its manufacturing method. The method of claim 1, The high temperature roll 11 of the fifth step, A method for producing toilet paper with bamboo pulp, characterized in that the heated state at a temperature of 30-150 ℃. The method of claim 1, The doctor blade 12 of the fifth step, The method of producing toilet paper with bamboo pulp, characterized in that to differentiate the size of the fine wrinkles (21) formed on the toilet paper by adjusting the adhesion angle. In the toilet paper made of pulp, Toilet paper made of bamboo pulp, characterized in that produced through the manufacturing method of any one of claims 1 to 6.

Description

translated from Korean

Toilet paper made of bamboo pulp and its manufacturing method (The product method and tissue from bamboo pulp)

The present invention relates to a toilet paper produced using bamboo pulp and a method of manufacturing the toilet paper. More specifically, the present invention relates to a toilet paper made of bamboo pulp and a method of manufacturing the same, which can produce fine and soft toilet paper using only bamboo pulp without mixing fibrous but fibrous long softwood pulp and rather short fiber hardwood

In general, toilet paper has a high water absorption while maintaining its softness, and even if it is wet, it must be manufactured by mixing coniferous pulp with a long fiber and hardwood with a small fiber to prevent tearing. This is because a long-fiber conifer should prevent the toilet paper from being easily torn when made of toilet paper, and a soft, hard-leaf pulp with a small fiber length should remain soft.

After all, due to the nature of the use of toilet paper, not only white paper used for general printing paper but also very different from industrial paper was required. A large difference is shown not only in the treatment of pulp of raw materials for paper production but also in the type and amount of additives used. Toilet paper is generally divided into rolled toilet paper, cosmetic toilet paper, napkins, kitchen towels, toilet paper towels, and the like, and may include wipes used as a means for wiping machines or machine parts for industrial use. In the case of rolled toilet paper, softness, water absorption and water release are very important. Cosmetics should have good softness and absorbency, but should be more water resistant than roll toilet paper. Napkins, kitchen towels and toilet paper towels are more absorbent than other toilet papers but require a higher resistance to water. Wipes are usually made in the form of nonwovens and require very high wet strength.

In terms of manufacturing process, although some other unit processes are involved, most of the processes are very similar to other papermaking processes. However, some of the processes may satisfy the characteristics required for the toilet paper even if the same process is applied to different conditions.

The present invention relates to a toilet paper manufactured using bamboo pulp and a method for manufacturing the toilet paper, although a fibrous but fibrous, long-fiber coniferous pulp and rather short-fiber hardwoods are not mixed with bamboo pulp to produce good and soft toilet paper. To provide a toilet paper made of bamboo pulp and a method of manufacturing the same.

The present invention relates to a method for manufacturing toilet paper, the first step: dissociating, damping and beating manufactured bamboo pulp; A second step: adding and mixing additives according to the characteristics of the general toilet paper, the toilet paper, and the napkin toilet paper; The third step: the step of the line to uniformly distribute the aggregated portion through the selector; A fourth step: a paper making system for spreading the pulp on the moving network to draw water and sheeting the paper; The fifth step is drying using the Yankee dryer 10 to dry on the surface of the hot roll 11, and the doctor blade 12 is adhered to the roll 11 to make fine wrinkles 21 on the toilet paper 20. Process of; Step 6: calendering, printing, embossing, and perforating to keep the thickness of the toilet paper constant, it is a manufacturing method for producing toilet paper with bamboo pulp for making toilet paper.

According to the present invention, the additive of the general toilet paper of the second stage is 0.1-5 parts by weight of the humectant, 0.1-5 parts by weight of the absorbent, 0.01-2 parts by weight of the softener, and added for fixing, relative to the weight of the bamboo pulp added. 0.01-5 parts by weight of a preservative is added; The additive of the cosmetic toilet paper is 0.1-5 parts by weight of the humectant, 0.01-5 parts by weight of the dry strength enhancer, 0.1-3 parts by weight of the absorbent, 0.01-2 parts by weight of the softener relative to the weight of the bamboo pulp added, 0.01-5 parts by weight of retentive agent is added for treatment; The additives of the toilet paper for napkin are 0.1-5 parts by weight of the wet humectant, 0.01-5 parts by weight of the dry strength enhancer, 0.1-2 parts by weight of the absorbent, 0.01-2 parts by weight of the softener, and fixation, relative to the weight of the bamboo pulp added. 0.01-5 parts by weight of retentive agent added for the purpose of injection; The high temperature roll 11 of the fifth step is warmed to a temperature of 30-150 ° C .; The doctor blade 12 of the fifth step is a manufacturing method for producing toilet paper with bamboo pulp to differentiate the size of the fine wrinkles 21 formed on the toilet paper by adjusting the adhesion angle.

In another aspect, the present invention is a toilet paper made of a pulp made of bamboo pulp produced by the manufacturing method through all the above-described technical details in the toilet paper made of pulp.

When toilet paper is manufactured using bamboo pulp according to the present invention, the cost of manufacturing toilet paper is reduced because it is not necessary to mix coniferous and hardwood pulp.

In addition, the present invention does not mix coniferous and hardwood pulp, the production cost is low, the amount of additives is small, the process is simple, and the utilization is high.

The present invention is a method for manufacturing toilet paper, the first step: dissociating, damping and beating the produced bamboo pulp. That is, the process of dissolving (pulling), dedusting (cleaning) and refining the pulp by using the bamboo pulp produced through the common bamboo, wherein the bamboo pulp used is the applicant of the present invention it is most preferable to use bamboo pulp produced through the manufacturing methods of the registered patent Nos. 10-547491 and 10-547492, which are registered with the Patent Office. Bamboo pulp of the present invention is to dissociate the pulp provided in the sheet form into a fiber state using a PULPER in the process of dissociation. This dissociation is an indispensable process in which pulp is processed. In addition, the dissociated bamboo pulp is subjected to the process of dust removal and confession, which removes foreign substances and impurities through the vibration damper in the dust removal process. In fact, the pulp manufacturing process, which produces fiber through wood, has already eliminated impurities, but it removes impurities that may be included during long periods of storage or during transportation or transportation. In the present invention, the addition amount of water is not particularly limited. In the process of processing pulp, water is necessarily added to produce any product, but the amount is different depending on the toilet paper manufacturing apparatus or system installed.

Of course, the process of beating is also referred to as refining, which is a process of causing fibrillation of pulp because the bond between fibers is very weak in the pulp itself. This process refers to the process of grinding the pulp finely, and also to agglomerated pulp and to loosen all of a certain form.

Next, according to the present invention, a second step: general toilet paper, cosmetic toilet paper, and napkins are added and mixed according to the characteristics of the toilet paper. In fact, toilet paper can be produced in various forms depending on the purpose of use. In other words, there is a general toilet paper, a toilet paper used for makeup, a toilet paper for napkins, etc., which can be further developed by producing a kind of towels and non-woven fabrics will be a kind of toilet paper. In other words, all of them are made of pulp with fiber. In the present invention, the general toilet paper, cosmetic toilet paper, napkin only toilet paper is made of many of these manufactured products, and these also have the characteristics, so there is a difference in the manufacturing method. There are no particular process differences, but some differences with the additives added. Various toilet paper manufacturing methods such as the present invention can be produced by selecting the toilet paper is discriminated by adding an additive to the pulp so beaten.

Next, the third step: the screening step of uniformly dispersing the aggregated portion through the screening machine. That is, after the additive is added to the pulp, the aggregated portion is uniformly dispersed through the selector. After the additive is added to the pulp through the two steps, a flocculated part is generated. It is preferable that the additives are easily mixed to form a compound, but depending on the situation, a phenomenon occurs in which the additive does not maintain uniformity due to aggregation and distribution of some pulp. At this time, agglomerated aggregates are produced here and there, and the process of unfolding and pulverizing them to induce the unevenness of additives is the process of screening.

Next, a fourth step: a sheet forming process is performed by spreading the pulp on the moving network to remove water and sheeting the pulp. The pulp, which has been selected in this way, must be manufactured in sheeted form to directly produce toilet paper. This sheeting form requires a process of spreading pulp by a certain amount in a space having a large surface area, and the selected pulp contains a large amount of water, which is difficult. Therefore, the pulp containing a large amount of water is spread evenly on the net. This is the stage of the papermaking process. At this time, a large amount of moisture is dropped to the bottom of the net used, and evenly spread. At this time, there is a method of installing the network as one, and a method of installing two can be used, which is known and can be selectively used.

Next step 5 is dried on the surface of the hot roll 11 using the Yankee dryer 10, and the doctor blade 12 is brought into close contact with the roll 11 to form fine wrinkles 21 on the toilet paper 20. The state of drying proceeds. That is, the pulp is transferred to the Yankee dryer shown and dried. The method used at this time is the method of winding a pulp outside the hot roll, and drying a pulp using the high temperature. When the pulp, which is already spread out finely in the form of a sheet, is wound around the surface of the roll of the Yankee dryer, the roll is already heated to a high temperature, thereby drying out the wet pulp. Of course, the doctor blade is kept in close contact with the roll side of the Yankee dryer as shown. The pulp is attached and rotated to the adhered roll, and the braid is attached in the direction of pushing the pulp. Therefore, the pulp that strikes the braid is subjected to the peeling process. In this case, the pulp is dried and closely adhered to the rolls, so that the beauty of the doctor braid forms fine wrinkles according to the action of the pulp, which provides a condition for retaining the softness in the state where the fine wrinkles are later changed into toilet paper. At this time, the size of the fine wrinkles can be changed as much as possible through the angle of the braid and the roll, the adhesion of the doctor blade (doctor blade) and the roll, that is, the larger the angle A is maintained in a close state below, the size of the creping is also small. Of course, on the contrary, decreasing the size of the angle increases the size of the fine wrinkles. In the case of rolled toilet paper or cosmetic toilet paper, where soft properties are important, dry creping is performed and napkins are wet creping.

Next, the sixth step: the toilet paper of the present invention is completed through the processes of calendering, printing, embossing, cutting line work, cutting, and packaging to keep the thickness of the toilet paper constant. That is, the toilet paper, which is not actually pulp discharged to one side in the form of fine wrinkles, is subjected to a calendering process according to its characteristics. This calendering process is a process used in the process of general papermaking, and it means the process of maintaining the thickness of cardboard, such as paper and toilet paper, uniformly. However, the present invention is a toilet paper manufacturing process. There is no need to overdo this calendering process as is used in the conventional process for producing feeders. This is because they are not trying to focus on improving the smoothness of the surface. In the case of toilet paper, it is not necessary to increase the printability, and because of its nature, the adsorption power of moisture is high, so printing using a large amount of dyes has a lot of effect of spreading. Therefore, the calendering process of the present invention is smooth, and in order to be able to overlap in two or three layers, a thinner calendering process must be added. Of course, to this end, the amount of pulp added is minimized, and the process of adhering from the top to the bottom is small. It is to refrain from carrying out a process of increasing the smoothness by passing between the two rolls and compressing the surface, and to reduce the thickness by adjusting the ratio of the dosage. At this time, a calendering process of thickness reduction using a roll may be used, in which the roll should be used for adjusting thickness rather than smoothness using a roll having a rough surface.

Then look at the composition and properties of the additives of the general toilet paper in the second step used in the present invention.

That is, the present invention can produce a toilet paper for toilet paper and toilet paper and napkin as described above. All of these additives (Addition of additives) are common and some may be different, in particular the conditions of the input amount is different. This is because it must be changed to a material suitable for the purpose. Therefore, in describing these, it demonstrates in detail according to said order.

First of all, in the case of general toilet paper, 0.1-5 parts by weight of the humectant, 0.1-5 parts by weight of the absorbent, 0.01-2 parts by weight of the softener, and 0.01-5 parts by weight of the retention agent added for fixing it is preferred to be introduced. The humectants can be used as a permanent humectant (polyamidepolyamine epichlorohydrin) and a temporary humectant, a permanent humectant is used PAE (polyamidepolyamine epichlorohydrin) resin, a temporary humectant Dialdehyde starch, glyoxal and the like are used. These humectants themselves form chemical crosslinks, some of which also form bonds with fibers. The mechanism by which they act as humectants is that a cross-linked resin forms a hydrophobic surface by applying a fiber bonding site. That is, by infiltrating the moistening agent into the toilet paper, it exhibits a durability against humidity. Some toilet paper may be easily torn or shed due to moisture due to the lack of wetted force, which is prevented from being torn by adding the wetted force. Of course, in the case of the moisturizing agent, the amount of the general toilet paper is used in the smallest amount, and the moistening agent in the napkin toilet paper is most likely to be used, but this is different depending on the characteristics of the material of the pulp. In the present invention, since it was possible to produce a variety of toilet paper of the highest quality to maintain the input amount, this ratio is observed.

The next used additives are 0.1-5 parts by weight of absorbent. Absorbents are used especially when absorbability is required. The principle is to increase the hydrophilic area by covering the hydrophobic areas of the paper with surfactants, while the use of surfactants can increase water absorption while inter-fiber bonding This increases the bulk and increases the total absorption. In the present invention, the amount of the absorbent added to the general toilet paper is the highest, followed by cosmetic toilet paper and napkin toilet paper. This is because the amount of absorption of general toilet paper is the highest. Furthermore, there is the term bulk in the above description, which is to enhance the swelling properties like fibers. If the bulkiness is high, the general toilet paper, which has to be highly absorbent in order to increase the surface area in contact with moisture, has the greatest bulkiness.

The following composition is a softener. As the softening agent, quaternary imidazolines (quater imidizolines) or dialkyldimethyl quaternary amines are mainly used. Glycol may also be used. Softeners reduce the surface tension of water molecules refluxing between fibers and reduce the bond between fibers as the water evaporates, reducing the bonds between the fibers, resulting in a much bulkier, less intense but soft touch. Can be obtained. In addition, the alkyl groups in these softeners provide an oily, silky feel that provides a bulky yet soft feel.

In fact, the present invention does not describe the introduction of this dye in the preparation of the claims. This is because most white dyes are added, but other colors may be added. Of course, toilet paper that has undergone bleaching of pulp may not contain any dye at all. This is because the type and amount of dye can vary depending on the color to be expressed and the chromaticity thereof. In the case of toilet paper and towels, direct dyes and cationic direct dyes are generally used.

As the last component to be added, a retentive agent is used, about 0.01-5 parts by weight of retentive agent is added. Most additives used in the manufacture of toilet paper require the use of retention agents because they do not have the ability to bind fibers themselves. Retention systems are divided into single polymer, dual polymer and micro particle systems. Alum, PAC, a low molecular weight high charge density cationic polymer, is used as a retention agent to improve retention by forming patches on the stock. High molecular weight polymers aggregate through a bridging mechanism between colloidal components or fines and allow them to adhere to the fibers. In this case, it is able to withstand general shearing force but not high shearing force generated from pulp. Therefore, high and low molecular weight polymers can be used together to solve these problems. Microparticles using bentonite, silica, organic microparticles, and the like can also be used, but toilet paper is expensive because of its high cost. One thing to keep in mind when using a preservative is to ensure good formation, and remember that high work and first pass retention generally worsens paperwork. Synthetic cationic polymers used as retention agents include polyacrylamide, polyDadMac (polydiallyldimethylammonium chloride), polyamines (polyamine) and polyethyleneimine (polyethyleneamine)

And the pH control is necessary, but the reason omitted in the claims is too natural, the range of the adjustment was also difficult to specify a lot of parameters depending on the toilet paper manufacturing apparatus or system equipped. This pH adjustment is used as a means to optimize the efficiency of chemical additives in the manufacture of towels and toilet paper. PAE humectants, for example, exhibit the best efficiency at pH 7.0-8.0. Yankee dryer applicators may also be affected by the pH of the stock and the O-ring spray for adhering / removing. The method of adjusting the pH depends on the acidity of the incoming pH. With an acid commonly used has a sulfuric acid (sulfuric acid), an alarm (alum) or carbon dioxide (CO_2). Caustic soda (sodium hydroxide, sodium hydroxide), liquid soda ash (liquid soda ash) is used as the base.

Unlike the common toilet paper, the additive of the toilet paper in the second step, 0.1-5 parts by weight of the wet strength agent, 0.01-5 parts by weight of the dry strength agent (0.1) by weight relative to the weight of the bamboo pulp, -3 parts by weight of absorbent, 0.01-2 parts by weight of softening agent, and 0.01-5 parts by weight of retention agent introduced for fixing are added. And the additives of the toilet paper for napkin, 0.1-5 parts by weight of the humectant, 0.01-6 parts by weight of the dry strength enhancer, 0.1-2 parts by weight of the absorbent, 0.01-2 parts by weight of the softener relative to the weight of the bamboo pulp 0.01-5 parts by weight of retentive agent added for fixation is added.

This input component and its dosage differ somewhat from the general toilet paper described above. These are all differentiated according to the use of each toilet paper produced. In any case, all of the components introduced in the general toilet paper manufacturing method described above are added to both the toilet paper and the napkin toilet paper. However, there is one more component that is added only to the toilet paper and the toilet paper for napkins, which is a dry strength enhancer.

That is, in the case of general toilet paper or towels, dry strength enhancers are not required because sufficient strength can be obtained by refining alone. However, it is sometimes used to improve strength unless it is confessed to maintain bulk. Cationic starch, CMC (carboxymethyl cellulose), polyacrylamide (polyacrylamide), guar gum (guar gum) are used as the dry strength enhancer.

On the other hand, in the Yankee dryer used in the present invention, the roll must be dried if it maintains a special temperature. The high-temperature roll 11 of the fifth step is a temperature of 30-150 ° C. Maintaining this temperature is suitable for the rate of drying and the content ratio of the moisture, and the yield to be produced can be properly maintained.

In addition, the doctor blade 12 of the fifth step, it is preferable to differentiate the size of the fine wrinkles 21 formed on the toilet paper by adjusting the contact angle, the description thereof is already omitted in this state.

The present invention is not unique to toilet paper produced using bamboo pulp. The toilet paper produced through the manufacturing method is also characterized. In other words, in the toilet paper made of pulp, toilet paper made of bamboo pulp produced through all the above-described manufacturing method has a great feature.

1 is an overall view of a system for producing toilet paper of the present invention,

Figure 2 is a side view of the Yankee dryer of the present invention.

<Brief description of the major symbols in the drawing shown>

Cited By (5)

Publication number	Priority date	Publication date	Assignee	Title

WO2013041986A3 *	2011-09-21	2013-05-23	Kimberly-Clark Worldwide, Inc.	Tissue product comprising bamboo
KR101588816B1	2015-01-30	2016-01-25	주식회사 모나리자	Tissue products that include bamboo pulp and a system and method of manufacturing thereof
CN110699999A *	2019-10-18	2020-01-17	重庆理文卫生用纸制造有限公司	Toilet paper performance improving method for processing commercial pulp based on different fiber characteristics
US11053643B2	2017-02-22	2021-07-06	Kimberly-Clark Worldwide, Inc.	Layered tissue comprising non-wood fibers
KR102406420B1 *	2021-07-22	2022-06-14	주식회사 제일페닉스	Medical paper and method for manufacturing the same
Family To Family Citations				

* Cited by examiner, † Cited by third party, ‡ Family to family citation

Similar Documents

Publication	Publication Date	Title
US9518364B2	2016-12-13	Wet laid sheet material of a microfibrillated material composition
JP6849669B2	2021-03-24	Dense film surface sizing
US6379498B1	2002-04-30	Method for adding an adsorbable chemical additive to pulp during the pulp processing and products made by said method
US9506195B2	2016-11-29	Compositions and methods of making paper products
US8133358B2	2012-03-13	Creped paper product
EP2665862B1	2018-05-16	Method for improving strength and retention, and paper product
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AU2001239938A1	2001-11-22	Method for adding an adsorbable chemical additive to pulp during the pulp processing and products made by said method
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US20030121627A1	2003-07-03	Tissue products having reduced lint and slough
AU8951298A	1999-02-11	Tissue paper treated with polyhydroxy fatty acid amide softener systems that are biodegradable
KR20090036284A	2009-04-14	The product method and tissue from bamboo pulp
JPH08510299A	1996-10-29	Method of treating tissue paper with a three-component biodegradable softener composition
MXPA05006482A	2005-08-26	Amino-functionalized pulp fibers.
RU2347038C1	2009-02-20	Composition
US8282777B2	2012-10-09	Disposable wipers and towels containing 40% or more post-consumer waste
JP2023002687A	2023-01-10	Fibrous structure products comprising layers each having different levels of cellulose nanoparticles
CN102304869A	2012-01-04	High water absorbent wet-strength paper and application thereof
BR112019021283B1	2023-02-28	METHOD FOR PRODUCING A SUBSTRATE, AND, SUBSTRATE
JP2009144272A	2009-07-02	Paper and method for producing paper
JP5654381B2	2015-01-14	Paper manufacturing method
BR112015019842B1	2021-12-21	LEAF MATERIAL OBTAINED BY WET FROM A MICROFIBRILLATED MATERIAL COMPOSITION

Priority And Related Applications

Priority Applications (1)

Application	Priority date	Filing date	Title
KR1020070101369A	2007-10-09	2007-10-09	The product method and tissue from bamboo pulp

Applications Claiming Priority (1)

Application	Filing date	Title
KR1020070101369A	2007-10-09	The product method and tissue from bamboo pulp

Legal Events

Date	Code	Title	Description
2007-10-09	A201	Request for examination	
2009-04-24	E902	Notification of reason for refusal	
2009-10-29	E601	Decision to refuse application	

Concepts

machine-extracted

Download Filter table

Name	Image	Sections	Count	Query match
Bambusa arundinacea		title,claims,abstract,description	40	0.000
Bambusa tulda		title,claims,abstract,description	39	0.000
Phyllostachys viridis		title,claims,abstract,description	39	0.000
bamboo		title,claims,abstract,description	39	0.000
tissues		title,abstract,description	6	0.000
Bambusa tulda		title	1	0.000
method		claims,abstract,description	40	0.000
Bambuseae		claims,abstract,description	38	0.000
manufacturing process		claims,abstract,description	36	0.000
additive		claims,abstract,description	26	0.000
water		claims,abstract,description	16	0.000
wrinkles		claims,abstract,description	12	0.000
additive		claims,abstract,description	11	0.000
calendering		claims,abstract,description	10	0.000
drying		claims,abstract,description	7	0.000
mixing		claims,abstract,description	6	0.000
printing		claims,abstract,description	6	0.000
beating		claims,abstract,description	5	0.000
embossing		claims,abstract,description	4	0.000
chemical substances by application		claims,description	18	0.000
humectant		claims,description	16	0.000
absorbent		claims,description	14	0.000
absorbent		claims,description	14	0.000
maintenance of location		claims,description	11	0.000
enhancing		claims,description	9	0.000
enhancer		claims,description	8	0.000
spreading		claims,description	5	0.000
cutting process		abstract,description	3	0.000
dusting		abstract	1	0.000

Show all concepts from the description section

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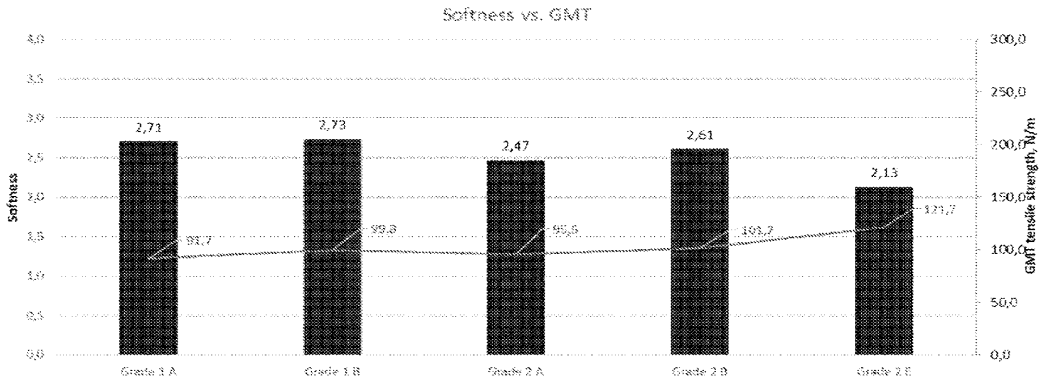


Fig. 1

(57) Abstract: The present disclosure relates to a single-ply tissue paper material having a basis weight less than 40 gsm and a GMT tensile strength of at least 60 N/m, comprising a non-wood tissue ply, comprising non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the of the non-wood tissue ply. The disclosure also relates to a single-ply tissue paper product and to a multi-ply tissue paper product comprising at least one non-wood tissue ply.

[Continued on next page]

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TISSUE PAPER MATERIAL AND TISSUE PAPER PRODUCT

TECHNICAL FIELD

The present disclosure relates to a single-ply tissue paper material, to a single-ply tissue paper product, and to a multi-ply tissue paper product, comprising at least one non-wood tissue ply comprising non-wood cellulose pulp fibres.

BACKGROUND

Tissue paper materials find extensive use in modern society. Toilet paper, and paper towels such as hand towels or household (kitchen) towels, facial tissues, tissue handkerchiefs, napkins, and industrial wipes are staple items of commerce. These products are typically made from papermaking pulp comprising wood fibres, such as hardwood and softwood fibres.

In the following, a "tissue paper product" relates to an absorbent paper product based on cellulose wadding which is also called tissue paper material or tissue paper base-sheet in this field of technology.

Tissue paper material is defined as a soft absorbent paper material having a low basis weight, of for example 8 to 45 g/m^2, preferably 10 to 35 g/m^2 per ply. The total basis weight of multi-ply tissue paper products may preferably be up to a maximum of 110 g/m^2, more preferably to a maximum of 80 g/m^2. Its density is typically below 0.6 g/cm^3, preferably below 0.30 g/cm^3 and more preferably in the range of 0.02 g/cm^3 and 0.20 g/cm^3. The production of tissue paper material is distinguished from conventional paper production, e.g. printing paper production, by its relatively low basis weight and relatively high tensile energy absorption index (see ISO 12625-4). Conventional paper and tissue paper also differ in general with regard to the modulus of elasticity that characterises the stress/strain properties of these generally planar products as a material parameter.

The fibres contained in the tissue paper are mainly cellulosic fibres, such as pulp fibres from chemical pulp (e.g. Kraft or sulphite), or mechanical pulp (e.g. ground wood, thermo mechanical pulp, chemo-mechanical pulp and/or chemo- thermo-mechanical pulp /CTMP). Pulps derived from both deciduous (hardwood) and coniferous (softwood) can be

used. Fibres may also come from non-wood plants e.g. cereal, bamboo, jute, or sisal. The fibres or a portion of the fibres may be recycled fibres, which may belong to any or all of the above categories. The fibres can be treated with additives, e.g. fillers, softeners, such as, but not limited to, quaternary ammonium compounds and binders, conventional dry-strength agents, temporary wet strength agents or wet-strength agents, in order to facilitate the original paper making or to adjust the properties thereof.

Tissue paper products in particular for use as hygiene- or wiping products primarily include all kinds of tissue paper materials including dry-creped tissue paper material, wet-creped tissue paper material, NTT (flat), TAD-paper material (Through Air Drying), tissue paper material based on structured or textured technologies such as ATMOS, NTT (textured), UCTAD, eTAD, QRT, PrimeLineTEX etc. and cellulose or pulp-wadding, or combinations, laminates or mixtures thereof. Typical properties of these hygiene- and wiping products include the ability to absorb tensile stress energy, their drapability, good textile-like flexibility, properties which are frequently referred to as bulk softness, a high surface softness and a high specific volume with a perceptible thickness. A liquid absorbency as high as possible and, depending on the application, a suitable wet and dry strength as well as an appealable visual appearance of the outer product's surfaces are desired. These properties, among others, allow these hygiene and wiping products to be used, for example, as cleaning wipes such as windscreen cleaning wipes, industrial wipes, kitchen paper or the like; as sanitary products such as for example bathroom tissue, handkerchiefs, household towels, towels and the like; as cosmetic wipes such as for example facials and as serviettes or napkins, just to mention some of the products that can be used. Furthermore, the hygiene- and wiping products can be dry, moist, wet, printed or pre-treated in any manner. In addition, the hygiene- and wiping products may be folded, interleaved or individually placed, stacked or rolled, connected or not, in any suitable manner.

The products described above can be used for personal and household use as well as commercial and industrial use. They are adapted to absorb fluids, remove dust, and for other cleaning purposes.

If tissue paper material is to be made out of pulp, the process essentially comprises a forming step that includes a headbox- and a forming wire section, and a drying section, e.g. including through air drying or conventional drying on a Yankee cylinder. The production process can also include a crepe process for tissue paper and, finally, typically a monitoring and winding area.

Tissue paper material can be formed by placing the fibres, in an oriented or random manner, on one or between two endless continuously rotating wires or felts of a paper making machine while simultaneously removing water.

Further dewatering and drying the formed primary fibrous web occur in one or more steps by mechanical and thermal means until a final dry-solid content of usually about 90 to 99% has been reached.

In case of creped tissue paper material making, this stage is followed by the crepe process which influences the properties of the finished tissue paper product in conventional processes. The conventional dry crepe process involves creping on a usually 3.0 to 6.5 m diameter drying cylinder, the so-called Yankee cylinder, by means of a crepe doctor blade with the aforementioned final dry-solids content of the raw tissue paper. Wet creping can be used as well, if lower demands are made of the tissue quality. The creped, finally dry raw tissue paper material, the so-called base tissue, is then available for further processing into the tissue paper product.

Instead of the conventional tissue making process described above, the use of a modified technique is possible in which an improvement in specific volume is achieved by a special kind of drying which leads to an improvement in the e.g. caliper, bulk, softness, etc. of the tissue paper material. This process, which exists in a variety of subtypes, is herein generally termed the structured tissue technique. Examples of structured tissue techniques are TAD ATMOS®, NTT(textured), UCTAD, eTAD, QRT, PrimeLineTex etc.

The processing step from the tissue paper material to the finished tissue paper product occurs in processing machines (converting machines) which include operations such as unwinding the tissue paper material (base tissue), calendering of the tissue, laminating, printing or embossing.

Several plies may be combined together by a combining operation of a chemical nature (e.g. by adhesive bonding), or of a mechanical nature (e.g. by knurling or so-called edge-embossing), or a combination of both. Examples of such process steps for combining plies together will be described in more detail in the below.

Further, the processing to finished tissue paper product may involve e.g. longitudinal cut, folding, cross cut etc. Moreover, individual tissue paper products may be positioned and brought together to form stacks, which may be individually packaged. Such processing

steps may also include application of substances like scents, lotions, softeners or other chemical additives.

When several plies are combined together using adhesive bonding, a film of adhesive is deposited over some or all of the surface of at least one of the plies, then the adhesive-treated surface is placed in contact with the surface of at least one other ply.

When several plies are combined together using mechanical bonding, the plies may be combined by knurling, by compression, by edge-embossing, union embossing and/or ultrasonic.

Mechanical and adhesive bonding may also be combined to combine several plies together to form a multi-ply product.

Embossing is to change the shape of a sheet from flat to shaped, so that there are areas that are raised and/or recessed from the rest of the surface. It therefore constitutes a deformation of the previously relatively flat sheet, and results in a ply having a particular relief. The thickness of the ply or of the multiple plies is in most cases increased after embossing compared with its initial thickness.

An embossing process is carried out between an embossing roll and an anvil roll. The embossing roll can have protrusions or depressions on its circumferential surface leading to embossed protrusions/depressions in the paper web. Anvil rolls may be softer than the corresponding embossing roll and may consist of rubber, such as natural rubber, or plastic materials, paper or steel. If the anvil roll is made of a softer material like rubber, a contact area/nip can be formed between the embossing roll (e.g. steel roll) and the anvil roll by the deformation of the softer roll.

By embossing, a pattern can be applied to a tissue paper fulfilling a decorative and/or functional purpose.

A functional purpose may be to improve the properties of the hygiene paper product, that is, the embossment may improve the product thickness, absorbency, bulk, softness etc.

A functional purpose may also be to provide a joint to another ply in a multi-ply product.

Tissue paper products display a number of physical properties which are of importance for their use for example as toilet paper, hand towels, kitchen towels, facial tissues, handkerchiefs, napkins, wipe or the like. Examples of such properties are their strength, softness, and absorbency (primarily for aqueous systems). These physical properties are

generally tuned for addressing common consumer demand in view of the intended use of the tissue paper product.

For example, tissue paper products need to retain their strength at least for a time period of use e.g. for wiping liquids or moisture.

For example, it is desired that tissue paper products have an absorbency so as to be suitable for their purpose such as for wiping liquids or moisture, cleaning etc.

At the same time, there are requirements regarding tactile properties such as softness as tissue paper products may be intended to come in intimate contact with the body and skin. Accordingly, it is desired that tissue paper products shall exhibit sufficient softness in order to ensure consumer's comfort.

However, some of the desired physical properties of tissue paper products are generally conflicting properties. One example is strength and softness. Often, as strength in a tissue paper product rises, the softness declines.

Hence, it is desired to provide a tissue paper product providing a good balance between required properties. For example, it is desired to provide a tissue paper product achieving a satisfactory balance between softness and strength or to provide a tissue paper product achieving a satisfactory absorption, strength and/or softness.

Further, there is a desire to reduce the consumption of wood fibre to produce tissue paper products. This desire is advocated by e.g. rising costs for wood fibre, concerns involving sustainable forest management, and other environmental reasons such as carbon foot print.

To this end, attempts have been made to replace some or all of the wood fibre in tissue paper products with for example recycled fibres and/or with non-wood fibres. However, since the fibre content in the pulp will naturally impact the above-mentioned physical properties of the resulting tissue paper material, the replacement of virgin wood fibres with other fibres in the pulp is not uncomplicated.

Thus, there is a need for improvement and/or alternatives for tissue paper products in view of one or more of the above-mentioned desires.

SUMMARY

An object of the present invention is to fulfill said need for improvement and/or alternatives.

To this end, it is proposed herein to use non-wood cellulose pulp fibres in tissue paper materials and tissue paper products.

The non-wood cellulose pulp fibres may be chemical pulp fibres.

Optionally, the non-wood cellulose pulp fibres may be never-dried fibres. "Never-dried" means herein that the fibres have not been subject to drying before use in the tissue making process. It is believed that the non-wood cellulose pulp fibres being never-dried may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

Optionally, the non-wood cellulose pulp fibres contain at least 15% hemicellulose. It is believed that such a hemicellulose content may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

Optionally, the non-wood cellulose pulp fibres contain no more than 15 % lignin. For example, the non-wood cellulose pulp fibres may contain no more than 12 % lignin. In yet another example, the non-wood cellulose pulp fibres may contain no more than 10% lignin. It is believed that such a lignin content may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

For example, the non-wood cellulose pulp fibres may contain at least 15% hemicellulose and no more than 15 % lignin, such as no more than 12 % lignin or no more than 10% lignin.

Optionally, the non-wood cellulose pulp fibres are pre-treated, to obtain the desired amounts of lignin and/or hemicellulose.

Further, the non-wood cellulose pulp fibres may have a relatively low average fibre length.

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1700 µm.

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1200 µm.

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1000 µm.

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 900 µm.

For example, the non-wood cellulose pulp fibres may have an average fibre length in the range of 750 to 1000 µm.

Further, it is believed that the non-wood cellulose pulp fibres having a relatively high breaking length, may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products. The breaking length is the initial breaking length of the non-wood cellulose pulp fibres as measured on the non-wood cellulose pulp fibres after the pulping process.

Optionally, the non-wood cellulose fibres have a breaking length of more than 3000 m, such as more than 5000 m.

For example, the non-wood cellulose fibres may have a breaking length of more than 3000 m and an average fibre length of less than 1700 µm, such as less than 1200 µm, less than 1000 µm or less than 900 µm.

For example, the non-wood cellulose fibres may have a breaking length of more than 5000 m and an average fibre length of less than 1700 µm, such as less than 1200 µm, less than 1000 µm or less than 900 µm.

Also, it is believed that the non-wood cellulose pulp fibres having a relatively high ratio between breaking length, and average fibre length may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

Optionally, the non-wood cellulose fibres have a breaking length/average fibre length of more than 3.7.

Optionally, the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.0.

Optionally, the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.5.

For example, the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 5, such as more than 5.5 or more than 6.5.

For example, the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 3.7 such as more than 4 and an average fibre length of less than 1700 µm, such as less than 1200 µm, less than 1000 µm, or less than 900 µm.

For example, the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 5, such as more than 5.5 or more than 6.5 and an average fibre length of less than 1700 µm, such as less than 1200 µm, less than 1000 µm, or less than 900 µm.

For comparison, it may be mentioned that different types of conventional hardwood and softwood pulps display lower breaking length/average fibre length ratios, than those suggested in the above for the non-wood cellulose fibres. This applies also to examples of never-dried hardwood and softwood pulps. Average ratios as calculated for different types of hardwood and softwood pulps are indicated in the table in the below.

Type of pulps	Average ratio
BEK	2.4
BHK	2.0
BSK	1.0
BSS	0.6
NBHK	2.3
NBSK	1.2
Never-dried HW	0.9
Never-dried SW	1.0

(BEK – Bleached Eucalyptus Pulp, BHK – Bleached Hardwood Kraft, BSK – Bleached Softwood Kraft, BSS – Bleached Softwood Sulfite, Northern Bleached Hardwood Kraft, Northern Bleached Softwood Kraft. The never-dried Hardwood (HW) and Softwood (SW) are sulfite.)

Also, several types of previously used non-wood cellulose pulp fibres have been found to display lower breaking length/average fibre length ratio than what is proposed in the above. For example, tested samples of dried bagasse fibre pulp was found to have an average ratio of 2.6, dried bamboo fibre pulp an average ratio of 1.2 and dried wheat fibre pulp an average ratio of 3.5.

For example, the non-wood cellulose fibres may be never-dried non-wood cellulose pulp fibres and the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 3.7, such as more than 4.0 or more than 4.5.

For example, the non-wood cellulose fibres may be never-dried non-wood cellulose pulp fibres and the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 5, such as more than 5.5 or more than 6.5.

The non-wood cellulose pulp fibres as proposed herein may be used together with hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

As mentioned in the above, optionally, a portion of or all non-wood cellulose pulp fibres are never-dried non-wood cellulose pulp fibres.

Optionally, the non-wood cellulose fibres are used with softwood cellulose pulp fibres. In this case, a portion of or all softwood cellulose fibres may be never-dried softwood cellulose pulp fibres.

For example, the softwood cellulose pulp fibres may comprise never-dried hardwood cellulose pulp fibres and/or dried softwood cellulose pulp fibres.

Optionally, the non-wood cellulose fibres are used with hardwood cellulose pulp fibres. In this case, a portion of or all hardwood cellulose fibres may be never-dried hardwood cellulose pulp fibres.

For example, the hardwood cellulose pulp fibres may comprise never-dried hardwood cellulose pulp fibres and/or dried hardwood cellulose pulp fibres.

Optionally, the non-wood cellulose pulp fibres as proposed herein may be achieved by treatment by a non-pressurised process.

Optionally, the non-wood cellulose pulp fibres as proposed herein may be achieved by treatment by a process with no use of sulfur.

For example, the non-wood cellulose pulp fibres may be achieved by treatment using methods similar to the methods described EP 2 048281 A1, EP 2 247781 B1, US20130129573 A1, EP 2 034 090 A1, US20110281298 A1, and/or US20130129573 A1.

Additionally or alternatively, the non-wood cellulose pulp fibres may be achieved by treatment using methods similar to the methods described in WO2020264311 A1, WO2020264322 A1, US20190091643 A1, US2592983.

For example, the non-wood cellulose pulp fibres may be achieved by the Phoenix Process TM, of Sustainable Fiber Technologies Inc.

It will be understood that the features as discussed in the above as being contributing to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products may be used separately or in different combinations.

Optionally, the non-wood cellulose pulp fibres are derived from agricultural waste or byproduct.

Optionally, the non-wood cellulose pulp fibres are derived from a member of the Pocacea family. For example, the non-wood cellulose pulp fibres may be derived from wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, and/or sorghum. Another example of a member of the Pocacea family is sugar cane, from which non-wood cellulose pulp fibres may be derived, for example from sugar cane bagasse.

Optionally, the non-wood cellulose pulp fibres are derived from a member of the Cannabaceae family. For example, the non-wood cellulose pulp fibres may be derived from hemp and/or hop.

Optionally, the non-wood cellulose pulp fibres are derived from agricultural waste or byproducts. For example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts of the members of the Pocacea family and/or Cannabaceae family such as exemplified in the above, i.e. including agricultural waste or byproducts from wheat straw, rice straw, barley straw, oat straw, rye grass, sugar cane bagasse, hemp or hop. In another example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts such as banana harvest residue (belongs to the family Musaceae), pineapple residue (belongs to the family Bromeliaceae), nut shell waste, bagasse from agave, hop residue and/or corn stover.

Optionally, the non-wood cellulose pulp fibres are derived from kenaf (belongs to the family Malvaceae), switchgrass , succulents, alfalfa (belongs to the family Fabaceae.), flax straw (belongs to the family Linaceae), palm fruits (Elaeis or Arecaceae), and/or avocado (Lauraceae).

Optionally, the non-wood cellulose pulp fibres are derived from one or more of wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, sorghum, banana harvest residue, pineapple residue, nut shell waste, sugar-cane bagasse, industrial hemp, and/or members of the Cannabaceae family, kenaf, switchgrass, succulents, alfalfa, corn stover, and flax straw.

Optionally, the non-wood cellulose pulp fibres are derived from wheat straw, oat straw, barley straw, and/or rye grass. For example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts of wheat straw, oat straw, barley straw, and/or rye grass.

For example, the non-wood cellulose pulp fibres may be derived from wheat straw, such as from agricultural waste or byproducts of wheat.

Optionally, the non-wood cellulose pulp fibres are derived from residues from sugar production. For example, the non-wood cellulose pulp fibres may be residues from beet.

Optionally, the non-wood cellulose pulp fibres are derived from sugarcane bagasse.

Optionally, the non-wood cellulose pulp fibres are derived from agave. For example, the non-wood cellulose pulp fibres may be derived from resides from agave syrup production or derived from agave bagasse.

Although the present disclosure relates primarily to tissue paper made of non-wood fibres, it is understood that the non-wood cellulose pulp fibres as described herein may also find use in other applications e.g. in wound care, in absorbent articles, for example diapers, sanitary napkins, and incontinence articles, in beauty care, and/or in nonwoven materials and products.

Herein, the non-wood cellulose pulp fibres as described in the above are proposed to be used to form a non-wood tissue ply, comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 30% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 40% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount from 20 to 50% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount from 25 to 35% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of less than 70 % by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of less than 60 % by dry weight of the non-wood tissue ply.

Optionally, the non-wood tissue ply further comprises wood pulp fibres, such as hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

Optionally, the non-wood tissue ply further comprises wood pulp fibres in an amount such that the wood pulp fibre amount plus the non-wood fibre amount constitutes 100% dry weight of the tissue paper ply.

Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 95/5.

Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 90/10.

Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 80/20.

For example, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply may be greater than or equal to 0/100.

For example, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply may be in the range of 70/30 to 30/70.

For example, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply may be in the range of 60/40 to 40/60.

Optionally, said non-wood cellulose pulp fibres are present throughout the non-wood tissue ply. In other words, at least some non-wood cellulose pulp fibres may be found in all parts of the ply, e.g. in all layers of the ply. The non-wood cellulose pulp fibres need not be uniformly distributed, but may be a result of e.g. stratified distribution of the non-wood cellulose pulp fibres. For example, the non-wood cellulose pulp fibres may be homogenously distributed in the ply. In another example, the non-wood cellulose pulp fibres may be heterogeneously distributed in the ply.

Optionally, when said non-wood tissue ply comprises two or more layers, at least one layer of the non-wood tissue ply comprises non-wood fibres. For example, said at least one layer maybe an outer layer of the non-wood tissue ply.

Optionally, when said non-wood tissue ply comprises two or more layers, each out of said two or more layers may comprise non-wood fibres.

Optionally, the non-wood tissue ply is produced by conventional wet press technology (CWP). By “is produced” means that the tissue paper material has been manufactured using conventional wet press technology, i.e. the tissue paper material is a CWP tissue paper material. For example, the tissue paper material may be a dry crepe tissue paper material.

Optionally, the non-wood tissue ply is produced by structured tissue technology. By “is produced” means that the tissue paper material has been manufactured using structured tissue technology, i.e. the tissue paper material is a structured tissue paper material.

Optionally, the non-wood tissue ply is produced by TAD (Through Air Drying) technology.
Optionally, the non-wood tissue ply is produced by ATMOS technology.
Optionally, the non-wood tissue ply is produced by UCTAD technology.
Optionally, the non-wood tissue ply is produced by textured NTT technology.

Optionally, the non-wood tissue ply is produced by eTAD technology, such as Advantage eTAD technology from Valmet.
Optionally, the non-wood tissue ply is produced by QRT technology.
Optionally, the non-wood tissue ply is produced by PrimeLine TEX technology.

In accordance with the invention, there is provided tissue paper materials and tissue paper products including the non-wood tissue ply as described in the above with the non-wood cellulose pulp fibres as described in the above.

Thus, in a first aspect, there is provided a single-ply tissue paper material according to claim 1.

Thus, there is provided a single-ply tissue paper material having a basis weight less than 40 gsm and a GMT tensile strength of at least 60 N/m, the tissue paper material comprising a non-wood tissue ply. The non-wood tissue ply comprises non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the tissue paper material.

Optionally, the tissue paper material has a GMT tensile strength of at least 70 N/m.

Optionally, the tissue paper material has a GMT tensile strength of at least 80 N/m.

Optionally, the tissue paper material has a basis weight of less than 30 gsm.

Optionally, the tissue paper material has a basis weight of less than 25 gsm.

Optionally, the tissue paper material has a basis weight greater than 10 gsm.

Optionally, the tissue paper material has a basis weight in the range from 14 gsm to 25 gsm.

In a second aspect, there is provided a single-ply tissue paper product comprising a single-ply tissue paper material according to the first aspect. This implies that the single-ply tissue paper product may consist of the single-ply tissue paper material.

In a third aspect, there is provided a multi-ply tissue paper product in accordance with claim 7. Thus there is provided a multi-ply tissue paper product comprising two or more plies, wherein an average basis weight of the plies is less than 40 g/m², and the multi-ply tissue paper product having a GMT tensile strength of at least 100 N/m, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres, said non-cellulose pulp fibres being present in an amount of at least 10% by dry weight of the non-wood tissue ply.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m, such as at least 150 N/m.

Optionally, the multi-ply tissue paper product according to the second aspect or the single-ply tissue paper product according to the first aspect, has an absorbency of at least 7 g/g.

Optionally, the multi-ply tissue paper product according to the second aspect or the single-ply tissue paper product according to the first aspect, has an absorbency of at least 8 g/g.

Optionally, the multi-ply tissue paper product according to the second aspect or the single-ply tissue paper product according to the first aspect, has an absorbency of less than 20 g/g, such as less than 18 g/g.

Optionally, the multi-ply tissue paper product or the single ply tissue paper product has an absorbency of 7 to 20 g/g.

Optionally, the multi-ply tissue paper product or the single ply tissue paper product has an absorbency of 8 to 15 g/g.

Optionally, a majority of the plies of the multi-ply tissue paper material are non-wood tissue plies.

Optionally, all of the plies of the multi-ply tissue paper material are non-wood tissue plies.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 30% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 40% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of no more than 70% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of no more than 60% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range from 15 % to 50% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range from 15 % to 40% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range from 25 % to 35% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises two to five plies.

Optionally, each of the plies of the multi-ply tissue paper product comprises the same amount of non-wood cellulose pulp fibres.

Optionally, at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 5% dry weight.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 10% dry weight.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 20% dry weight.

Optionally, the multi-ply tissue paper product comprises one or more plies with no non-wood cellulose pulp fibres.

Optionally, said at least one non-wood tissue ply is an outer ply of said multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises at least two non-wood tissue plies, wherein the non-wood tissue plies form a first and a second outer ply of the multi-ply tissue paper product.

Optionally, for each of the alternatives relating to a multi-ply tissue paper product in the above, the non-wood ply may be such as defined in the above in any one of the options relating to the first aspect.

Optionally, the at least one non-wood tissue ply of the multi-ply tissue paper product comprises a single-ply tissue paper material in accordance with the first aspect as described in the above.

In a fourth aspect, there is provided a single-ply tissue paper material having a basis weight less than 40 gsm and an absorbency of at least 3 g/g, comprising a non-wood

tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

Optionally, the tissue paper material has an absorbency of at least 4 g/g.

Optionally, the tissue paper material has an absorbency of at least 5 g/g.

Optionally, the tissue paper material is produced by CWP (Conventional Wet Pressed) technology.

Optionally, the tissue paper material is produced by structured tissue technology.

Optionally, the tissue paper material is produced by structured tissue technology and have an absorbency of at least 6 g/g.

Optionally, the tissue paper material is produced by structured tissue technology and have an absorbency of at least 7 g/g.

Optionally, the tissue paper material is produced by structured tissue technology and have an absorbency of at least 8 g/g.

Optionally, the structured tissue technology is TAD technology.

Optionally, the tissue paper material has a GMT tensile strength of at least 60 N/m.

Optionally, the tissue paper material has a GMT tensile strength of at least 70 N/m.

Optionally, the tissue paper material has a GMT tensile strength of at least 80 N/m.

For example, the tissue paper material may have a GMT tensile strength of at least 100 N/m.

For example, the tissue paper material may have a GMT tensile strength of at least 150 N/m.

Optionally, the tissue paper material has a basis weight of less than 30 gsm.

Optionally, the tissue paper material has a basis weight of less than 25 gsm.

Optionally, the tissue paper material has a basis weight of more than 10 gsm.

Optionally, the tissue paper material has a basis weight of more than 15 gsm.

For example, the tissue paper material may be produced by CWP technology, and have a basis weight from 15 to 20 gsm and an absorption of at least 5 g/g.

For example, the tissue paper material may be produced by CWP technology, and have a basis weight from 20 to 30 gsm and an absorption of at least 4 g/g.

For example, the tissue paper material may be produced by CWP technology, and have a basis weight above from 30 gsm and an absorption of at least 3 g/g.

For example, the tissue paper material may be produced by CWP technology, and the basis weight (gsm) x the absorption (g/g) may be at least 75 (g/m2).

For example, the tissue paper material may be produced by CWP technology, and the basis weight (gsm) x the absorption (g/g) may be at least 80 (g/m2).

For example, the tissue paper material may be produced by CWP technology, and the basis weight (gsm) x the absorption (g/g) may be at least 90 (g/m2).

For example, the tissue paper material may be produced by structured tissue technology, and have a basis weight from 15 to 20 gsm and an absorption of at least 8 g/g.

For example, the tissue paper material may be produced by structured tissue technology, and have a basis weight from 20 to 30 gsm and an absorption of at least 7 g/g.

For example, the tissue paper material may be produced by structured tissue technology, and have a basis weight above from 30 gsm and an absorption of at least 6 g/g.

For example, the tissue paper material may be produced by structured tissue technology, and the basis weight (gsm) x the absorption (g/g) may be at least 120 (g/m2).

For example, the tissue paper material may be produced by structured tissue technology, and the basis weight (gsm) x the absorption (g/g) may be at least 140 (g/m2).

For example, the tissue paper material may be produced by (g/m2) technology, and the basis weight (gsm) x the absorption (g/g) may be at least 180 (g/m2).

Optionally, the tissue paper material may have a thickness of above 0.08 mm.

Optionally, the tissue paper material may have a thickness below 0.5 mm.

In a fifth aspect, there is provided a single-ply tissue paper product comprising a single-ply tissue paper material according to the fourth aspect in the above.

In a sixth aspect, there is provided a multi-ply tissue paper product comprising two or more plies, wherein an average basis weight of the plies is less than 40 gsm, and the multi-ply tissue paper product having an absorption of at least 4 g/g, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

Optionally, the multi-ply tissue paper product has an absorbency of at least 5 g/g.

Optionally, the multi-ply tissue paper product has an absorbency of at least 6 g/g.

Optionally, at least one ply of the multi-ply tissue paper product is produced by CWP (Conventional Wet Pressed) technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology. For example, the structured tissue technology may be TAD technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 7 g/g. For example, the ply may be produced by TAD technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 8 g/g. For example, the ply may be produced by TAD technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 9 g/g. For example, the ply may be produced by TAD technology.

Optionally all plies of the multi-ply tissue paper product are produced by structured tissue technology. For example, all of the plies may be produced by TAD technology.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 100 N/m.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 150 N/m.

For example, the multi-ply tissue paper product has a GMT tensile strength of at least 200 N/m.

For example, the multi-ply tissue paper product has a GMT tensile strength of at least 300 N/m.

For example, the multi-ply tissue paper product has a GMT tensile strength of at least 400 N/m.

Optionally, a majority of the plies of the multi-ply tissue paper material are non-wood tissue plies.

Optionally, all of the plies of the multi-ply tissue paper material are non-wood tissue plies.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 30% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 40% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of no more than 70% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of no more than 60% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range between from 15 % to 50% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range between from 15 % to 40% by dry weight the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range between from 25 % to 35% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises two to five plies.

Optionally, each of the plies of the multi-ply tissue paper product comprises the same amount of non-wood cellulose pulp fibres.

Optionally, at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 5% dry weight.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 10% dry weight.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 20% dry weight.

Optionally, the multi-ply tissue paper product comprises one or more plies with no non-wood cellulose pulp fibres.

Optionally, said at least one non-wood tissue ply is an outer ply of said multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises at least two non-wood tissue plies, wherein the non-wood tissue plies form a first and a second outer ply of the multi-ply tissue paper product.

Optionally, for each of the alternatives relating to a multi-ply tissue paper product in the above, the non-wood ply may be such as defined in the above in any one of the options relating to the fourth aspect.

Optionally, the at least one non-wood tissue ply of the multi-ply tissue paper product comprises a single-ply tissue paper material in accordance with the fourth aspect as described in the above.

The single-ply tissue paper product and the multi-ply tissue paper product as disclosed herein may for example be a tissue paper product for personal hygiene.

Optionally, the single-ply tissue paper product and the multi-ply tissue paper product disclosed herein may for example be toilet paper, hand wipes, paper napkins, facial tissue, handkerchiefs, or a kitchen towel or an industrial wipe.

The single-ply tissue paper product and the multi-ply tissue paper product may be embossed and/or calendared as is known in the art.

Optionally, the plies of the multi-ply product may be joined by ply bonding, such as for example embossing or knurling. For example, the multi-ply product may be joined by nesting.

Optionally, the plies of the multi-ply product may be joined by Goffra-Incolla technology.

Herein is disclosed a four-ply tissue product, such as a bathroom tissue product, such as toilet paper, having a basis weight of less than 80 g/m^2, such as 55 to 75 g/m^2, wherein each ply comprises wood cellulose fibres, such as hardwood and/or softwood cellulose fibres, and wheat straw cellulose fibres in an amount of 10 to 60 % by dry weight, such as 10 to 50 % by dry weight, 10 to 40 % by dry weight, 10 to 30 % by dry weight or 10 to 20 % by dry weight, the four-ply tissue product having a GMT tensile strength of at least

250 N/m, such as at least 300 N/m and/or an absorbency of at least 8 g/g, such as at least 9 g/g.

Each ply of said four-ply tissue product may have a basis weight of less than 30 g/m^2, such as 10 to 25 g/m^2. Each ply of said four-ply tissue product may comprise the same amount of wheat straw cellulose fibres.

The wheat straw cellulose fibres of said four-ply tissue product may have an average fibre length in the range of 750 to 1000 µm, such as 800 to 900 µm or 825 to 875 µm. Said wheat straw cellulose fibres may contain at least 15 % hemicellulose and/or no more than 15 % lignin.

Herein is also disclosed a three-ply tissue product, such as a bathroom tissue product, such as toilet paper, having a basis weight of less than 70 g/m^2, such as 40 to 60 g/m^2, wherein each ply comprises wood cellulose fibres, such as hardwood and/or softwood cellulose fibres, and wheat straw cellulose fibres in an amount of 10 to 60 % by dry weight, such as 10 to 50 % by dry weight, 10 to 40 % by dry weight, 10 to 30 % by dry weight or 10 to 20 % by dry weight, the three-ply tissue product having a GMT tensile strength of at least 200 N/m, such as at least 250 N/m and/or an absorbency of at least 8 g/g, such as at least 9 g/g.

Each ply of said three-ply tissue product may have a basis weight of less than 30 g/m^2, such as 10 to 25 g/m^2. Each ply of said three-ply tissue product may comprise the same amount of wheat straw cellulose fibres.

The wheat straw cellulose fibres of said three-ply tissue product may have an average fibre length in the range of 750 to 1000 µm, such as 800 to 900 µm or 825 to 875 µm. Said wheat straw cellulose fibres may contain at least 15 % hemicellulose and/or no more than 15 % lignin.

Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

In the drawings:

Fig. 1 is a diagram illustrating softness and GMT tensile strength for a number of base sheet samples including various amounts of non-wood fibre;

Fig. 2 is a diagram illustrating softness versus GMT tensile strengths for the base sheet samples of Fig. 1 comprising 0% non-wood fibre and 30% non-wood fibre;

Fig. 3 is a diagram illustrating softness and GMT tensile strength for a number of multiply tissue samples including various amounts of non-wood fibre;

Fig. 4 is a diagram illustrating the absorption for the tissue samples of Fig. 3;

Fig. 5 is a diagram illustrating the thickness for the tissue samples of Fig. 3;

Fig. 6 is a diagram of absorbency values obtained for tissue paper materials obtained in Example 4;

Fig. 7a is a diagram of absorbency values obtained for tissue paper materials obtained in Example 5;

Fig. 7b is a diagram of absorbency values obtained for tissue paper products obtained in Example 5;

Fig. 8 is a diagram of absorbency values obtained for tissue paper products obtained in Example 6;

Fig. 9 is a diagram of absorbency values obtained for tissue paper products obtained in Example 7; and

Fig. 10 is a diagram of absorbency values obtained for the tissue paper products obtained in Example 8, including variants of the tissue paper products obtained in Example 5.

DETAILED DESCRIPTION

The description in the below relates to examples of tissue paper materials and tissue paper products as obtained using the non-wood cellulose pulp fibres as proposed herein.

EXAMPLE 1: Single-ply tissue paper materials (base sheets)

Five different tissue paper materials were prepared.

The five different tissue paper materials are base sheets and suitable for forming bathroom tissue.

The samples were prepared using CWP technology to provide a dry creped tissue.

Two different grades of tissue were targeted:
Grade 1 (G1): soft bathroom tissue
Grade 2 (G2): standard bathroom tissue

The original fibre recipe for the two grades, without any non-wood fibre content is:

Trial ref	**Reference furnish**
Grade G1	50% softwood (never-dried pulp) – 50% hardwood (Eucalyptus – dried pulp)
Grade G2	70% softwood (never-dried pulp) – 30% hardwood (never-dried pulp)

The trial aimed at introducing different levels of non-wood fibrous pulp instead of standard wood pulp to assess base paper properties and consequently finished product quality.

The tissue machine is a Crescent former with suction press roll configuration, with a 2 layers Headbox: 50% Top Layer, 50% Bottom Layer.

The G1 grade was run in a stratified mode (different recipes on the 2 layers of the base paper), the G2 grade was run in homogenous mode (same recipe on both layers of the base paper), with target specifications as in the below:

G1:
Headbox: 2 layers
Blade: 20° ceramic
Basis weight: 16.5 g/m2
Thickness (10p): 0.97 mm/10 plies
MD dry tensile/ ply: 140 N/m
CD dry tensile/ply: 50 N/m
MD stretch: 18%

G2:

Headbox: 1 layer

Blade: 10° ceramic

Basis weight: 16 g/m2

Thickness (10p): 1.15 mm/10 plies

MD dry tensile/ ply: 150 N/m

CD dry tensile/ply: 60 N/m

MD stretch: 16%

The amount of non-wood fibres introduced ranged from 0 to 50% of the total blend. The compositions of the various base sheets are indicated in the table in the below:

Grade	Grade	Grade 1		Grade 2			
Trial	Trial	G 1A	G1B	G 2A	G2B	G2D	G2E
Over-all furnish	hardwood (dried pulp)	50%	50%				
	softwood (never-dried pulp)	50%	30%	70%	50%	40%	30%
	hardwood (never-dried pulp)			30%	30%	30%	20%
	non-wood fibre (never-dried pulp)	0%	20%	0%	20%	30%	50%

The non-wood cellulose fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp had a lignin content of 12.8% and a hemicellulose content of 18.0%.

The conventional short fibre content was made out of Hardwood dried pulp being a Eucalyptus dried pulp, and Hardwood never-dried pulp being a hardwood never-dried sulfite pulp.

The conventional long fibre content was made out of Softwood. In this example, the Softwood fibre pulp was also never-dried sulfite pulp. The breaking length, average fibre length, and ratio breaking length/average fibre length of the hardwood never-dried pulp, softwood never-dried pulp and hardwood dried pulp (eucalyptus) were as indicated in the table below:

	Non-wood	Hardwood (dried)	Softwood (never-dried)	Hardwood (never-dried)
Breaking length (m)	3775	1724	1755	882
Average fibre length (µm)	748	714	2165	929
Ratio breaking length/fibre length (-/micro)	5.05	2.41	0.81	0.95

The non-wood cellulose pulp fibres substituted mostly conventional long fibre both for its intrinsic strength properties and the tensile developed after refining. Despite this, additional strength generated needed a decrease on the long fibre refining line.

Grade	Grade	Grade 1		Grade 2			
Trial	Trial	G 1A	G1B	G 2A	G2B	G2D	G2E
Long fibre line	softwood (never-dried pulp)	100%	100%	100%	100%	80%	60%
	non-wood fibre					20%	40%
	Refining kwh/T	60	50	70	32	32	37
Short fibre line	hardwood (dried pulp)	100%	70%				
	hardwood (never-dried pulp)			100%	60%	60%	40%
	non-wood fibre		30%		40%	40%	60%
	Refining		none	none	15	18	48
Headbox	Configuration	Stratified	Stratified	Homogenous	Homogenous	Homogenous	Homogenous
	Yankee layer	100% SF	100% SF	30% SF + 70% LF	50% SF + 50% LF	50% SF + 50% LF	50% SF + 50% LF
	Hood layer	100% LF	40% SF + 60% LF	30% SF + 70% LF	50% SF + 50% LF	50% SF + 50% LF	50% SF + 50% LF

The content of non-wood fibres, conventional long fibres, and conventional short fibres in each of the tissue paper materials is indicated in the table in the below:

Grade	Trial reference	Non wood fibre content	Long fibre content %	Short fibre content %	Long fibre line refining kwh/T	Short fibre line refining kwh/T
Grade 1 (soft grade)	G1-A	0%	50%	50%	60	0
	G1-B	20%	30%	50%	50	0
Grade 2 (standard grade)	G2-A	0%	70%	30%	70	0
	G2-B	20%	50%	30%	32	15
	G2-D	30%	40%	30%	32	18
	G2-E	50%	30%	20%	37	48

Dry tensile strength in CD and MD directions and panel softness, were measured for the various samples, with the results as indicated in the table in the below and in Figs. 1 and 2.

	Basis weight	MD dry tensile	CD dry tensile	GMT dry tensile	MD stretch	Panel
	g/m²	N/m - 1 ply	N/m - 1 ply	N/m - 1 ply	%	
G1 - A	16.8	145	51	86	20.1	2.7
G1 - B	17.2	151	56	92	18.6	2.7
G2 - A	16.1	130	54	83	19.2	2.5
G2 - B	16.2	156	64	100	18.2	2.6
G2 - E	16.5	192	81	125	18.8	2.1

Fig. 1 is a combined bar chart and linear chart, where the bars represent the softness values and the line indicates the GMT tensile strength of the tissue paper materials G1-A, G1-B, G2-A, G2-B, and G2- E of Table 1.

The samples of the different Grades denoted A, are all samples with no non-wood fibre content, whereas the samples of the different Grades denoted with other letters comprise increasing amounts of non-wood fibre content (in alphabetical order).

No general trend for the relationship between the GMT strength and the softness in view of the non-wood cellulose fibre content may be seen which is valid for all of the different Grades. For the grade G1 being the softer grade, the softness values with or without non-wood fibres are similar. For the grade G2 being the standard grade, the softness values deviate more, but the GMT strength is increasing with increasing non-wood content.

Surprisingly the GMT strength is seen to increase with increasing content of non-wood fibre in the two different grades. Turning to Fig. 2, the basesheet softness and strength are again visualized, this time for samples including 0% non-wood versus samples including 30% non-wood. The samples with 30% non-wood display advantageous softness and GMT tensile strength.

Further, another surprising result is that all of the Grades display a GMT strength and a softness which is within limits rendering them useful for tissue paper products.

EXAMPLE 2: Multi-ply products

Three different types of multi-ply products, MP1, MP2 and MP3 were prepared. For each type of multi-ply product, samples were made with different overall non-wood fibre content, using the base sheets of different grades and non-wood fibre content as described in the above.

The plies of the multi-ply products were assembled by means of Goffra-Incolla technology. All converting parameters were the same for the different non-wood content of each of the products MP1, MP2, MP3.

MP1:

4-ply product

	Embossing top ply	**Basesheet Top ply**	**Basesheet Middle ply**	**Basesheet Middle ply 2**	**Basesheet Bottom ply**
MP1 0%	Feather (RT 20D)	Grade 1 A	Grade 2 A	Grade 2 A	Grade 1 A
MP1 32%	Feather (RT 20D)	Grade 1 B	Grade 2 E	Grade 2 E	Grade 1 B

MP2:

4-ply product

	Embossing top ply	**Basesheet Top ply**	**Basesheet Middle ply**	**Basesheet Middle ply 2**	**Basesheet Bottom ply**
MP2 0%	Ornament (RT71D)	Grade 1 A	Grade 2 A	Grade 2 A	Grade 1 A
MP2 20%	Ornament (RT71D)	Grade 1 B	Grade 2 B	Grade 2 B	Grade 1 B
MP2 30%	Ornament (RT71D)	Grade 1 B	Grade 2 E	Grade 2 E	Grade 1 B

MP3:

3-ply product

	Embossing top ply	**Basesheet Top ply**	**Basesheet Middle ply**	**Basesheet Middle ply 2**	**Basesheet Bottom ply**
MP3 0%	Seven (RT305)	Grade 1 A	Grade 2 A	-	Grade 1 A
MP3 20%	Seven (RT305)	Grade 1 B	Grade 2 B	-	Grade 1 B
MP3 30%	Seven (RT305)	Grade 1 B	Grade 2 E	-	Grade 1 B

The resulting multi-ply tissues were tested for various parameters, and the results are displayed in the below table.

	Number of	Non-wood dry weight (average)	Firmness	Basis weight	Thickness	GMT	Softness Panel	Absorption
	plies	%		(g/m²)	(1 sheet) mm	N/m		g/g
MP1 0%	4	0	61	63,8	0,58	267	1,7	9,0
MP1 32%	4	32	60	64,8	0,57	335	1,7	8,6

MP2 0%	4	0	59	63,0	0,53	255	1,7	9,3
MP2 20%	4	20	55	65,8	0,55	309	1,6	8,8
MP2 30%	4	30	54	65,9	0,55	329	1,5	9,0
MP3 0%	3	0	54	46,3	0,43	167	1,6	9,6
MP3 20%	3	20	47	48,2	0,44	200	1,6	9,0
MP3 30%	3	30	48	48,2	0,44	206	1,6	9,3

The results will be further discussed in the below with reference to Figs. 3 to 6.

Fig. 3 is a combined bar chart and linear chart, where the bars represent the softness values of the samples and the line indicates the GMT tensile strength.

In Fig. 3, as well as in the following Figs 4 to 6, for each type of multiply tissue paper material MP1, MP2, MP3, the samples are presented from left to right and with the sample having 0 percentage non-wood content to the left, and in increasing order of non-wood content towards the right in the figures.

As demonstrated by Fig. 3, the softness values for each type of multiply tissue paper material MP1, MP2, and MP3 is relatively constant or decreases only insignificantly with increasing amount of non-wood content. (A significant difference in the softness values (panel softness) would be about 0.2 points.) Thus, the results indicate that the softness is not significantly affected in the samples comprising various amounts of non-wood as compared to the samples comprising no non-wood.

Further, for each of the types MP1, MP2, and MP3, the GMT tensile strength increases with increasing amount of non-wood content. The increase in GMT tensile strength is significant, which was surprising. Thus, the results indicate that the GMT tensile strength is significantly increased in the samples comprising various amounts of non-wood as compared to the samples comprising no non-wood.

Thus, the results indicate that the balance between the softness and GMT strength in the samples comprising various amounts of non-wood, is better than for the samples with no non-wood content, i.e. increased GMT strength is achieved at about the same softness.

A satisfactory result for a tissue paper product comprising non-wood would be a balance being about the same as for a tissue paper product with no non-wood content. Based on the tests performed, it may therefore be assumed that the non-wood cellulose pulp fibres used herein are useful for replacing wood fibres in numerous different multi-ply and single ply tissue paper products while achieving at least satisfactory results in terms of softness and strength.

Turning to absorption, Fig. 4 is a bar chart illustrating the absorption g/g of the different samples of the three types of tissue paper material MP1, MP2, and MP3. As seen in the results, for each of the types MP1, MP2, and MP3, the highest value for absorption is obtained for the sample with no non-wood content. However, no general trend regarding the impact of increasing non-wood amount on the absorption values may be seen. Further, the variations in the measured absorption values are mainly insignificant, as a significant difference for absorption is about 0,5 g/g.

Thus, the results indicate that the absorption is not significantly affected in the samples comprising various amounts of non-wood, and instead the absorption is as good in the samples with various amounts of non-wood content as in the sample comprising no non-wood.

Turning to thickness, Fig. 5 is a bar chart illustrating the thickness (mm) of the different samples of the three types of tissue paper material MP1, MP2, and MP3. The results indicate that the thickness is not significantly affected in the samples comprising various amounts of non-wood as compared to the samples comprising no non-wood.

EXAMPLE 3: Bathroom tissue products

Hereinbelow are described two four-ply bathroom tissue products of relatively higher basis weight and higher thickness (P1 and P2) as well as two three-ply bathroom tissue products of relatively lower basis weight and lower thickness (P3 and P4).

In the manufacture of the base tissues for the respective bathroom tissue products, the conventional long fibre content was made from softwood and the conventional short fibre

content was made from hardwood. The softwood pulp and hardwood pulp used in the manufacture of the base tissues were never-dried sulfite pulps.

The non-wood pulp used in the manufacture of the base tissues for P1 and P3 was a never-dried cellulose fibre pulp derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The wheat straw cellulose fibres had an average length weighted fibre length in the range of 825–875 µm (Morfi fiber analyzer).

It is contemplated that similar base tissue and tissue product properties may be obtained irrespective of which forming technology (e.g., two-layer headbox or homogenous headbox) is used when manufacturing the base tissues.

Four-ply products P1 and P2

Two different top ply base tissues, T1 and T2, and two different bottom ply base tissues, B1 and B2, were manufactured on a conventional dry crepe paper machine, the tissue machine being a Crescent former with a two-layer headbox. The top ply and bottom ply base tissues were manufactured in a stratified mode, the composition of the furnish for the respective layers being as set out in the following table.

	T1 and B1	T2 and B2
Hood layer	Softwood pulp Non-wood pulp	Softwood pulp
Yankee layer	Hardwood pulp	Hardwood pulp

Two different middle ply base tissues, M1 and M2, were manufactured on a conventional dry crepe paper machine, the tissue machine being a Twin Wire former with a homogenous headbox.

The resulting base tissues are characterised in the following table.

	T1	T2	M1	M2	B1	B2
Composition (% dry weight)						
Softwood pulp	45	55	70	80	45	55
Hardwood pulp	45	45	20	20	45	45
Non-wood pulp	10	0	10	0	10	0
Basis weight (g/m^2)	≈ 16	≈ 16	≈ 15.5	≈ 15.5	≈ 19	≈ 19

Two different four-ply bathroom tissue products (toilet paper), P1 and P2, were manufactured by Goffra-Incolla technology assembly of four plies of base tissue as set out in the following table.

	P1	P2
Top ply	T1	T2
Middle plies	2 x M1	2 x M2
Bottom ply	B1	B2

Properties of the manufactured four-ply bathroom tissue products are reported in the following table. Results for P1 are means of 24 datapoints from 3 different production runs using base tissues from different production dates. Results for P2 are means of a larger number of datapoints collected from a larger number of production runs.

	P1	P2
Basis weight (g/m^2)	65.4	65.7
Thickness per sheet (mm)	0.59	0.56
GMT strength (N/m)	352	335
Ball burst (N)	6.3	6.7
Softness panel	82	82

Three-ply products P3 and P4

Two different top/bottom ply base tissues, T3 and T4, were manufactured on a conventional dry crepe paper machine, the tissue machine being a Crescent former with a two-layer headbox. The top/bottom ply base tissues were manufactured in a stratified mode, the composition of the furnish for the respective layers being as set out in the following table.

	T3	T4
Hood layer	Softwood pulp Non-wood pulp	Softwood pulp
Yankee layer	Hardwood pulp	Hardwood pulp

Two different middle ply base tissues, M3 and M4, were manufactured on a conventional dry crepe paper machine, the tissue machine being a Twin Wire former with a homogenous headbox.

The resulting base tissues are characterised in the following table.

	T3	T4	M3	M4
Composition (% dry weight)				
Softwood pulp	45	55	70	80
Hardwood pulp	45	45	20	20
Non-wood pulp	10	0	10	0
Basis weight (g/m^2)	≈ 16	≈ 16	≈ 19	≈ 19

Two different three-ply bathroom tissue products (toilet paper), P3 and P4, were manufactured by Goffra-Incolla technology assembly of three plies of base tissue as set out in the following table.

	P3	P4
Top ply	T3	T4
Middle ply	M3	M4
Bottom ply	T3	T4

Properties of the manufactured three-ply bathroom tissue products are reported in the following table. Results for P3 are means of 31 datapoints from 5 different production runs using base tissues from different production dates. Results for P4 are means of a larger number of datapoints collected from a larger number of production runs.

	P3	P4
Basis weight (g/m^2)	50.3	50.4
Thickness per sheet (mm)	0.50	0.48
GMT strength (N/m)	290	264
Ball burst (N)	4.4	4.7
Softness panel	80	80
Absorption (g/g)	9.2	9.4

Thus, in summary, the results indicate that introduction of various amounts of the non-wood cellulose fibres into different tissue paper materials results in acceptable or insignificant changes in parameters relevant for the function of the tissue paper material, such as the GMT strength, the softness, the absorption and/or the thickness, as compared to the same tissue paper material without non-wood fibre content.

The advantageous results are believed to be at least partially due to the use of the non-wood fibres, and in particular the various features which may be contributing to the advantageous properties of tissue paper materials and products including the non-wood fibres as set out in the above.

For example, as in the samples in the above, the non-wood cellulose pulp fibre may have a breaking length/average fibre length ratio greater than 4. Also, the non-wood pulp fibres may be never-dried. Further, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts such as one out of wheat straw, oat straw, barley straw, and/or rye grass, for example wheat.

However, other combinations of features as described in the above for the non-wood cellulose fibres may be made by a person skilled in the art to provide the tissue materials and tissue products as proposed herein.

Hence, the results, although relating to specific examples of tissue paper materials and tissue paper products are believed to indicate that the non-wood fibres as such may be used to provide advantageous results in for a wider range of tissue paper materials and tissue paper products.

EXAMPLE 4: (TAD Tissue paper material)

One-ply tissue paper materials intended for use as kitchen towels were produced using TAD technology with different dry content of non-wood fibre.

Two versions of the tissue paper materials were made, one comprising 0% dry weight non-wood fibres, and one comprising 30% by dry weight non-wood fibres.

The non-wood fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp of this type generally has a lignin content of less than 15 % and a hemicellulose content of more than 15 %.

The breaking length, average fibre length, and ratio breaking length/average fibre length of the non-wood cellulose fibre pulp are indicated in the table below:

	Non-wood fibre
Breaking length [m]	5338
Average fibre length[µm]	854
BL/av fibre length	6.25

The conventional short fibre content was made out of dried hardwood cellulose fibre pulp. The dried hardwood cellulose fibre pulp was dried Eucalyptus fibre pulp, BEK (Bleached Eucalyptus Kraft).

The conventional long fibre content was made out of dried softwood cellulose fibre pulp. In this example, the dried softwood cellulose fibre pulp was NBSK (Northern Bleached Softwood Kraft).

The breaking length/average fibre length ratio of BEK in general has been found to be about 2.4, and the breaking length/average fibre length ratio of NBSK has been found to be about 1.2, as indicated in the table in the Summary section in the above.

The machine was a stratified machine with 3 layers headbox, fed with 2 fibre lines:

- The long fibre line is feeding the Hood and Yankee layers of the headbox
- the short fibre line is feeding the middle layer of the headbox

The overall furnish of the reference and the trial were the following

- Reference: 42% BEK – 58% NBSK
- Trial: 12% BEK– 58% NBSK – 30% straw

The different fibres were split and treated as follow:

Trial	Trial	reference	trial
Overall furnish	NBSK	58%	58%
	BEK	42%	12%
	Non-wood	0	30%
Long fibre line	NBSK	83%	83%
	Non-wood	17%	17%
	Refining	160 kwh/T	160 kwh/T
Short fibre line	BEK	100%	0%
	Non-Wood	0%	100%
	Refining	30 kwh/T	none
Headbox	Configuration	stratified	stratified
	Yankee layer	41.5% NBSK + 8.5% BEK	41.5% NBSK + 8.5% BEK
	Middle layer	100% BEK	100% Non-wood
	Hood layer	41.5% NBSK + 8.5% BEK	41.5% NBSK + 8.5% BEK

Chemistry was added to provide dry and wet tensile strength, and was kept constant for the different qualities.

The average base sheet properties are as follows

	Basis weight (g/m²)	Thickness (1 sheet) mm	Dry tensile MD (N/m)	Dry tensile CD (N/m)	Stretch MD (%)	GMT (N/m)	Wet tensile MD (N/m)	Wet tensile CD (N/m)	ABSORPTION (g/g)
Reference	22.1	0.43	257	189	15.0	220	87.1	68.4	13.7
Trial 30% Non-wood	22.4	0.45	276	205	13.9	237	87.5	63.4	14.5

Despite no refining on the short fibre line, the tissue paper material containing non-wood fibres tends to be stronger than the reference paper material without non-wood.

As seen from the values in the table in the above, and as illustrated by the diagrams in Fig. 1, the trial with non-wood is significantly more absorbent than the reference tissue paper material without non-wood.

Thus, the tissue paper material including 30% non-wood fibres was even more absorbent than the tissue paper material including 0% non-wood fibre.

EXAMPLE 5: TAD tissue paper material and 2-ply TAD tissue paper product

Two-ply tissue paper products intended for use as kitchen towels were produced using TAD technology. The two-ply tissue paper products were produced from tissue paper materials (base sheets) produced using TAD technology and with different dry content of non-wood fibre.

The non-wood fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp of this type generally has a lignin content of less than 15 % and a hemicellulose content of more than 15 %.

The breaking length, average fibre length, and ratio breaking length/average fibre length of the non-wood cellulose fibre pulp are indicated in the table below:

	Non-wood fibre
Breaking length [m]	5493
Average fibre length[µm]	861
BL/av fibre length	6.38

The softwood cellulose fibre pulp and the hardwood cellulose pulp were similar to those used in Example 1 in the above.

Tissue paper material 1 (TP1) was made using 0% dry content of non-wood fibres.

Tissue paper material 2 (TP2) was made using 20% dry content of non-wood fibres.

Tissue paper material 3 (TP3) was made using 30% dry content of non-wood fibres.

The proportions between the conventional short fibre i.e. the Eucalyptus fibre pulp BEK (Bleached Eucalyptus Kraft), the conventional long fibre content, i.e. the Softwood fibre pulp NBSK (Northern bleached softwood kraft), and the non-wood fibres are indicated in the table in the below.

Conditions		TP1 (0%)	TP2 (20%)	TP3 (30%)
Overall furnish	BEK	25%	5%	
	NBSK	75%	75%	70%
	Non-wood		20%	30%
Refining kwh/T	Long fibres	160	150	150
Refining kwh/T	Short fibres	32	Off	Off

The machine was a stratified machine. Long fibre line was feeding Hood and Yankee layers of the headbox; the short fibre line feeding the middle layer.

For TP1, Long fibre line was 100% NBSK, and Short fibre line was eucalyptus BEK .

For TP2 and TP3, non-wood fibre substituted or all of the eucalyptus (BEK). The non-wood fibre was not refined.

Chemistry was added to provide dry and wet tensile strength, and was kept constant for the 3 qualities TP1, TP2 and TP3.

Chemical flows were equally split between both fibre lines.

Basis weight, thickness, dry tensile strength and absorption were measured for the resulting tissue paper materials. The results are indicated in the table in the below.

	Non-wood content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT	Absorption (g/g)
TP1	0%	21.2	0.4	334	245	286	14.0
TP2	20%	21.3	0.4	265	232	248	13.9
TP3	30%	21.4	0.4	279	234	255	14.7

Fig. 2a is a diagram illustrating the absorption of the tissue paper material comprising 0 % non-wood cellulose pulp fibres as compared to the absorption of the tissue paper material comprising 30% non-wood cellulose pulp fibre.

As seen in Fig. 2a and indicated in the table, the tissue paper material comprising 30% non-wood fibre displayed better absorption than the tissue paper material comprising 0% non-wood fibre. The tissue paper material comprising 20% non-wood cellulose pulp fibre displayed similar absorption as the tissue paper material comprising 0% non-wood cellulose pulp fibre.

The tensile strength of the tissue materials comprising non-wood cellulose pulp fibre is slightly less than the tensile strength of the tissue material with no non-wood cellulose pulp fibre. However, the deviation in tensile strength is not very significant and the tensile strength is still within acceptable limits.

Two-ply products were formed using the reference tissue paper material TP1 comprising 0% non-wood fibre and the tissue paper material TP3 comprising 30% non-wood fibre as described in the above.

2-ply product 1 (2P-1): 2 plies of the TP1, meaning that the 2-ply product comprises 0% non-wood fibres.
2-ply product 2 (2P-2): 2 plies of TP3, meaning that the 2-ply product comprises 30% dry weight non-wood fibres.

The 2-ply tissue paper products were produced by assembling the tissue paper materials (base sheets) using nested 2-ply technology.

Basis weight, thickness, tensile strength, softness panel and absorption was measured for the three multi-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT (N/m)	Softness panel	Absorption (g/g)
2P-1	0%	41.5	0.72	647	457	544	5.6	13.5
2P-2	30%	41.1	0.74	581	431	500	5.5	14.4

Fig. 2b illustrates the absorption of the two-ply tissue paper products. As seen in Fig. 2b and in the table above, the two-ply tissue paper product comprising 30% by dry weight non-wood fibres (2P-2) displayed a higher absorption at a comparable basis weight and thickness than the two-ply tissue paper product comprising no non-wood fibres.

The dry tensile strength results of the two-ply tissue paper product comprising 30% by dry weight of non-wood fibres (2P-2) were satisfactory to the intended use of the two-ply tissue paper product as a kitchen towel. Further, the softness of the two-ply tissue paper product comprising 30% by dry weight non-wood fibres (2P-2) displayed a similar softness to the two-ply tissue paper product comprising no non-wood fibres.

In all, the results indicate that the two-ply tissue paper products comprising non-wood fibres will display at least a similar absorption as the multi-ply tissue paper product comprising no non-wood fibre. Also, dry tensile strength and softness of the two-ply tissue products are satisfactory. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

Example 6: CWP Tissue paper product

Three-ply tissue paper products intended for use as kitchen towels were produced using CWP technology. The three-ply tissue paper products were produced from tissue paper

materials (base sheets) produced using CWP technology and with different dry content of non-wood fibre.

The pilot machine used was a Crescent former with suction presser roll configuration, with a 2 layers Headbox: 50% Top Layer, 50% Bottom Layer.

The machine was run in homogenous mode (same recipe on both layers of the base paper), but 2 fibre lines were used and treated differently.

The amount of non-wood fibre introduced ranged from 0 to 50% of the total blend for producing the tissue paper materials (base sheets).

The non-wood fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp had a lignin content of 12.8 and a hemicellulose content of 18.0.

The conventional short fibre content was made out of Hardwood. The Hardwood fibre pulp was never-dried pulp.

The conventional long fibre content was made out of Softwood. In this example, the Softwood fibre pulp was also never-dried pulp. The breaking length and morphology of the hardwood and softwood fibre pulp were as indicated in the table below:

	Non-wood (never-dried)	Softwood (never-dried)	Hardwood (never-dried)
Breaking length (m)	3775	1755	882
Average fibre length (microm)	748	2165	929
Fibre width (microm)	20	29	21
Fibre coarseness (mg/m)	0.13	0.20	0.13
Ration breaking length/fibre length (-/micro)	5.05	0.81	0.95

The composition of the different tissue paper materials (base sheets) and the refining level used is indicted in the below

Trial reference	Non-wood content	Long fibre content	Short fibre content	Long fibre line refining	Short fibre line refining
		%	%	kwh/T	kwh/T
G3-A	0%	85%	15%	150	0
G3-B	20%	65%	15%	120	10
G3-C	50%	45%	5%	80	10

The different fibres were split in the different layers of the stock preparation as follows:

Trial	Trial	G3-A	G3-B	G3-C
Overall furnish	softwood (never dried pulp)	85%	65%	45%
	hardwood (never dried pulp)	15%	15%	5%
	Straw	0%	20%	50%
Long fibre line	softwood (never dried pulp)	100%	100%	100%
	Straw	0%	0%	0%
	Refining kwh/T	150	120	80
Short fibre line	hardwood (never dried pulp)	100%	43%	9%
	Straw		57%	91%
	Refining	No	10	10
Headbox	Configuration	Homogenous	Homogenous	Homogenous
	Yankee layer	85% LF + 15% SF	65% LF + 35% SF	45% LF + 55% SF
	Hood layer	85% LF + 15% SF	65% LF + 35% SF	45% LF + 55% SF

Chemistry was added to provide dry and wet tensile strength, and was kept constant for the different qualities.

Average base sheet properties

Trial reference			BW	Caliper	MD	Strech MD	CD	MD wet	CD Wet	Dry/Wet
			g/m2	mm/10-ply	N/m	%	N/m	N/m	N/m	%
	Non-wood content	Target	18	1.2	290	17	145	90	30	25
		Min	17.5	0.9	280	15	130	65	25	21
		Max	18.5	1.4	350	19	170	100	35	
G3-A	0%	Average	17.9	0.97	299	18.3	136	77	27	26
		std	0.3	0.11	14	1.4	8	2	3	2
G3-B	20%	Average	18.5	0.95	327	17.9	141	85	28	26
		std	0.5	0.08	38	3.0	15	10	4	4
G3-C	50%	Average	18.7	1.00	293	16.7	139	67	23	23
		std	0.6	0.03	17	1.7	10	11	1	3

Trial reference	Non-wood content	Long fibre content	Short fibre content	Long fibre line refining	Short fibre line refining	GMT	Absorption g/g
		%	%	kwh/T	kwh/T		
G3-A	0%	85%	15%	150	0	201	6.7
G3-B	20%	65%	15%	120	10	215	6.5
G3-C	50%	45%	5%	80	10	202	6.3

Despite the lower long fibre content and the lower refining level, the tissue paper materials with non-wood cellulose pulp fibre had similar or higher tensile strength than the tissue paper material without non-wood cellulose pulp fibre.

As for absorption, the tissue paper materials with non-wood cellulose pulp fibre did not differ significantly from the tissue paper materials without non-wood cellulose pulp fibre.

Multi-ply products were formed out of the tissue paper materials (basesheets with)the different non-wood fibre contents. The multi-ply products where three-ply products formed by nesting.

Multi-ply product 1: G3A+ G3A+ G3A – i.e. 3 plies with 0% non-wood fibre, and fibre content by dry weight of the entire multi-ply product 1 is 0%.

Multi-ply product 2: G3B+G3B+ G3B – I.e. 3 plies with 20% non-wood fibre, and fibre content by dry weight of the entire multi-ply product 2 is 20%.

Multi-ply product 3: G3B+G3C+G3b – i.e. 2 plies with 20% non-wood fibre and 1 ply with 50% non-wood fibre, giving a fibre content by dry weight of the entire multi-ply product 3 being 30%.

Basis weight, thickness, tensile strength, softness panel and absorption were measured for the three multi-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT (N/m)	Softness panel	Absorption (g/g)
MP1	0%	55.2	0.71	623	234	382	4.4	9.2
MP2	20%	55.6	0.69	799	309	497	4.2	9.6
MP3	30%	56.5	0.73	695	252	418	4.3	9.6

Fig. 3 is a diagram over the absorption values of the three different multi-ply products MP1, MP2, and MP3. As seen from the table and in Fig. 3, the absorption of the multi-ply tissue paper products comprising 20% or 30% by dry weight of the non-wood fibres were even better than the absorption of the multi-ply tissue paper product comprising no non-wood further. Also, as indicated in the table in the above, the multi-ply tissue paper products comprising non-wood fibres displayed values for dry tensile strength and softness which were comparable to that of the multi-ply tissue paper product comprising no non-wood fibre.

In all, the results indicate that the multi-ply tissue paper products comprising non-wood fibres will display at least similar properties as the multi-ply tissue paper product comprising no non-wood fibre. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

Example 7: HYBRID tissue paper product

Two-ply tissue paper products intended for use as kitchen towels were formed comprising one ply being produced with structured tissue technology and one ply being produced with CWP (Conventional Wet Pressed) technology.

A reference two-ply tissue paper product (HYB1) comprising 0% non-wood fibres was formed from one tissue paper material ply produced by TAD technology being TP1 as described in Example 2 in the above, and one tissue paper material ply produced by CWP technology being G3-A as described in Example 3 in the above.

A two-ply tissue paper product (HYB2) comprising 25% non-wood fibres was formed from one tissue paper material ply produced by TAD technology and comprising 30% by dry weight non-wood fibre being TP3 as described in example 2 in the above, and one tissue paper material ply produced by CWP technology comprising 20% by dry weight non-wood fibre, being G3-B as described in example 3 in the above.

The two-ply tissue paper products were assembled by nesting.

Basis weight, thickness, tensile strength, softness panel and absorption were measured for the three multi-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT (N/m)	Softness panel	Absorption (g/g)
HYB1	0%	40.4	0.73	503	270	368	4.6	13.3
HYB2	25%	39.0	0.75	456	309	375	4.4	13.9

Fig. 4 is a diagram over the absorption values of the two two-ply tissue paper products HYB 1 and HYB2. As seen from the table above and in Fig. 4, the absorption of the multi-ply tissue paper product comprising 25% by dry weight of the non-wood fibres was even better than the absorption of the multi-ply tissue paper product comprising no non-wood. Also, as indicated in the table in the above, the multi-ply tissue paper product comprising non-wood fibres displayed values for dry tensile strength and softness which were comparable to that of the multi-ply tissue paper product comprising no non-wood fibre.

In all, the results indicate that the multi-ply tissue paper products comprising non-wood fibres will display at least similar properties as the multi-ply tissue paper product comprising no non-wood fibre. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

EXAMPLE 8: varying thickness

Two-ply tissue paper products comprising two plies made by TAD technology and similar to 2P-1 and 2P-2, as obtained in the above Example 2, were used as a starting point.

To vary the thickness of the two-ply products, the assembly of the two plies in each product was varied by varying the nip used when nesting the two plies together. Thus, one two-ply product with original thickness, one two-ply product with increased thickness, and one two-ply product with decreased thickness was formed for each of the qualities 2P-1 and 2P-2, as indicated in the above.

Basis weight, thickness, tensile strength, softness panel and absorption were measured for the two two-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	Softness panel	Absorption (g/g)
2P-1 Decreased thickness	0	42.5	0.71	707	507	5.0	13.3
2P-1 original	0	41.9	0.75	613	467	5.2	13.2
2P-1 Increased thickness	0	43.3	0.79	608	430	5.2	13.0
2P-2 Decreased thickness	30	40.5	0.73	513	488	4.6	14.3
2P-2 original	30	40.4	0.76	518	478	4.7	14.7
2P-2 Increased thickness	30	40.2	0.82	462	421	4.5	14.7

The absorption over thickness achieved for the two qualities 2P-1 and 2P-2 are illustrated in Fig. 5.

As may be seen in Fig. 5 and as indicated in the table above, the absorption of the two-ply paper tissue product 2P-2 comprising non-wood fibres is higher than the absorption the two-ply paper tissue product 2P-1 comprising no non-wood fibres for all of the various thicknesses.

Further, the results indicate that the absorption results are stable to thickness variations.

In all, the results indicate that the multi-ply tissue paper products comprising non-wood fibres will display at least similar properties as the multi-ply tissue paper product comprising no non-wood fibre. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

Although the results in the above were achieved for specific examples of tissue paper materials and tissue paper products, the finding that the non-wood cellulose pulp fibres and the non-wood plies as described herein are indeed suitable for forming tissue paper materials and tissue paper products may be applied to a wide range of such materials and products.

EXAMPLE 9: Non-wood pulp

Non-wood pulp was manufactured in the form of a never-dried cellulose fibre pulp derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. By analysis of samples taken during manufacture, the non-wood pulp was characterised as set out in the following table.

	Length weighted fiber length (µm)	Fiber width (µm)	Breaking length (m)	Breaking length / fiber length ratio
Minimum	785	19	5870	7.2
Average	862	20	6788	8.1
Maximum	965	22	7790	9.5
Number of data points	22	21	24	11

DEFINITIONS

Tissue paper material: The term "tissue paper material" as used herein refers to the one-ply base tissue as obtained from a tissue machine.

Layer: The tissue paper material may comprise one or more layers, i.e. it may be a single-layered or a multi-layered web. The term "layer" refers to a stratum within the web having

a defined fibre composition. The one or more layers is/are formed by depositing one or more streams of pulp furnishes onto a wire with a pressurized single-or multi-layered headbox.

Ply: The term "ply" as used herein refers to the one or more plies of tissue paper material in the final tissue paper product as are obtained after processes, i.e. converting, one or more base tissue webs. Each individual ply consists of a tissue paper material comprising one or more layers, e.g. one, two, or three layers.

Hardwood: As hardwood we understand herein fibrous pulp derived from the woody substance of deciduous trees (angiosperms). For example, hardwood includes eucalyptus. Typically, hardwood fibres are relatively short fibres. For example, the hardwood fibres may have an average fibre length less than 1700 µm. The hardwood fibres may for example have a diameter of 15 to 40 µm and a wall thickness of 3 to 5 µm.

Softwood: as softwood we understand fibrous pulp derived from the woody substance of coniferous trees (Gymnosperms). Typically, softwood fibres are relatively long fibres. For example, the softwood fibres may have an average fibre length above 1700 µm, such as above 1950 micron, for example the soft wood fibres may have an average fibre length in a range from 1700 to 2500. µm. The softwood fibres may for example have a diameter of from 30 to 80 µm, and a wall thickness of from 2 to 8 µm.

Conventional short fibres: As conventional short fibres we understand herein hardwood fibres as described in the above. Generally, the conventional short fibres may have an average fibre length less than 1700 µm.

Conventional long fibres: As conventional long fibres we understand herein softwood fibres as described in the above. Generally, the conventional long fibres may have an average fibre length greater than 1700 µm.

CWP & structured tissue technology:
As described in the above, paper tissue webs can be produced in several ways. Conventional paper machines have been used for many years for that purpose, to produce such conventional webs at a relatively low cost.

An example of a conventional paper tissue web process is the dry crepe process which involves creping on a drying cylinder, the so-called yankee cylinder, by means of a crepe doctor. Wet creping can be used as well, if there are lower demands on the tissue quality. The creped, finally dry raw tissue paper, the so-called base tissue, is then available for further processing into the paper product for a tissue paper product.

Recently, more advanced methods have been developed, such as e.g. Through Air Drying (TAD), Advanced Tissue Molding System (ATMOS) and similar methods for producing structured tissue webs. A common feature for these latter methods is that they result in a more structured web with a lower density than a web produced on a conventional paper machine.

As used herein the term CWP technology (Conventional Wet Pressed technology) refers to conventional paper web processes, in which the tissue is formed on a forming fabric and dewatered by pressing with one or more pressure roll nips. The process may involve transfer of the sheet to a Yankee dryer and removing the sheet from the Yankee surface by a doctor blade in a creping process. CWP technology as used herein includes for example dry crepe technology, wet crepe technology, and flat NTT (New Tissue Technology).

As used herein, the term structured tissue technology relates to the newer technologies for producing a structured tissue web. Such methods will not employ the high pressure used to dewater the web in the CWP process. Therefore, structured tissue technology is sometimes referred to as non-compressing de-watering technology. The structured tissue technology may for example be TAD (Thru-Air-Dried), UCTAD (Uncreped-Through-Air-Dried) or ATMOS (Advanced-Tissue- Molding-System), textured NTT, QRT, PrimeLineTEX technology and eTAD technology.

The structured tissue technology methods are known from prior art, for example TAD is known from US5853547; and ATMOS from US 7744726, US7550061 and US7527709; and UCTAD from EP 1 156925 and WO 02/40774.

TAD technology has been developed since the 1960's and is well known to a person skilled in the art. It generally involves developing functional properties of the tissue by moulding the fibre mat on a structured fabric. This results in the fibre mat forming a

structured tissue which may acquire high bulk and absorption due to air passing through the web while drying the web when still on the structured fabric.

ATMOS technology is a production method developed by Voith and which is also well known to a person skilled in the art.

Another example is textured NTT (New Tissue Technology). Textured NTT was designed to overcome some of the limitations of ATMOS by pressing at even higher pressures before transferring to the Yankee. A shoe press is used in the first pressing section between the former felt and a belt with cells designed to provide absorptive capacity and increase strength. The NTT technology may reduce the Yankee Hood drying load as compared to ATMOS.

Yet other examples are Prime Line Tex technology as rendered available by Andritz for production of textured tissue, and eTAD technology as rendered available by Valmet.

METHODS

Lignin content:

The measurement of residual lignin content in the pulp fibres has been carried out according to the draft standard ISO/DIS 21436: Pulps-Determination of lignin content – Method of acid hydrolysis 1), which includes:

i) the gravimetric measurement of the residue after acid hydrolysis (AIL : Acid Insoluble Lignin or Klason Lignin), also described in the Tappi T222 om-02 method 2 ; and

ii) the measurement of soluble lignin (ASL : Acid Soluble Lignin), also described in the technical note Tappi UM2503 .

3.1) Sample preparation: The samples were disintegrated with a grinder/mixer. Their dry matter contents were determined before analysis, by drying in an oven of an aliquot of 2-3 g at 105°C, according to the ISO 638 standard 4 .

3.2) Measurement of acid insoluble lignin (AIL or Klason lignin) after acid hydrolysis An aliquot of ~1 g was hydrolysed with a solution of sulfuric acid, firstly at ambient temperature (2 h) and then under reflux during 4 h (Procedure B of the future standard). After cooling, the suspension was filtered and washed and the solid residue was collected, dried and weighted. The acid insoluble lignin content in the sample was determined by difference between the dry hydrolysis residue weight and the ash weight, reported to the dry mass content of the initial sample. Note 1 : Detection limit (DL) ~0.1% ; Quantification limit (QL) ~0.5%.

3.3) Measurement of acid soluble lignin. The absorbance at 205 nm of the hydrolysate (i.e. the filtrate collected during the filtration of the suspension, cf 3.2), were measured. The acid soluble lignin content (ASL) was determined according to the predefined extinction coefficient of the lignin (i.e. 110 L/g.cm). Note 2 : : Detection limit (DL) ~0.1% ; Quantification Limit (QL) ~0.5% Remark: This quantification method is sensitive to the contaminants being present into the sample. Each compound other than hemicelluloses and cellulose and the acid insoluble minerals are susceptible to interfere with the measurement of the hydrolysis residue and with the acid soluble lignin.

Hemicellulose

The determination of the contents of the main polysaccharides in the pulp (arabinane, galactane, glucane, xylene, and mannane) has been made by using high performance anion exchange chromatography with a pulsed amerometric detector, HPAE/PAD-Dionex® analysis of free monosaccharides (arabinose, galactose, glucose, xylose and mannose) after sulphuric acid hydrolysis of the sample pulp. The cellulose and the hemicellulose content in the pulp sample is determined according to standard method ISO / DIS21437 – Pulps: Determination of carbohydrate (under publication) after calibration. The samples studied are chemical pulp which has not required extraction of aceton beforehand. In contrast, the samples have been dried. However, considering the pulp state (wet lap sheets), samples were grinded before analysis. Dry content of the grinded samples was measured according to NF EN ISO 638:2008.

Basically the method is quantifying the amounts of sugars (monosaccharides) after hydrolysis of cellulose and hemi using the ISO / DIS 21437 – Pulps: Determination of carbohydrate. Then, calculation is made backwards to estimate level of hemicelluloses (knowing proportion of sugars in hemi and cellulose)

Basis weight

Basis weight is determined in accordance with ISO 12625-6: 2016.

The basis weight is determined in g/m^2.

Thickness per sheet:

Thickness is determined in accordance with ISO 12625-3:2014.

GMT strength:

GMT strength (Geometric Mean Tensile strength) refers to the square root of the product of the machine direction dry tensile strength and the cross-direction dry tensile strength of a tissue web/product.

The GMT strength is determined in accordance with ISO 12625-4:2016.

A load cell of 100N was used.

Absorption:

Absorption is herein the water absorption capacity of the tissue paper. Water absorption capacity is the amount of water the sample is able to absorb, reported in g/g (i.e. g water / g material in sample).

Absorption was measured according to ISO12625-8:2010.

The water is deionized water, conductivity ≤ 0.25 mS/m at 25ºC, in accordance with ISO14487.

Softness panel:

Panel softness is determined by evaluation made by panel members. The panelists rank products in terms of softness. The Softness Panel values are therefore comparative values enabling a comparison between the samples tested, rather than an absolute parameter.

The softer the product/tissue base sheet is rated the higher the value will be.

Softness values of tissue paper products (finished goods) and tissue base sheets are not directly comparable as there are different scales/reference products.

Each sample is composed of one product, i.e. a multi-ply tissue paper product.

The dimensions of the samples are therefore the dimensions of the finished products.

Samples are placed in MD before the panelists.

Samples are conditioned for minimum 2 hours in a controlled area at 23ºC and 50% relative humidity.

The different samples are comfort rated by five or ten panelists, and an average comfort rating for each product is determined over the panelists.

Hence, softness panel values are comparative values within a test and indicate the perceived softness of a product.

For the purpose of this application, softness panel values given in one and the same table are comparable and indicate the perceived relative softness of the products tested. The higher the value of the rating, the more comfortable is the product.

Average fibre length measurement:

Fibre length measurement was made using the standard for fibre analyser: ISO 16065-2:2014: Pulps – Determination of fibre length by automated optical analysis – Part 1: Unpolarized light method.

Length-weighted mean length was used and the average of the length – weighted fibre-length distribution.

Breaking length measurement

The breaking length is the calculated upper limit of length of a uniform paper strip that would support its own weight if it were suspended at one end. Breaking length (m) = 102 x T/R, where T = Tensile strength, N/m, and R = basis weight, g/m2.

The breaking length is a pulp characteristic obtained by tensile strength and basis weight measurements as measured on lab handsheets produced in accordance with EN ISO 5269-2. (Tensile strength: ISO 12625-4:2016; basis weight: ISO 12625-6: 2016)

Ratio of breaking length measurement/average fibre length measurement

The ratio of breaking length/average fibre length is herein using the values of the fibre length measurement and the breaking length measurements as achieved according to the methods in the above, the average fibre length measurement being reported in µm, and the breaking length being reported in m.

It may be noted that the breaking length, as well as the average fibre length, are pulp characteristics. Accordingly, the measurements of these properties are to be performed on the pulp as received from the pulping process, before reaching the papermaking process, such as before entering the stock preparation in a paper machine. Thus, the measurements are done prior to any mechanical and/or chemical and/or enzymatic treatment for strength adjustment which may occur during the paper making process.

Ball-burst

Ball-burst is determined according to ISO 12625-9:2015.

Fiber width

Fiber width is herein determined using a Morfi fiber analyzer.

ITEMIZED LIST OF EMBODIMENTS

1. A single-ply tissue paper material having a basis weight less than 40 gsm and an absorbency of at least 3 g/g, comprising a non-wood tissue ply, said non-wood tissue ply
comprising non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

2. A single-ply tissue paper material according to item 1, wherein the tissue paper material has an absorbency of at least 4 g/g.

3. A single-ply tissue paper material according to any one of the previous items, wherein the tissue paper material has an absorbency of at least 5 g/g.

4. A single-ply tissue paper material according to any one of the previous items being produced by CWP (Conventional Wet Pressed) technology.

5. A single-ply tissue paper material according to any one of the items 1 to 3, being produced by structured tissue technology and having an absorbency of at least 6 g/g.

6. A single-ply tissue paper material according to any one of the items 1 to 3, being produced by structured tissue technology and having an absorbency of at least 7 g/g.

7. A single-ply tissue paper material according to any one of the items 1 to 3, being produced by structured tissue technology and having an absorbency of at least 8 g/g.

8. A single-ply tissue paper material according to any one of the previous items, wherein the tissue paper material has a GMT tensile strength of at least 60 N/m.

9. A single-ply tissue paper material according to any one of the previous items, wherein the tissue paper material has a GMT tensile strength of at least 70 N/m.

10. A single-ply tissue paper material according to any one of the previous items, wherein the tissue paper material has a GMT tensile strength of at least 80 N/m.

11. A single-ply tissue paper material according to any one of the preceding items, having a basis weight of less than 30 gsm.

12. A single-ply tissue paper material according to any one of the preceding items, having a basis weight of less than 25 gsm.

13. A single-ply tissue paper material according to any one of the preceding items, having a basis weight of more than 10 gsm.

14. A single-ply tissue paper material according to any one of the preceding items, having a basis weight of more than 15 gsm.

15. A single-ply tissue paper product comprising a single-ply tissue paper material according to any one of the items 1 to 14.

16. A multi-ply tissue paper product comprising two or more plies, wherein an average basis weight of the plies is less than 40 gsm, and the multi-ply tissue paper product having an absorption of at least 4 g/g, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

17. A multi-ply tissue paper product according to item 16, wherein the multi-ply tissue paper product has an absorbency of at least 5 g/g.

18. A multi-ply tissue paper product according to item 16 or 17, wherein multi-ply tissue paper product has an absorbency of at least 6 g/g.

19. A multi-ply tissue paper product according to any one of the items 16 to 18, wherein at least one ply of the multi-ply tissue paper product is produced by CWP (Conventional Wet Pressed) technology.

20. A multi-ply tissue paper product according to any one of the previous items, wherein at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 7 g/g.

21. A multi-ply tissue paper product according to any one of the previous items, wherein at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 8 g/g.

22. A multi-ply tissue paper product according to any one of the previous items, wherein at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 9 g/g.

23. A multi-ply tissue paper product according to any one of the previous items but item 19, wherein all plies of the multi-ply tissue paper product are produced by structured tissue technology.

24. A multi-ply tissue paper product according to any one of the items 16 to 23, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 100 N/m.

25. A multi-ply tissue paper product according to any one of the items 16 to 24, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m.

26. A multi-ply tissue paper product according to any one of the items 16 to 25, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 150 N/m.

27. A multi-ply tissue paper product according to any one of the items 16 to 26, wherein at least 50 % of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply
comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

28. A multi-ply tissue paper product according to any one of the items 16 to 27, wherein all of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply
comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

29. A multi-ply tissue paper product according to any one of the items 16 to 28, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.

30. A multi-ply tissue paper product according to any one of the items 16 to 29, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the multi-ply tissue paper product.

31. A multi-ply tissue paper product according to any one of the items 16 to 30, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.

32. A multi-ply tissue paper product according to any one of the items 16 to 31, wherein said multi-ply tissue paper material or product comprises two to five plies.

33. A multi-ply tissue paper product according to any one of the items 16 to 32, wherein each ply of the multi-ply product comprises the same amount of non-wood cellulose pulp fibres.

34. A multi-ply tissue paper product according to any one of the items 16 to 33, wherein at least two plies comprise different amounts of non-wood cellulose pulp fibres.

35. A multi-ply tissue paper product according to any one of the items 16 to 34, wherein said at least one non-wood tissue ply is an outer ply of said multi-ply tissue paper material.

36. A multi-ply tissue paper product according to item 35, wherein the multi-ply tissue paper material comprises at least two non-wood tissue plies, the non-wood tissue plies forming a first and a second outer ply of the multi-ply tissue paper product.

37. A multi-ply tissue paper product according to any one of the items 16 to 36, wherein said non-wood tissue ply is formed by a single-ply tissue paper material in accordance with any one of items 1 to 14.

38. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres contain at least 15% hemicellulose.

39. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres contain no more than 15 % lignin.

40. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1700 µm.

41. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1200 µm.

42. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1000 µm or less than 900 µm.

43. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose fibres have a breaking length of more than 3000 m or more than 5500 m.

44. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 3.7.

45. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.0.

46. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein

the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.5, such as more than 5, more than 5.5 or more than 6.5.

47. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres are derived from a member of the Pocacea family, such as from wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, sugar cane bagasse and/or sorghum.

48. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres are derived from a member of the Cannabaceae family, such as from hemp and/or hop.

49. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres are agricultural waste or byproduct, such as derived from agricultural waste or byproduct of the Pocacea family and/or Cannabaceae family such as exemplified in the above, including agricultural waste or byproduct from wheat straw, rice straw, barley straw, oat straw, rye grass, sugar cane bagasse, hemp or hop and/or wherein the non-wood cellulose pulp fibres are derived from agricultural waste or byproduct such as banana harvest residue (belongs to the family Musaceae), pineapple residue (belongs to the family Bromeliaceae), nut shell waste, bagasse from agave, hop residue and/or corn stover.

50. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein the non-wood cellulose pulp fibres are derived from kenaf (belongs to the family Malvaceae), switchgrass , succulents, alfalfa (belongs to the family Fabaceae), flax straw (belongs to the family Linaceae), palm fruits (Elaeis or Arecaceae), and/or avocado (Lauraceae).

51. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 15%.

52. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 20%.

53. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 70 % by dry weight.

54. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 60 % by dry weight.

55. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein said non-wood tissue ply further comprises wood pulp fibres, such as hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

56. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to item 55, wherein said non-wood tissue ply comprises wood pulp fibres in an amount such that the wood pulp fibre amount plus the non-wood fibre amount constitutes 100% dry weight of the non-wood tissue ply.

57. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to item 55 or 56, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 95/5.

58. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the items 55 to 57, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 90/10.

59. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the items 55 to 58, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 80/20.

60. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the previous items, wherein said non-wood cellulose pulp fibres are present throughout the non-wood tissue ply or plies.

61. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the previous items, wherein said non-wood tissue ply or plies comprises two or more layers, and at least one layer comprises non-wood cellulose pulp fibres.

62. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, said non-wood tissue ply or plies being produced by conventional wet press technology (CWP).

63. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, said non-wood tissue ply or plies being produced by structured tissue technology, for example TAD (Through Air Drying), ATMOS, textured NTT, UCTAD, eTAD, QRT or PrimeLineTEX.

64. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, wherein a portion or all non-wood cellulose pulp fibres are never-dried non-wood cellulose pulp fibre.

65. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, comprising softwood cellulose pulp fibres and wherein a portion or all softwood cellulose fibres are never-dried softwood cellulose pulp fibre.

66. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding items, comprising hardwood cellulose pulp fibres and wherein a portion or all hardwood cellulose fibres are never-dried hardwood cellulose pulp fibre.

67. Single-ply tissue paper product or multi-ply tissue paper product according to any one of the items 15 to 66, the tissue paper product being for personal hygiene, such as toilet paper, hand wipes, paper napkins, facial wipes, handkerchiefs or the tissue paper product being a kitchen towel or industrial wipe.

CLAIMS

1. A single-ply tissue paper material having a basis weight less than 40 gsm and a GMT tensile strength of at least 60 N/m, comprising a non-wood tissue ply, said non-wood tissue ply
comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

2. A single-ply tissue paper material according claim 1, wherein the tissue paper material has a GMT tensile strength of at least 70 N/m.

3. A single-ply tissue paper material according claim 1 or 2, wherein the tissue paper material has a GMT tensile strength of at least 80 N/m.

4. A single-ply tissue paper material according to any one of the preceding claims, having a basis weight of less than 30 gsm.

5. A single-ply tissue paper material according to any one of the preceding claims, having a basis weight of less than 25 gsm.

6. A single-ply tissue paper product consisting of a single-ply tissue paper material according to any one of the claims 1 to 5.

7. A multi-ply tissue paper product comprising two or more plies, wherein an average basis weight of the plies is less than 40 gsm, and the multi-ply tissue paper product having a GMT tensile strength of at least 100 N/m, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply
comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

8. A multi-ply tissue paper product according to claim 7,
wherein the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m.

9. A multi-ply tissue paper product according to claim 7 or 8, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 150 N/m.

10. A multi-ply tissue paper product according to any one of the claims 7 to 9, wherein at least 50 % of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

11. A multi-ply tissue paper product according to any one of the claims 7 to 10, wherein all of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

12. A multi-ply tissue paper product according to any one of the claims 7 to 11, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.

13. A multi-ply tissue paper product according to any one of the claims 7 to 12, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the multi-ply tissue paper product.

14. A multi-ply tissue paper product according to any one of the claims 7 to 13, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.

15. A multi-ply tissue paper product according to any one of the claims 7 to 14, wherein said multi-ply tissue paper material or product comprises two to five plies.

16. A multi-ply tissue paper product according to any one of the claims 7 to 15, wherein each ply of the multi-ply product comprises the same amount of non-wood cellulose pulp fibres.

17. A multi-ply tissue paper product according to any one of the claims 7 to 15, wherein at least two plies comprise different amounts of non-wood cellulose pulp fibres.

18. A multi-ply tissue paper product according to any one of the claims 7 to 17, wherein said at least one non-wood tissue ply is an outer ply of said multi-ply tissue paper material.

19. A multi-ply tissue paper product according to claim 18, wherein the multi-ply tissue paper material comprises at least two non-wood tissue plies, the non-wood tissue plies forming a first and a second outer ply of the multi-ply tissue paper product.

20. A multi-ply tissue paper product according to any one of the claims 7 to 19, wherein said non-wood tissue ply is formed by a single-ply tissue paper material in accordance with any one of claims 1 to 5.

21. A single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 6 to 20, wherein the tissue paper product has an absorbency of at least 7 g/g.

22. A single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 6 to 21, wherein the tissue paper product has an absorbency of at least 8 g/g.

23. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres contain at least 15% hemicellulose.

24. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres contain no more than 15 % lignin.

25. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein

the non-wood cellulose pulp fibres have an average fibre length of less than 1700 µm.

26. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1200 µm.

27. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1000 µm or less than 900 µm.

28. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length of more than 3000 m or more than 5500 m.

29. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 3.7.

30. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.0.

31. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.5, such as more than 5, more than 5.5 or more than 6.5.

32. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from a member of the Pocacea

family, such as from wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, sugar cane bagasse and/or sorghum.

33. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from a member of the Cannabaceae family, such as from hemp and/or hop.

34. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are agricultural waste or byproduct, such as derived from agricultural waste or byproduct of the Pocacea family and/or Cannabaceae family such as exemplified in the above, including agricultural waste or byproduct from wheat straw, rice straw, barley straw, oat straw, rye grass, sugar cane bagasse, hemp or hop and/or wherein the non-wood cellulose pulp fibres are derived from agricultural waste or byproduct such as banana harvest residue (belongs to the family Musaceae), pineapple residue (belongs to the family Bromeliaceae), nut shell waste, bagasse from agave, hop residue and/or corn stover.

35. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from kenaf (belongs to the family Malvaceae) , switchgrass , succulents, alfalfa (belongs to the family Fabaceae.), flax straw (belongs to the family Linaceae), palm fruits (Elaeis or Arecaceae), and/or avocado (Lauraceae).

36. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 15%.

37. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein

said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 20% by dry weight.

38. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 70 % by dry weight.

39. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 60 % by dry weight.

40. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply further comprises wood pulp fibres, such as hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

41. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to claim 40, wherein said non-wood tissue ply comprises wood pulp fibres in an amount such that the wood pulp fibre amount plus the non-wood fibre amount constitutes 100% dry weight of the non-wood tissue ply.

42. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to claim 40 or 41, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 95/5.

43. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 40 to 42, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 90/10.

44. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 40 to 43, wherein

the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 80/20.

45. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood cellulose pulp fibres are present throughout the non-wood tissue ply or plies.

46. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises two or more layers, and at least one layer comprises non-wood fibres.

47. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, said non-wood tissue ply or plies being produced by conventional wet press technology (CWP).

48. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, said non-wood tissue ply or plies being produced by structured tissue technology, for example TAD (Through Air Drying), ATMOS, NTT(textured), UCTAD, QRT, eTAD or PrimeLineTEX.

49. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein a portion of or all non-wood cellulose pulp fibres are never-dried non-wood cellulose pulp fibre.

50. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, comprising softwood cellulose pulp fibres and wherein a portion of or all softwood cellulose fibres are never-dried softwood cellulose pulp fibre.

51. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims,

comprising hardwood cellulose pulp fibres and wherein a portion of or all hardwood cellulose fibres are never-dried hardwood cellulose pulp fibre.

52. Single-ply tissue paper product or multi-ply tissue paper product according to any one of the claims 6 to 51, the tissue paper product being for personal hygiene, such as toilet paper, hand wipes, paper napkins, facial wipes, handkerchiefs or the tissue paper product being a kitchen towel or industrial wipe.

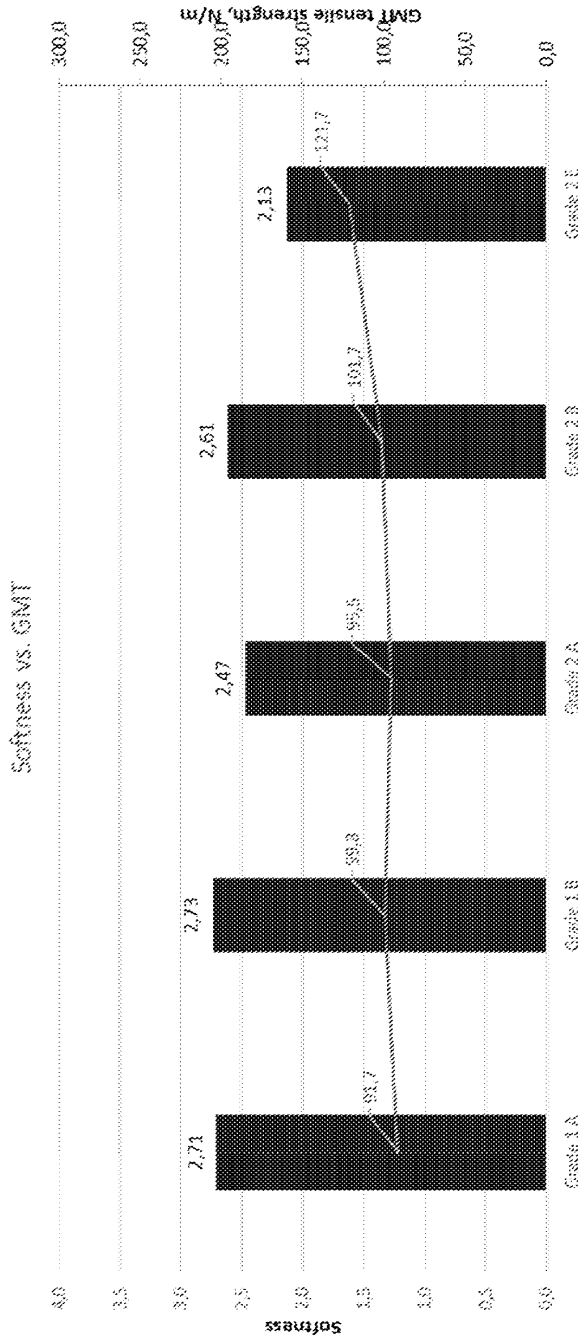

Softness vs. GMT
GMT tensile strength, N/m
300,0
250,0
200,0
150,0
100,0
50,0
0,0
Softness
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
2,71
2,73
2,47
2,61
2,13
121,7
103,7
95,5
89,8
85,7
Grade 1A
Grade 1B
Grade 2A
Grade 2B
Grade 2C

Fig. 1



Fig. 2

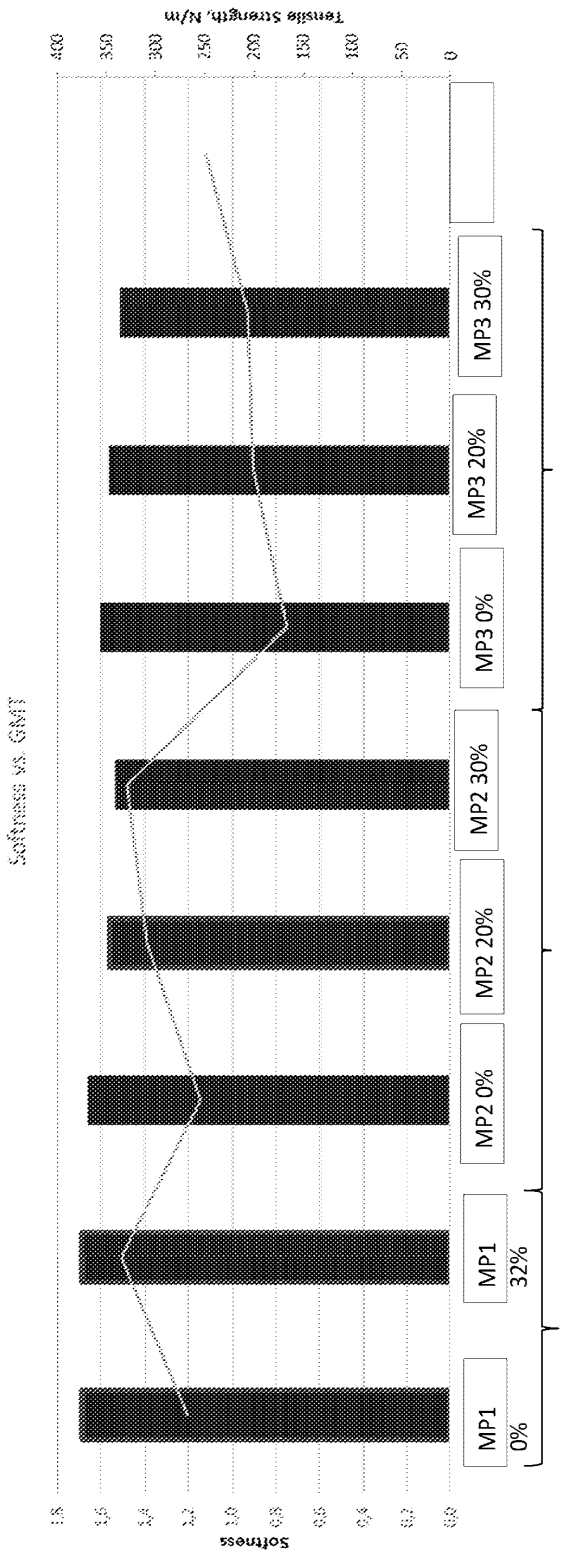

Softness vs. GMT
Softness
Tensile Strength, N/m
MP1 0%
MP1 32%
MP2 0%
MP2 20%
MP2 30%
MP3 0%
MP3 20%
MP3 30%
MP1
MP2
MP3

Fig. 3

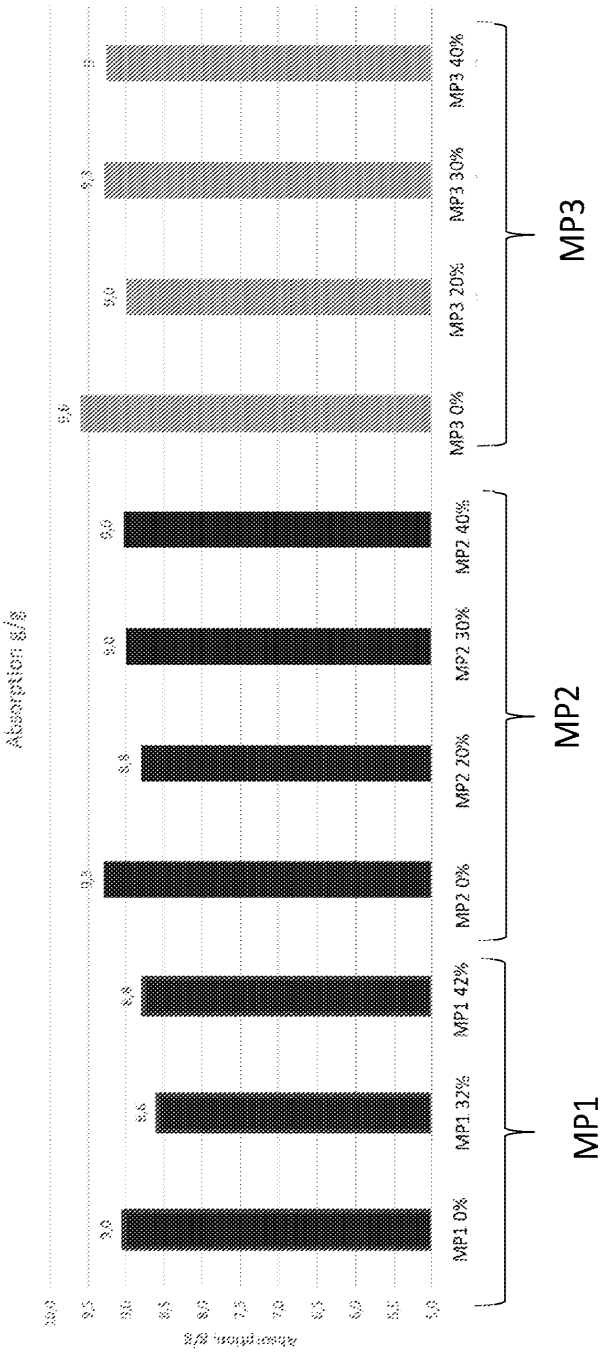


Fig. 4

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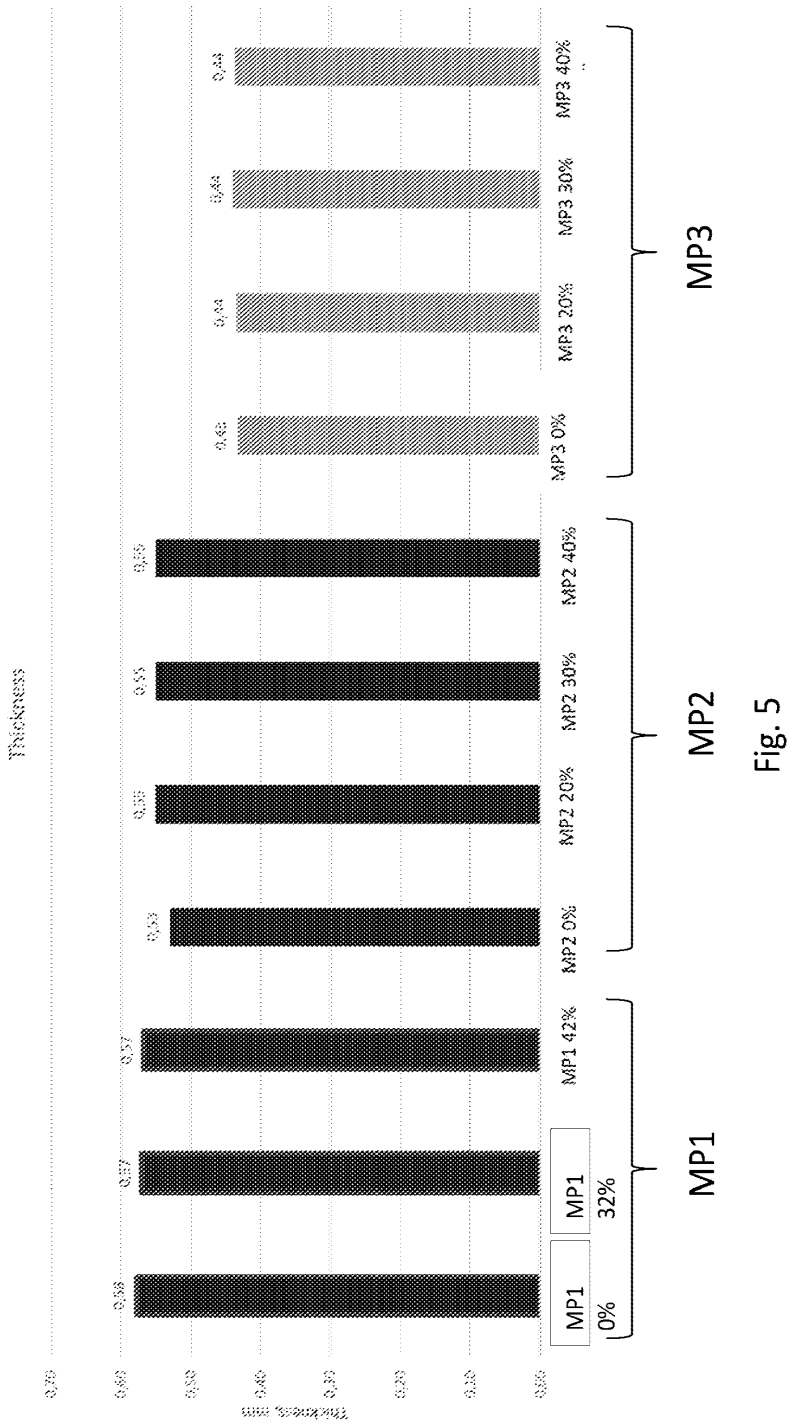

Thickness
Thickness, mm
0,70
0,60
0,50
0,40
0,30
0,20
0,10
0,00
0,58
0,57
0,57
0,53
0,55
0,55
0,55
0,44
0,44
0,44
MP1 0%
MP1 32%
MP1 42%
MP2 0%
MP2 20%
MP2 30%
MP2 40%
MP3 0%
MP3 20%
MP3 30%
MP3 40%
MP1
MP2
MP3

Fig. 5

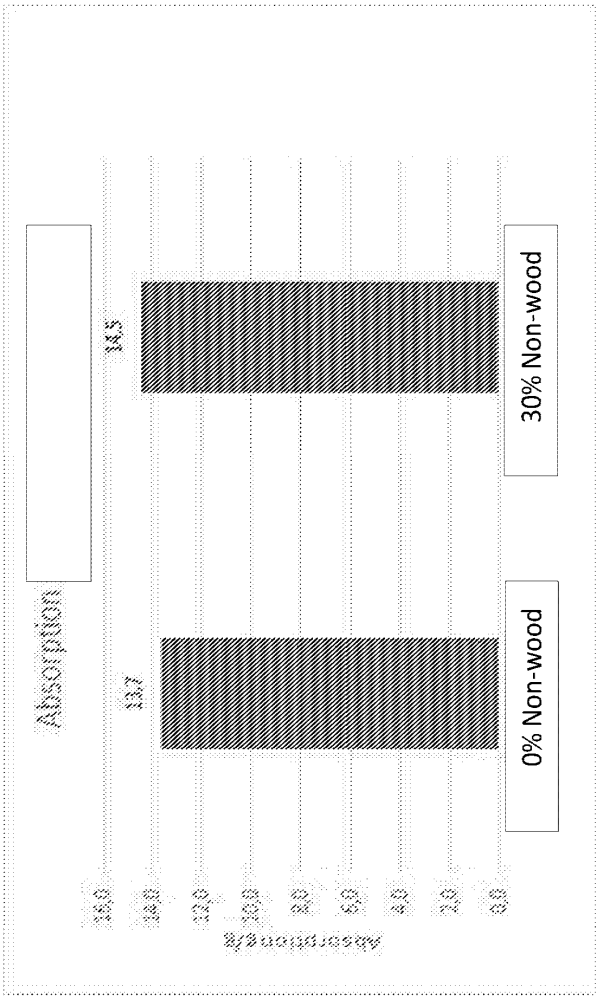

Absorption
14.5
13.7
30% Non-wood
0% Non-wood
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Absorption g/g

Fig. 6

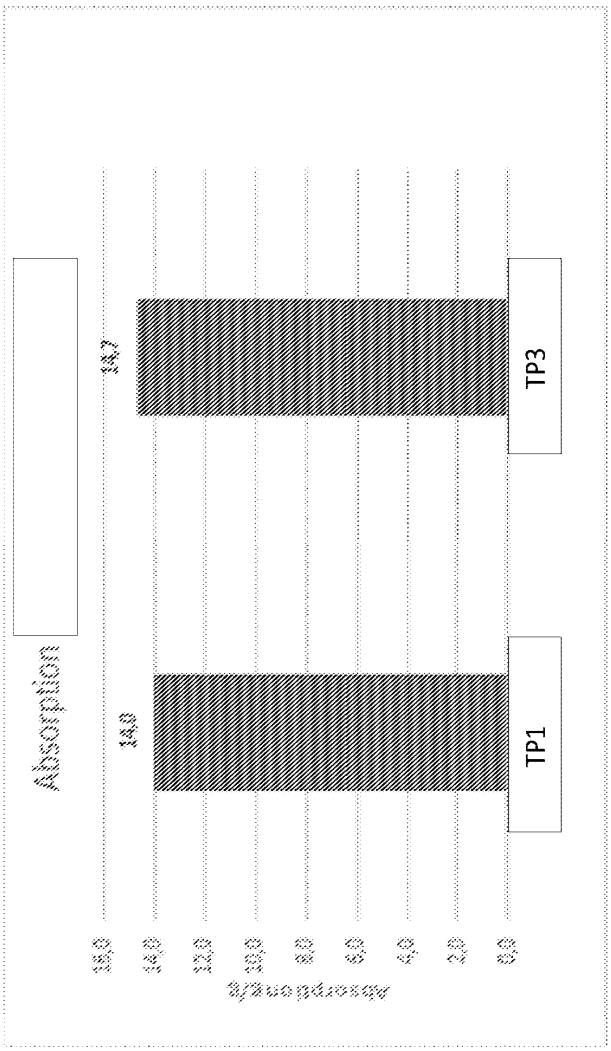

Absorption
14.7
14.0
TP3
TP1
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Wavenumber

Fig. 7a

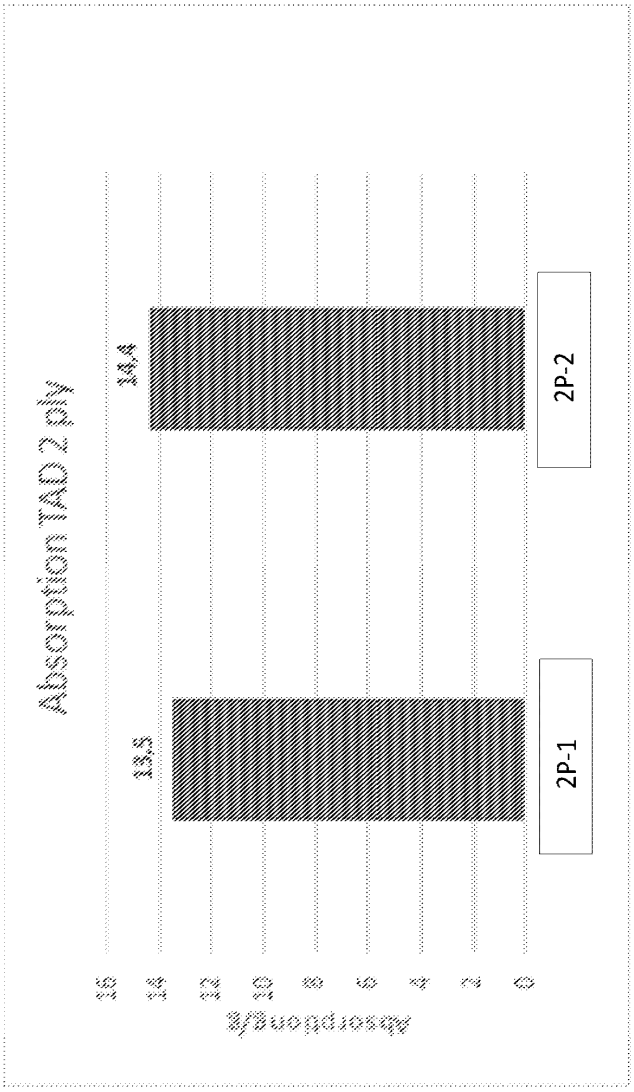

Absorption TAD 2 g/y
13,5
14,4
2P-1
2P-2
Absorption g/h
16
14
12
10
8
6
4
2
0

Fig. 7b

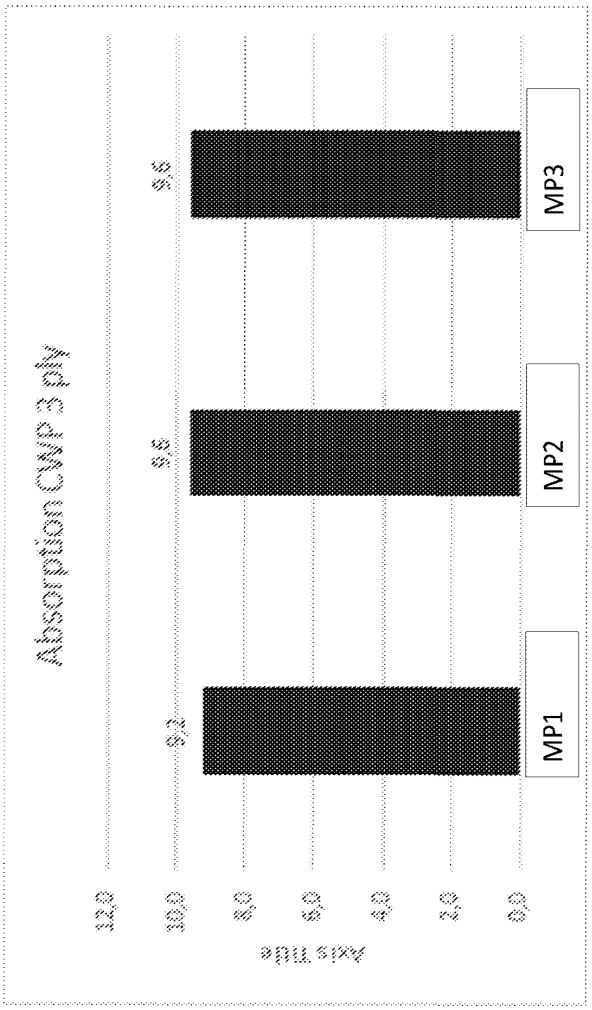

Absorption CWP 3 gly
Axis Title
120
100
80
60
40
20
0
92
88
88
MP1
MP2
MP3

Fig. 8

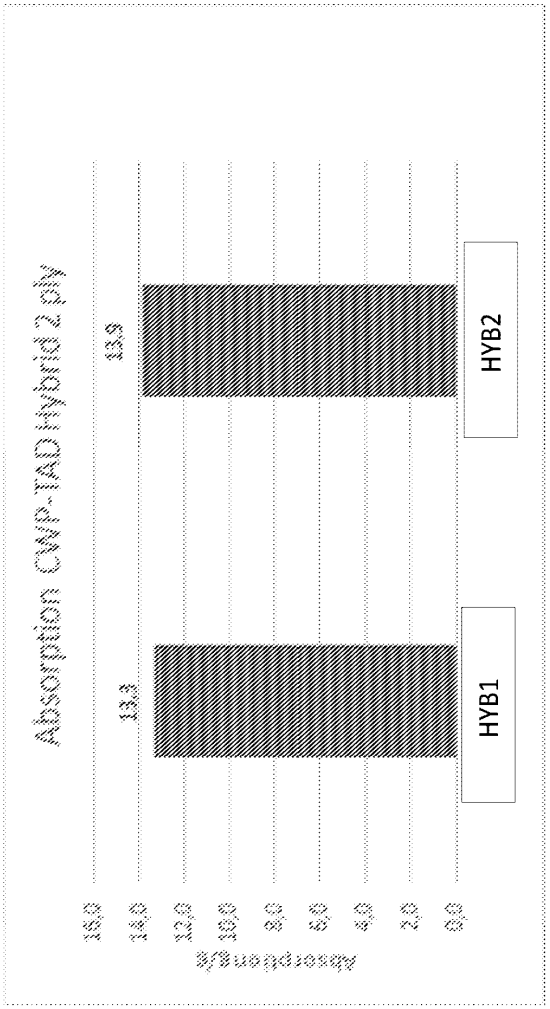

Absorption CWP-TAD hybrid 2 ply
13.3
13.9
HYB1
HYB2
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Absorption g/g%

Fig. 9

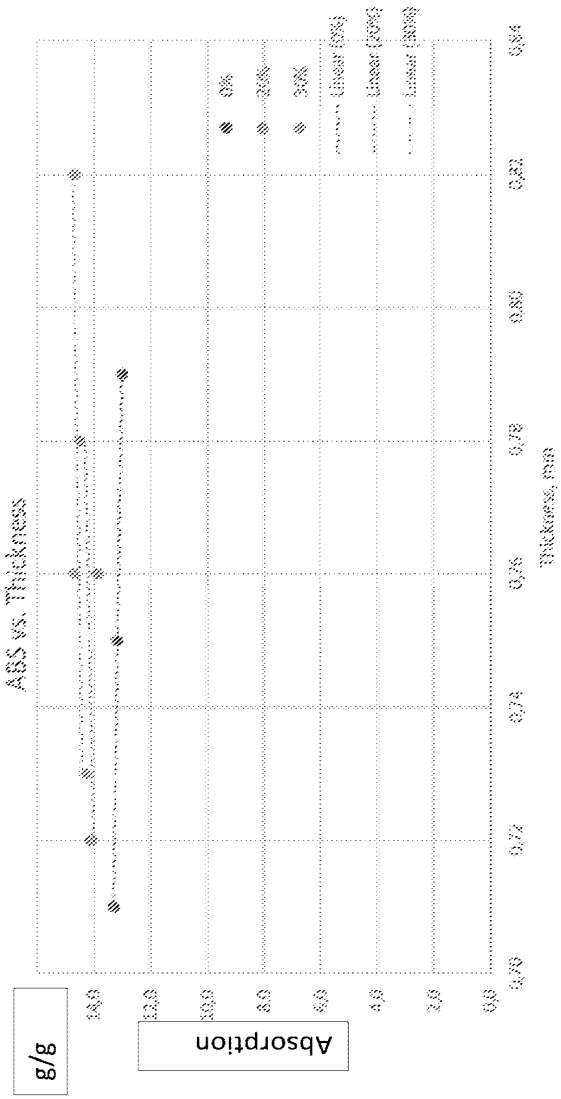

ABS vs. Thickness
Absorption
g/g
Thickness, mm
0%
20%
30%
Linear (0%)
Linear (20%)
Linear (30%)

Fig. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2022/050598

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: A47K, D21F, D21H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20180142419 A1 (ROUSE KAYLA ELIZABETH ET AL), 24 May 2018 (2018-05-24); paragraphs [0001], [0047], [0066]; Table 4	1-3, 21-23, 27-31, 33-35, 42-44, 46-48, 50-52
A	--	4-20, 24-26, 32, 36-41, 45, 49
X	US 20200232166 A1 (ROUSE KAYLA ELIZABETH ET AL), 23 July 2020 (2020-07-23); paragraphs [0005], [0010], [0021], [0052], [0069]-[0073]; claim 1; Tables 2-3	7-10, 12-15, 17-19, 21-23, 25-27-35, 38-48, 50-52
A	--	1-6, 11, 16, 20, 24, 36-37, 49

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11-07-2022	11-07-2022

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	John Sjöberg Telephone No. + 46 8 782 28 00

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20130071678 A1 (SHANNON THOMAS GERARD), 21 March 2013 (2013-03-21); paragraphs [0057], [0107]; claims 9,16; Table 6	1, 4-9, 11-17, 20-23, 27-31, 33-37, 42-44, 46-51
A		2-3, 10, 18-19, 24-26, 32, 38-42, 45
	--	
X	US 20190100878 A1 (SHANNON THOMAS GERARD ET AL), 4 April 2019 (2019-04-04); paragraphs [0017], [0026], [0050], [0027]; claims 14,16	1, 6, 12-13, 21-24, 27-31, 33-35, 42-44, 46-48, 50-51
A		2-5, 7-11, 14-20, 25-26, 32, 36-41, 45, 49, 52
	--	
X	US 10428465 B2 (ROUSE KAYLA ELIZABETH ET AL), 1 October 2019 (2019-10-01); column 13, line 40 - column 14, line 18; column 15, line 54 - column 15, line 56; claims 1,4	1, 6, 23-24, 27-31, 33-35, 42-44, 46, 50-51
A		2-5, 7-22, 25-26, 36-41, 45, 47-49, 52
	--	
X	US 20180135248 A1 (COLLINS LYNDA ELLEN ET AL), 17 May 2018 (2018-05-17); paragraph [0051]; claims 1,12,15; Table 5	1, 6, 23-24, 27-31, 33-35, 42-44, 46-48, 50-51
A		2-5, 7-22, 25-26, 36-41, 45, 49, 52
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X	US 20180142421 A1 (ROUSE KAYLA ELIZABETH ET AL), 24 May 2018 (2018-05-24); paragraph [0045]; claims 1,7-8	7, 23, 27-31, 33-35, 42-44, 46-48, 50-51
A		1-6, 8-22, 24-26, 36-41, 45, 49, 52
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2022/050598

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.

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PGR2026-00078

Continuation of: second sheet

International Patent Classification (IPC)

D21H 27/00 (2006.01)
D21H 11/12 (2006.01)
A47K 10/00 (2006.01)
A47K 10/16 (2006.01)
D21F 11/14 (2006.01)
D21H 27/38 (2006.01)

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				GB	2574744	B	22/06/2022
				KR	20190116335	A	14/10/2019
				MX	2019008742	A	02/10/2019
				US	20210292973	A1	23/09/2021
				US	11053643	B2	06/07/2021
				WO	2018156109	A1	30/08/2018
US	20130071678	A1	21/03/2013	AU	2012311164	B2	22/01/2015
				BR	112014005592	A2	21/03/2017
				CA	2847064	A1	28/03/2013
				CN	103814173	B	02/03/2016
				CO	6910179	A2	31/03/2014
				EP	2758593	B1	20/03/2019
				KR	101497884	B1	02/03/2015
				KR	20140068073	A	05/06/2014
				MX	2014002400	A	05/06/2014
				MX	337233	B	18/02/2016
				SA	112330828	B1	06/12/2015
				TW	I577855	B	11/04/2017
				TW	201319358	A	16/05/2013
				US	8524374	B2	03/09/2013
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				US	20160069029	A1	10/03/2016
				US	20140284010	A1	25/09/2014
				US	20130299107	A1	14/11/2013
				US	9222224	B2	29/12/2015
				US	8778505	B2	15/07/2014
				WO	2013041986	A2	28/03/2013
US	20190100878	A1	04/04/2019	AU	2015397128	B2	16/07/2020
				BR	112017024038	A2	24/07/2018
				EP	3302200	B1	07/10/2020
				ES	2838799	T3	02/07/2021
				KR	20180013965	A	07/02/2018
				MX	2017014274	A	20/04/2018
				US	10145066	B2	04/12/2018
				US	10519601	B2	31/12/2019
				US	20180135249	A1	17/05/2018
				WO	2016195627	A1	08/12/2016
US	10428465	B2	01/10/2019	NONE			

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				US	10132036	B2	20/11/2018
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				US	20200102705	A1	02/04/2020
				US	10947673	B2	16/03/2021
				US	20210156093	A1	27/05/2021

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(25) Filing Language: English

(26) Publication Language: English

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(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **ANDERSSON, Anders** [SE/SE]; Skäppargränd 4a, S-444 31 Stenungsund (SE).

(74) Agent: **Valea AB**; Lindholmspiren 5, S-417 56 Göteborg (SE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

WO 2010/008331 A1

(54) Title: STACK OF FOLDED MATERIAL

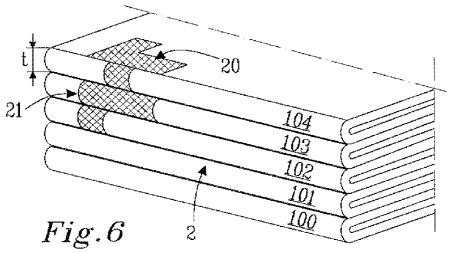


Fig. 6

(57) Abstract: A stack (1) comprising one or more web-shaped materials (12, 23), at least one of said web-shaped materials having a visual pattern (20), wherein a similar pattern is seen as an edge pattern (21) on a face side (2) of the stack. There is also provided a method to produce such a stack.

STACK OF FOLDED MATERIAL

TECHNICAL FIELD

The present invention relates to a stack of folded material, such as paper or nonwoven. More particularly, it relates to a stack of tissue products such as toilet and kitchen paper, paper towels, handkerchiefs, wiping material and the like. The invention further relates to a method of forming a stack.

BACKGROUND OF THE INVENTION

Products made of web-shaped material, like paper or nonwoven, are traditionally used for a number of applications at home, in industry, office, public areas etc. Examples of such products are toilet paper, household towels, napkins, facial tissue, handkerchiefs, hand towels and wiping materials. Different applications place different demands on the product. In many cases, it is desired that the products have a pleasing visual appearance and/or a visual appearance that should communicate a message, e.g. the logotype of the company producing or selling the products.

It is well-known in the art to apply visually pleasing visible patterns on a web-shaped material in order to improve the visual appearance. The pattern may for example be printed or applied by using coloured adhesive.

For some of the above-mentioned products, the manufacturing comprises a step, wherein one or more of the web-shaped material is/are folded into stacks. Normally, there is also a preceding step, wherein the web-shaped material is divided into individual sheets by e.g. perforation lines or cutting lines. Examples of products that are normally sold in stacks are facial tissue, hand towels, wiping materials and napkins. Also toilet paper and household towels are sometimes sold in folded stacks. For this kind of products, there is normally no synchronization between an applied visible pattern and the distance between the folds or the sheet size. When the web-shaped material is folded into a stack, the sides of the stack constituted by the folds of the web-shaped material will therefore have an arbitrary pattern, which may impair the total visual appearance of the stack. Furthermore, since the applied visible pattern is often indicative of the type or function of the material from which

the stack is made, this characteristic is not ascertainable when viewing the sides of the stack.

WO 01/09023 (The Procter & Gamble Company) discloses how a pattern, called indicia, can be applied to the end surfaces of a rolled paper product providing a functional benefit or an aesthetically-pleasing pattern. In an alternative embodiment a cut-and-stack configuration is described, e.g. facial tissue, with a pattern on at least one edge. It is also said that the planar surface of the sheets may be printed. In an embodiment shown in Fig. 2 of the document, the pattern on the end surface of the roll continues over the circumferential (or xy-) surface of the roll. The document further states that the indicia on the end surfaces could be aesthetically coordinated with the xy-surface print, e.g. the end surfaces could have small animals and the xy-surface large animals which match the small ones. According to the document WO 01/09023, the indicia are preferably applied to the end surfaces of the paper product by printing.

Since printing on the end surfaces implies an extra process step, the manufacturing will consequently be more complex and costly. In order to keep the "aesthetical coordination" between the xy-surface and the indicia at the end surfaces, the patterns of different application units, printing the xy-surface and end surfaces respectively, should be matched to each other from a pattern design point of view. If a pattern change is made, both the xy-pattern and the end surface pattern must be exchanged simultaneously.

There is therefore a need for a method, which in a more simple way can provide a visually pleasing product having a visually pleasing planar surface as well as visually pleasing sides of the stack. There is a further need for a product in the form of a stack, which stack is more readily identifiable.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a stack which is more readily identifiable.

This object is achieved in accordance with the present invention by providing a stack according to claim 1. The stack is formed from an intermediate web, the stack having a first face side and a second face side, the first and second face sides facing in opposite directions, the first face side comprising a first plurality of edge portions formed by a first

set of folds in the intermediate web and the second side face comprising a second plurality of edge portions formed by a second set of folds in the intermediate web, the edge portions having a thickness (t), the intermediate web comprising at least a first web-shaped material having a web extension direction, the first web-shaped material being provided with a first visible pattern having a repeat length (r) in the web extension direction of the first web-shaped material, wherein adjacent folds of the first set of folds are separated by a distance L in the web extension direction along the first web-shaped material, and adjacent folds of the second set of folds are separated by the distance L in the web extension direction along the first web-shaped material such that the distance L satisfies the equation:

$L = n \cdot r + k \cdot t$

where n is a positive integer, r is the repeat length, t is the edge portion thickness and k is a constant, with k being selected such that an edge pattern is formed on at least one of the first and second face sides of the stack, which edge pattern approximates the first visible pattern on the first web-shaped material.

By appropriate choice of k, an aesthetic effect of having a similar pattern to the first visible pattern on the first web-shaped material on at least one face side of the stack is achieved. This can for example be used when marketing and using such stacks, since it will be possible to visually ascertain what the stack contains without having to open the stack. The visual design is strengthened since a similar pattern is used both on the planar surface of the first web-shaped material and on at least one face side of the stack. Purely as an example, a user pulling a hand towel from an at least partly transparent or open dispenser, wherein the stack can be seen, will notice that his towel has the same pattern as the stack. The facilitator will easily be able to refill the dispenser with the same kind of stack again, since he/she sees from the outside of the stack what visible pattern has been used.

In one embodiment both face sides of the stack fulfil the equation $L = n \cdot r + k \cdot t$ as defined above. Both face sides may have the same set of parameter values for L, n, r, k, and t, i.e. they could have the same pattern. An example of both face sides having the same visible pattern is achieved by letting the first web-shaped material have a first visible pattern being visible from both sides thereof, e.g. applied by laminating two or more plies with a coloured adhesive. The two face sides may also have different sets of parameter values for L, n, r, k, and t, using e.g. a first web-shaped material with different printed

patterns on its two sides or using an intermediate web comprising two or more web-shaped materials.

In a preferred embodiment the absolute value of the coefficient k ($|k|$) fulfils $0.5 < |k| < 2$, preferably $0.6 < |k| < 1.5$ and most preferably $0.8 < |k| < 1.2$. In an especially preferred embodiment the coefficient k is essentially equal to +1.

The coefficient n may be chosen to be an integer from 1 to 20, preferably from 1 to 10, and most preferably from 1 to 5.

Preferably, the first visible pattern comprises distinct decorative elements.

In a further embodiment, substantially all folds are substantially perpendicular to the web extension direction. The folds can be chosen to be substantially perpendicular to the machine direction of the first web-shaped material. Some of the edge portions may comprise separation lines, e.g. perforations and/or cuts, dividing the first web-shaped material into sheets.

In another embodiment, the majority of the visible edge portions is formed by a folded web-shaped material of the first web-shaped material, that is no separation line is visible from the outside of the stack.

The intermediate web may comprise two web-shaped materials, the first and a second web-shaped material, that are interfolded with each other. It is then possible to let the first web-shaped material form a first planar surface of the intermediate web and the second web-shaped material form an opposing second planar surface of the intermediate web, the first planar surface having the first visible pattern, the second planar surface having a second visible pattern, and each planar surface fulfilling $L = n \cdot r + k \cdot t$, as defined in claim 1, independent of the other planar surface.

In yet another embodiment, the intermediate web comprises separate sheets, having three, four or more panels, and wherein two consecutive separate sheets overlap each other by at least essentially one panel. In this respect, a panel is that part of a sheet located between a certain fold and its adjacent fold.

In a further embodiment, the first web-shaped material has a thickness of at least 200 µm, preferably at least 250 µm, and most preferably 300 µm. The first web-shaped material may be made of through-air-dried paper.

In a second aspect of the invention a method for producing visually pleasing stacks is provided: The method comprising the steps of:

- applying a first visible pattern to a first web-shaped material having a web extension direction, the first visible pattern having a repeat length (r) in the web extension direction of the first web-shaped material,
- forming an intermediate web from the first web-shaped material,
- folding the intermediate web in an accordion-like manner along a first set and a second set of folds extending in an edge direction being perpendicular to the web extension direction, the first set of folds forming a first plurality of edge portions of the first face side of the stack and the second set of folds forming a second plurality of edge portions of the opposite second face side of the stack, each fold of each set of folds being separated by a distance L in the web extension direction along the first web-shaped material, wherein the folding of the intermediate web is carried out such that the distance L satisfies the equation:

$L = n \cdot r + k \cdot t$

where n is a positive integer, r is the repeat length, t is the edge portion thickness and k is a constant, with k being selected such that an edge pattern is formed on at least one of the first and second sides of the stack, which edge pattern is perceived as similar to the first visible pattern on the first web-shaped material.

In one embodiment both face sides of the stack fulfil the equation $L = n \cdot r + k \cdot t$. In a preferred embodiment the absolute value of the coefficient k ($|k|$) fulfils $0.5 < |k| < 2$, preferably $0.6 < |k| < 1.5$ and most preferably $0.8 < |k| < 1.2$. In an especially preferred embodiment the coefficient k is essentially equal to +1.

In another embodiment of the second aspect of the invention a method is provided for forming a stack of two web-shaped materials. The method then further comprises the steps of:

- applying a second visible pattern to a second web-shaped material, the second visible pattern being similar to the first visible pattern or different,
- forming an intermediate web of the first and second web-shaped materials,

- interfolding the first and second web-shaped materials when folding the intermediate web, the first web-shaped material forming a first planar surface of the intermediate web and the second web-shaped material forming the opposing planar surface of the intermediate web, each of the planar surfaces thus having a visible pattern and fulfilling the equation $L = n \cdot r + k \cdot t$, independent of the other planar surface.

The methods described above may also comprise a further step:
- perforating or cutting the intermediate web at separation lines, wherein the distance between the separation lines is chosen to provide sheets of a suitable size. The separation lines can be located so that each sheet overlaps the following sheet by at least substantially one panel.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will hereinafter be further explained by means of non-limiting examples with reference to the appended figures where;

Fig. 1 is a schematic drawing of a stack comprising folded web-shaped material;

Fig. 2 shows the web-shaped material used to form the stack of Fig. 1;

Fig. 3 shows, in a partly folded and divided state, an intermediate web which is used to form the stack of Fig. 1;

Fig. 4 shows a magnified part of the web of Fig. 3;

Fig. 5 shows a first web-shaped material for forming a stack according to a first embodiment of the invention;

Fig. 6 shows a part of a stack formed of the first web-shaped material of Fig. 5;

Fig. 7 shows a stack with curved top and bottom;

Fig. 8 shows a first web-shaped material having a first visible pattern;

Fig. 9 shows schematically a stack made of the material of Fig. 8;

Fig. 10 shows an intermediate web used to form a stack according to a second embodiment of the invention;

Fig. 11 shows the first and second web-shaped materials used for the intermediate web of Fig. 10;

Fig. 12 shows an intermediate web used to form a stack according to a third embodiment of the invention;

Fig. 13 shows the first and second web-shaped materials used for the intermediate web of Fig. 12;

Fig. 14 shows an intermediate web used to form a stack according to a fourth embodiment of the invention;

Fig. 15 shows the first web-shaped material used for the intermediate web of Fig. 14;

Fig. 16 shows an intermediate web used to form a stack according to a fifth embodiment of the invention;

Fig. 17 shows the first web-shaped material used for the intermediate web of Fig. 16;

Fig. 18 shows a first web-shaped material used to form a stack according to a sixth embodiment of the invention, and

Fig. 19 shows the intermediate web made of the first web-shaped material of Fig. 18,

It should be noted that the drawings have not been drawn to scale, and that the dimensions of certain features have been exaggerated for the sake of clarity. The same reference numbers are used in more than one figure to denote the same feature.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The invention will, in the following, be exemplified by embodiments. It should however be realized that the embodiments are included in order to explain principles of the invention and not to limit the scope of the invention defined by the appended claims.

Figures 1 to 4 illustrate the general principle of construction of a stack of a folded web-shaped material, while Figures 5 and 6 show a first embodiment according to the invention.

Figure 1 shows an exemplary stack 1 formed from an intermediate web. The stack has two face sides, a first face side 2 facing forward in Fig 1, and a second face side 3 opposite to the first face side 2. The stack further has a top side 4, a bottom side 5, a first end side 6, and a second end side 7 opposing the first end side 6. An edge direction, depicted by arrow 8, is defined as the direction which is in the plane of the first face side 2 and parallel to the top side 4. The first face side 2 comprises a first plurality of edge portions 9, 10, 11 formed by a first set of folds in the intermediate web and the second face side 3 comprises a second plurality of edge portions formed by a second set of folds in the intermediate web. Each such edge portion has a thickness t which normally corresponds to the thickness of a fold in a web (see Fig. 4). The stack has the dimensions: height h, defined as the distance between the top side 4 and the bottom side 5, width w between the face sides 2, 3 and length l between the end sides 6, 7. The edge portions 9, 10, 11 extend in the edge direction 8.

Herein the term "web-shaped material" is used for a web which extends in the machine direction of a production line. The web's length is considerably longer than its width. The web may be wound on a roll. Typical examples are webs of tissue paper or nonwoven. A web-shaped material can comprise one or more plies. In order to improve the visual appearance and/or to provide indicia indicative of the type or function of the material, a visible pattern can be applied to the web-shaped material. The web-shaped material is used as a raw material for making stacks of folded product.

For present purposes, the term "intermediate web" is used for a web just before the step of forming stacks. An intermediate web can comprise one, two or more web-shaped materials. If two or more web-shaped materials are used, they may be interfolded with each other, having sheet separation lines, e.g. cutting lines or perforation lines, which may

be relatively displaced between the two or more interfolded web-shaped materials. An intermediate web can also comprise separate sheets partly overlapping each other. An intermediate web has two planar surfaces, each opposing the other.

The exemplary stack of Figure 1 illustrates the simplest case wherein the stack is produced by folding a first web-shaped material 12 back and forth into panels in an accordion-like manner. In this example, the intermediate web is the same as the first web-shaped material 12. The first web-shaped material 12 is shown in Figure 2 and the partly folded intermediate web 13 in Figure 3. The intermediate web 13 comprises a number of sheets 14. The sheets 14 are also indicated in Figure 2. A sheet 14 has a length c, in this case corresponding to four panels 15, and a width b, corresponding to the stack length l of Figure 1. A panel is the part of a sheet located between a certain fold 16, belonging to e.g. the first set of folds, and its adjacent fold 17, belonging to the other set of folds. Adjacent folds of the first set of folds 16 are separated by a distance L in the web extension direction 19 along the first web-shaped material 12, and, in the same way, adjacent folds of the second set of folds 17 are separated by the distance L in the web extension direction 19 along the first web-shaped material 12. In this example, the distance L is the length of two panels 15. Since the intermediate web is folded like an accordion, every second fold 16 belonging to the first set of folds will be at the first face side 2 and its adjacent folds 17 belonging to the second set of folds at the second face side 3. As described above, each edge portion will have the thickness t corresponding to the thickness of a fold, in Figures 1-4 about twice the thickness of the intermediate web 13. The sheets are delimited from each other by separation lines 18, for example in the form of perforation lines. The web extension direction 19 is given by the extension of the first web-shaped material 12. The intermediate web extends in the same direction when it is still in a flat condition before being folded into a stack. It is further to be noted that the dimensions of a panel 15 is the same as that of the bottom 5 or top 4 side of the stack in Figure 1. The web extension direction 19 is perpendicular to the edge direction 8.

As can be seen in Figure 3, the intermediate web 13 is folded at the folds 16, 17. The folds are indicated by lines in Figure 2 but in reality they have a certain width since the fold makes up the edge portions having the thickness t. A fold 16, 17 is substantially perpendicular to the web-extension direction 19. The term fold is herein used for actual folds, i.e. folds where the intermediate web is folded when forming the stack. There may,

as well, be folds made earlier in the process but afterwards flattened out, but these are not regarded as folds.

An intermediate web 13 may be continuous, but in most cases it is discontinuous, i.e. divided into individual sheets. The division into sheets is done at the separation lines, for example cutting lines or perforation lines. In a cutting line, the intermediate web is cut through and the resulting sheets are not connected to each other. In a perforation line, the intermediate web is only partly cut through and the sheets are still partly connected to each other. A cutting line or a perforation line can be perpendicular or close to perpendicular to the web extension direction 19. For technical reasons, e.g. a cutting knife edge not impacting over the whole width of the web at the same time, the separation lines 18 may be localised to be a few degrees away from perpendicular. The cutting knife edge may have a straight or wavy profile.

In Figure 3 the separation lines 18 are located at folds 17 of the second set of folds. A stack made of this intermediate web, having sheets comprising four panels, will thus have one face side, where every second edge portion comprises a fold with a separation line 18. The other edge portions, as well as the edge portions on the opposing face side, are made up of folds not comprising any separation lines. It would also be possible to locate the separation lines in between folds.

Figure 4 shows two folded sheets from the intermediate web 13 of Figure 3 next to each other. The magnification shows the thickness t of the edge portion 12. For clarity, the thickness d of the first web-shaped material and the thickness t of the edge portion are exaggerated in relation to the panel size. It is clearly seen that the thickness t of the edge portion is about twice the thickness d of the first web-shaped material. In the fold, the material of the intermediate web is partly compressed, making up the "inner" curve of the fold and partly elongated making up the "outer" curve of the fold.

A first embodiment according to the present invention is shown in Fig. 5 and 6. In this embodiment, the first web-shaped material 12 makes up the intermediate web 13. Figure 5 shows an example of the first web-shaped material 12 with a first visible pattern 20, which has been applied to the surface of the first web-shaped material in an earlier process step e.g. by printing or using a coloured adhesive. The intermediate web is intended to be folded back and forth to form a stack like the one described above. The

first set of folds being bent forwards will form the first plurality of edge portions 100, 101, 102, 103, 104 at the first face side 2 of the stack. The second set of folds being bent backwards will form the second plurality of edge portions 105, 106, 107, 108 at the second face side 3 of the stack. The edge portions will have the thickness t when in the stack. The intermediate web is divided into sheets having the length c, corresponding to four panels. The separation lines 18 dividing the sheets are localised in every fourth fold 105, 107. In the stack illustrated in Fig 6, the separation lines 18 will be at the second face side 3 (not shown in Fig. 6). The distance L in the web extension direction 19 along the first web-shaped material 12 between adjacent folds of the same set of folds 16 is, in this example, half of the sheet length c. The first visible pattern 20 is regular and has a repeat length r in the web extension direction 19. The repeat length r is defined by the distance along the first web-shaped material until the same pattern is repeated in the web extension direction 19.

In Figure 6, the intermediate web 13 of Figure 5 is shown as folded. Since the stack is seen from the first face side 2, the first plurality of edge portions 100, 101, 102, 103, 104 are visible. Each edge portion shows a part of the first visible pattern 20. In accordance with the invention, all these parts will together make up an edge pattern 21, which is seen on the first face side 2 of the stack 1. The edge pattern 21 approximates the first visible pattern 20 as seen on the first web-shaped material 12. For present purposes, the term "approximates" means that the edge pattern 21 need not be identical to the first visible pattern, but it will nevertheless be perceivable by an observer of normal intelligence and eyesight as being similar to the first visible pattern.

The first visible pattern 20 is preferably chosen to comprise decorative elements, like e.g. flowers, symbols or logotypes. The size of the decorative elements could be anywhere from a couple of millimetres to many centimetres. The visibility of the decorative elements can be enhanced by having distinct decorative elements with unpatterned surface in between the decorative elements.

A first visible pattern 20 comprising straight lines only extending in the web extension direction, would give a stack having a face side with straight lines. However, in such a pattern, there would not be a defined repeat length and the invention as defined by the claims would not be applicable.

Edge pattern 21 being similar to the first visible pattern 20 means that they are almost analogous patterns in shape. The edge pattern 21 could be somewhat stretched or compressed in the height direction h of the stack 1 (see Fig.1) in relation to the first visible pattern 20 seen on the first web-shaped material. The edge pattern 21 may also be upside down in relation to the first visible pattern 20. Also, the edge pattern 21 could be somewhat less distinct than the first visible pattern 20. It is however possible to recognize the decorative elements of the first visible pattern 20 in the edge pattern 21. If the height h of the stack 1 is high enough, even a full pattern repeat, or more, of the applied first visible pattern 20 may be recognised from a face side of the stack.

In general terms the following equation is used when forming a stack according to the invention:

$$L = n \cdot r + k \cdot t \qquad \text{(Eq. 1)}$$

where

- L is the distance L in the web extension direction along the first web-shaped material between adjacent folds of the same set of folds of the intermediate web,
- r is the repeat length of the first visible pattern in the web extension direction,
- n is a positive integer,
- k is a coefficient, and
- t edge portion thickness.

The coefficient k is chosen such that that the edge pattern 21 seen on a face side of the stack approximates the first visible pattern 20 on the first web-shaped material. If k is chosen to be +1 or -1 the edge pattern 21 will have the same size as the first visible pattern 20, as long as the stack is not compressed afterwards. The + or – sign influences the orientation of the pattern on the face side, where - will give a pattern which is upside down. $|k| > 1$ will give a pattern which is compressed in the stack height direction, while $|k| < 1$ will give a pattern which is elongated in the stack height dimension, and also somewhat blurred. It has been found that letting k be equal to +1, k = 1, gives a very pleasingly aesthetical effect. The effects of different values for k are summarized in Table 1 below:

Value of k	Effect on the edge pattern 21 as compared to the first visible pattern 20
k = 1	The edge pattern will be the same as the first visible pattern, having the same size and orientation. Edge portions have correct orientation.

k = -1	The edge pattern has the same size, but each edge portion will be "upside down" blurring the general impression.
0 < k <1	The edge pattern will be elongated compared to the first visible pattern since portions of the pattern are shown at more than one edge portion. Results in some blurring. The blurring is worse close to 0 and disappears when approaching 1.
-1 < k < 0	The edge pattern will be elongated compared to the first visible pattern since portions of the pattern are shown at more than one edge portion. Each edge portion "upside down". Both these effects result in blurring.
k > 1	Edge pattern will appear compressed. Edge portions have correct orientation, but portions of the first visible pattern are not shown since k > 1. The further away from 1, the stronger is the effect.
k< -1	Edge pattern will appear compressed. Edge portions are upside down. Portions of the first visible pattern are not shown since k>1, so the blurring effect of edge portions upside down is less than for -1 < k < 0.
k = 0	Straight lines at the face side if the applied pattern is located at the edge portion, otherwise no pattern at the face side. k = 0 implies that L = n • r , i.e. perfect fit between L and r. Not comprised by the invention.

Table 1. The effects of different values for k.

The effect of blurring depends on how detailed the first visible pattern 20 is. A simple pattern without fine details is easier to recognise as a similar edge pattern 21 and therefore k can deviate more from the preferred k = +1. For a simple pattern without fine details the direction of the edge portions are not critical and k = -1 will just give the impression that the edge pattern is turned upside down, but still similar to the first visible pattern.

Also how compressed or elongated the edge pattern 21 can be in relation to the first visible pattern 20 and still be perceived as similar depends on how simple or detailed the visible pattern is. It has been found that for commonly used visible patterns, such as logotypes or decorative elements, the absolute value of the coefficient k ($|k|$) should fulfil $0.5 < |k| < 2$, preferably $0.6 < |k| < 1.5$ and most preferably $0.8 < |k| < 1.2$.

The n is a positive integer. Normally n is quite low, from 1 to 20, preferably 1 to 10 and most preferably 1 to 5. With normal sheet sizes and panel sizes, values of n being higher

than 20 would indeed fulfil Eq. 1, but it would be difficult to distinguish decorative elements.

The characterizing distances, L and r are defined as measured along the surface of the first web-shaped material 12 in the web extension direction 19. The first visible pattern 20 is applied to the first web-shaped material. If the intermediate web 13 is continuous or has sheets that follow after each other without overlaps, the distances will be the same when measured along the intermediate web 13 as along the first web-shaped material 12. However, if the intermediate web 13 comprises separate sheets, being cut from the same first web-shaped material and made to partly overlap, or sheets with a gap in between, which would be possible when combining a first and a second web-shaped material, the distances when measured along the intermediate web 13 will not be the same as along the web-shaped material.

The relative location of the edge portions to each other on the first web-shaped material 12 depends on the folding technology. In the case of using sheets partly overlapping each other, the distance between two consecutive edge portions of the intermediate web 13 is two panel widths. The distance L, which is measures on the first web-shaped material 12, depends on how much the sheets overlap. Purely as an example, if using three-panel sheets with one panel overlap, the distance L will be three panels. If instead there was a gap in between the sheets, the distance L would be less than two panels.

In the illustrated embodiment of Figures 5 and 6, the following relation is valid:

$$L = 2 \cdot r + (-1) \cdot t \qquad \text{(Eq. 2)}$$

The first visible pattern 20 repeats almost, but not exactly, twice between two consecutive edge portions 101, 102. The difference is $(-1) \cdot t$, i.e. the coefficient k (see Eq. 1) is -1. Fulfilling Eq. 1 means that the first visible pattern 20 "moves" a little between an edge portion 101 and the next edge portion 102. In this embodiment, this "movement" corresponds to the thickness t of the edge portion. The parts of first visible pattern 20 which will appear on each edge portion form the constituent components of the edge pattern 21. The - sign in Eq. 2 means that the pattern 20 appears upside down, i.e. in reverse direction, when seen as the edge pattern 21 on the stack face side in Figure 6 as compared to when seen on the intermediate web 13 and on the top of the stack in Figure 6. The absolute value of k, $|k|$, equals 1 indicating that the edge pattern 21 on the face side has the same size as the pattern 20 of the first web-shaped material.

The stack of Figure 1 is shown as having a substantially rectangular parallelepiped shape having a plane top side 4 and a plane bottom side 5. In reality, the stack will often have top and bottom sides that not are plane but instead have a curvature like in Fig. 7. However, that will not influence a pattern seen on the face sides of the stack.

It is a normal procedure in production to compress the stack so that it takes up less space and/or to obtain a predetermined number of sheets into a stack of a pre-determined size. The compression may compensate for variations in thickness of the first web-shaped material. The compression is performed in the height direction h of the stack. The edge pattern seen on the edge portions will therefore be compressed in the same direction, but will still be perceived as similar to the pattern seen on the intermediate web. The stack might be wrapped in a banderol to keep the compression, but when the banderol is released the stack has a certain spring-back and tends to increase its height again. If the stack is put in a dispenser, it might be compressed once again.

The first web-shaped material may comprise one, two, three or four or more plies. The plies may be similar or the first web-shaped material may comprise two or more plies having different properties, for example different grammage, different extensibility, different colour, different background embossing and/or different raw material. The web-shaped material can for example be made of absorbent material such as tissue paper or nonwoven. The plies can be attached to each other by methods known to the man skilled in the art, e.g. glue lamination, mechanical embossing, edge embossing and/or ultra-sonic embossing. The web-shaped material can have undergone other process steps before or after applying the visible pattern but before folding, such as embossing, spraying chemicals on the surface, e.g. lotion or wetting agents.

For present purposes, a tissue paper is defined as a soft absorbent paper having a basis weight below 65 g/m^2 and typically between 8 and 50 g/m^2. The greater the number of plies, the lower is generally the basis weight of each ply. A normal value for a ply in a multi-ply product is 10-25 g/m^2. Basis weight is measured according to standard ISO 12626-1: 2005. The density of the tissue paper is typically below 0.60 g/cm^3, preferably below 0.30 g/cm^3 and more preferably between 0.08 and 0.20 g/cm^3. Thickness is measured according to standard ISO 12626-3: 2005. Density is calculated from basis weight and thickness. The tissue paper may be creped or non-creped. Any creping may

take place in wet or dry condition. The tissue paper can be through-air dried (TAD), and/or dried on a Yankee cylinder. The thickness of a tissue paper is typically between 50 and 600 µm when leaving the tissue paper machine. The lower end of the range may be reached for calendered dry-creped papers with low basis weight, while values at the higher end e.g. could be reached by an uncalendered TAD paper on a structured TAD fabric. Embossing is a well known and common way of increasing the thickness of a tissue paper.

The fibres contained in the tissue paper are mainly pulp fibres from chemical pulp, mechanical pulp, thermo mechanical pulp, chemo mechanical pulp and/or chemo thermo mechanical pulp (CTMP). The fibres may also be recycled fibres. When pulp fibres are used it is assumed that pulp fibres of all different kinds normally used in tissue manufacturing are comprised. Also other pulp of cellulose fibres can be used, like cotton linters, bast cells such as ramie, linen and jute, straw pulp, bamboo pulp, bagasse, sisal, rice straw and hemp. The tissue paper may also contain other types of fibres enhancing e.g. strength, absorption or softness of the paper. These fibres may be made from regenerated cellulose or synthetic material such as polyolefins, polyesters, polyamides etc.

For present purposes, a nonwoven material is defined as a manufactured sheet, web or batt of directionally or randomly orientated fibres, bonded by friction, and/or cohesion and/or adhesion, excluding paper, and products which are woven, knitted, tufted, stitch-bonded incorporating binding yarns or filaments, or felted by wet-milling, whether or not additionally needled. The fibres may be of natural or man-made origin. They may be staple or continuous filaments or formed in situ.

There are several ways of applying a visible pattern to a web-shaped material. One way is to print the web-shaped material by e.g. the flexographic process. For a multi-ply web-shaped material, one or more plies can be printed, either on the outside of the web-shaped material or on an internal surface in a web-shaped material having more than one ply. However, in order to achieve the desired visual effect the pattern should be visible from the outside, at least from one side of the web-shaped material, even when it is printed on an internal surface, so in that case the web-shaped material has to be at least somewhat transparent. The printing may be done in a separate process step or as part of

a process also comprising a bundling process.

Another way of applying visible patterns is to use coloured adhesive when attaching the plies of a multi-ply web-shaped material to each other. Often lamination is combined with embossing. Suitable lamination processes are well-known to the man skilled in the art: nested, foot-to-foot, décor embossing and/or "goffra incolla"-lamination. The pattern should be visible from the outside of the web-shaped material, so the material should be at least somewhat transparent when using coloured adhesive. Normally, when using coloured adhesive for lamination, the pattern is visible from both external surfaces of the web-shaped material. A stack formed of such a material will consequently have edge patterns on both face sides of the stack.

The visible pattern may be just embossed, but if embossed, it is preferred to use a coloured adhesive to laminate plies in a multi-ply web-shaped material.

Different colours can be used, e.g. in 4-colour printing, combining coloured adhesive and print ink or by using more than one coloured adhesive.

The first visible pattern 20 is normally designed so that it should fit the circumference of a roll, e.g. a printing roll or an embossing roll. The pattern normally repeats an integer number of times. For runnability reasons, i.e. in order to run the printing roll and/or embossing roll as smoothly as possible, the pattern is normally designed so that the pattern subtends an oblique angle to the running direction of that roll. To achieve the object of the invention, the important repeat length is however the repeat in the web extension direction.

The colour repeat, i.e. the length in the machine direction until the same colour repeats, is normally the same as the pattern repeat. It is however also possible that the colour repeat is a multiple of the pattern repeat or vice versa. The colour may also be independent of the pattern repeat. If the colour repeat differs from the pattern repeat r and two colours or more are used, the edge pattern 21 may comprise edge portions 9, 10, 11 having different colours, which together build up the edge pattern 21.

It is preferred to use a web-shaped material that is relatively thick compared to standard tissue paper. This can be achieved by using a TAD paper, by embossing the paper to

attain extra thickness, using multiple plies and/or by folding more than one web-shaped material onto each other.

In most cases the web extension direction 19 coincides with the running direction of the production line, the so-called machine direction. See for example Figure 8, where the machine direction is denoted by MD. In Figure 8, the decorative element 22 mimics a leaf. The edge direction 8 is perpendicular to the machine direction, i.e. parallel to the cross-machine direction CD. The example of Fig. 8 fulfils the equation:

$$L = 1 \cdot r + 1 \cdot t \qquad \text{(Eq. 3)}$$

so that n equals +1 and k equals +1. Comparing two consecutive edge portions 9, 10 of the first plurality of edge portions, the portion of the leaf seen at the edge portion has "moved" by a distance of t.

In Fig 8, one sheet has a length c of four panels, and the sheet extend between two consecutive separation lines 18. The separation lines 18 are located at folds 17. The edges of the sheet are marked by dashed lines in Fig. 8. As can be seen, the longitudinal edges of the sheet, which are directed in the machine direction MD, intersect some of the leaves. When folding the intermediate web like an accordion a certain intersected leaf will repeat after r.

Moreover, it is noted that since, according to Eq. 3, the distance L is not equal to the repeat length r, the intersected leaf will move a little sideways when viewing a stack from one of the end sides 6, 7 as in Figure 9. When viewing the stack from the end side 6, one layer will show an intersected leaf, the next layer no leaf, the following layer an intersected leaf displaced sideways by t, the next layer no leaf and the following layer an intersected leaf displaced by t. The end side will thus give a checked impression. The pattern of stripes seen at the end side will be related to the visible pattern by having the same colour but will not be perceived as similar.

The intermediate web, of which the stack is comprised, can be a continuous folded web, a perforated folded web, a web of separate sheets after each other, with or without a distance in between, or separate sheets partly overlapping each other. If the stack comprises separate sheets, they may be dispensed from the stack by letting one sheet "pull" the next by friction forces between the surfaces of the sheets.

Figures 1 to 9 show intermediate webs 13, wherein the individual sheets 14 are delimited from each other by separation lines. In this example, the separation lines are placed at folds, but the separation lines can instead be located outside the folds. The length of a sheet c can be independent of the panel size, although the sheet length is mostly a multiple of the panel size.

It is instead possible to have a folded web without separation lines. The delimitation into individual sheets could then be done manually by a user or with an arrangement in a dispenser, which is used to feed the web from the stack. The arrangement could for example comprise a straight or wavy knife edge for severing the web.

Figures 10 and 11 show a second embodiment, wherein the intermediate web 13 of Figure 10 comprises two web-shaped materials, a first web-shaped material 12 and a second web-shaped material 23, which are interfolded with each other. Individual sheets 14 can be separate or connected to the next sheet 14 in the same web-shaped material by a separation line. The web-shaped materials are positioned so that the sheets of one web-shaped material are partly overlapping with the sheets of the other web-shaped material, in this case by about half their lengths. The length of a sheet 14, denoted by c, is two panels. The sheets of the first web-shaped material 12 will form the edge portions 9, 10, 11 of one face side of the stack. The sheets of the second web-shaped material 23 will form the edge portions 24, 25 of the opposing face side of the stack. The distance L in the web extension direction along the first web-shaped material between adjacent folds of the same set of folds of the intermediate web is in this case the same as the sheet length c, and should fulfil Eq.1 above. The second web-shaped material may also have a distance L fulfilling Eq. 1 above. In this embodiment with two interfolded web-shaped materials, the edge portion thickness t corresponds to two folds, one in the first web-shaped material 12 and one in the second web-shaped material 23, so the thickness t at the edge portion will be about four times the thickness d of an individual web-shaped material. In this example, all edge portions, except for the ones adjacent to the top side 4 and bottom side 5 of the stack, will comprise separation lines. The intermediate web 13 is however folded in such a way that the separation lines cannot be seen from the outside of the stack. Figure 11 shows the two web-shaped materials in a flat condition.

In Figure 12 a third embodiment is illustrated, wherein the intermediate web 13 comprises two interfolded web-shaped materials 12, 23. The sheet length c is four panels and the

sheets 14 are separated by separation lines 18. The distance L in the web extension direction along the web-shaped material between adjacent folds of the same set of folds of the intermediate web is in this case two panels. Two consecutive edge portions 9, 10 on the same face side are therefore located on the same sheet 14. When the intermediate web 13 is folded, one face side will have all the edge portions of the first web-shaped material 12 and the other face side will have all the edge portions of the second web-shaped material 23. Every second edge portion 24 of the second web-shaped material 23 will be located on a separation line. A stack formed from the intermediate web will have one face side where the second web-shaped material 23 is visible and which has a separation line at every second edge portion, while the opposing face side of the stack where the first web-shaped material 12 is visible has no visible separation line, except for at the top and bottom of the stack. Figure 13 shows the two web-shaped materials in a flat condition before folding.

In embodiments in which the intermediate web comprises two web-shaped materials, as in the second and third embodiment, a first visible pattern can be applied to the first web-shaped material 12 and a second visible pattern can be applied to the second web-shaped material 23, the second visible pattern being either similar to the first visible pattern or different. The intermediate web 13 is formed by combining the first 12 and second web-shaped materials 23, and interfolding them. The first web-shaped material 12 forms a first planar surface of the intermediate web 13 and the second web-shaped material 23 forms the opposing planar surface of the intermediate web 13, each planar surface thus having a visible pattern and each planar surface fulfilling Eq. 1, independent of the other planar surface. A stack formed by such an intermediate web has edge patterns 21 on both its face sides 2, 3. The edge pattern on the first face side 2 is formed by the first web-shaped material 12 and the edge pattern on the opposing second face side 3 formed by the second web-shaped material 23. Such a stack may also comprise one web-shaped material having a pattern and the other web-shaped material having no visible pattern.

Figure 14 shows a fourth embodiment, where the intermediate web 13 comprises separate sheets 14 that are partly overlapping in a so called "multi-fold" arrangement. In this example, a three-panel sheet is overlapping with one panel with both the sheet before and after. The edge portions 9, 10, 11 of the first plurality of edge portions on one face side of the stack are formed by the first fold in every sheet. The edge portions 24, 25 of

the second plurality of edge portions on the other face side of the stack are formed by the second fold in every sheet. Figure 15 illustrates the first web-shaped material 12. The distance L in the web extension direction along the first web-shaped material 12 between adjacent folds of the same set of folds of the intermediate web equals in the embodiment of Figures 14 and 15 three panels. In this embodiment, the sheet length c is also three panels.

In a fifth embodiment, shown in Figures 16 and 17, a four-panel sheet is overlapping by two panels. The distance L in the web extension direction along the first web-shaped material between adjacent folds of the same set of folds of the intermediate web equals in the embodiment of Figures 16 and 17 four panels. In this embodiment, the sheet length c is also four panels.

The first visible pattern 20 can also be designed to work for a length-fold converting line, i.e. a machine line making the folds along the running direction of the machine line. The web extension direction 19 is in that case perpendicular to the edge direction 8 and extends in the cross-machine direction CD as shown in the sixth embodiment in Figures 18 and 19. The ingoing web moving in the machine direction MD is split up into individual paths 24 at separation lines 18. Each path has a width which is the same as the sheet length c and is folded into two halves along a fold 16, 17, with each half having a width of about one panel. The individual paths are then positioned so that they overlap each other by a panel, resulting in interfolded sheets 14. All sheets have been formed from the same ingoing web. The distance L in the web extension direction along the first web-shaped material between adjacent folds of the same set of folds of the intermediate web is in this case four panels. The resulting stack, when folding the intermediate web 13, resembles the stack according to the second embodiment in Figure 10. The man skilled in the art will understand that stacks like the ones of the third, fourth and fifth embodiment, as well as other variants, can be formed by varying how the paths 24 are folded and how they are located when placed on top of each other,

In conventional converting machine lines, many process steps like printing, embossing, glue lamination and folding are made in the same line. The visible pattern is then applied in the same line as is also performing the folding operation. It is therefore possible for the machine control system to synchronize the visible pattern with the folding operation in such a way that Eq. 1 is fulfilled. The basic synchronisation of the visible pattern to the

folds, in turn governing where the edge portions will be located, is done when the visible pattern is designed. When running the line, fine-tuning of the synchronisation can for example be done by adjusting the speed of the roll applying the visible pattern, normally in a printing unit or a glue application unit. Normally, the size of the panel is fixed, and therefore the application of the visible pattern on the first web-shaped material is adjusted to the folds and not vice versa.

When producing a product having separate sheets overlapping each other, like for example the fourth embodiment illustrated in Figures 14 and 15, a suitable production method is to apply the pattern to the first web-shaped material, fold the first web-shaped material into panels, cut the first web-shaped material into separate sheets and then retard the speed so that the sheets partly overlap each other, thereby forming the intermediate web, and finally form the stack of the intermediate web.

A favourable effect of the invention is achieved in a stack having very straight face sides. In real stacks, however, there will sometimes be some edge portions being located further out from the stack than the adjacent ones. Such edge portions will then take relatively more space and partly hide the adjacent edge portions. The edge pattern will still be visible but somewhat obscured; nevertheless, such a stack is also comprised by the invention.

The embodiments above illustrate several combinations of parameters, such as number of web-shaped materials, sheet sizes, pattern sizes, overlaps of sheets, localisation of folds, separation lines, etc, but the invention is not restricted to the illustrated embodiments. Instead, the man skilled in the art is at liberty to combine these parameters freely in many ways to create the products he desires within the scope of the appended claims.

CLAIMS

1. A stack (1) formed from an intermediate web (13), said stack having a first face side (2) and a second face side (3), said first and second face sides facing in opposite directions, said first face side comprising a first plurality of edge portions (9, 10, 11) formed by a first set of folds (16) in said intermediate web and said second side face comprising a second plurality of edge portions (24, 25) formed by a second set of folds (17) in said intermediate web, said edge portions having a thickness (t), said intermediate web comprising at least a first web-shaped material (12) having a web extension direction (19), said first web-shaped material (12) being provided with a first visible pattern (20) having a repeat length (r) in said web extension direction of said first web-shaped material,
characterized in that
adjacent folds (16) of said first set of folds are separated by a distance L in the web extension direction along said first web-shaped material and adjacent folds (17) of said second set of folds are separated by said distance L in the web extension direction along said first web-shaped material such that the distance L satisfies the equation:
$L = n \cdot r + k \cdot t$
where n is a positive integer, r is said repeat length, t is said edge portion thickness and k is a constant, with k being selected such that an edge pattern (21) is formed on at least one of said first (2) and second (3) face sides of the stack, which edge pattern (21) approximates said first visible pattern (20) on the first web-shaped material.

2. The stack (1) according to claim 1, wherein both face sides (2, 3) of said stack fulfil the equation $L = n \cdot r + k \cdot t$ as defined in claim 1.

3. The stack (1) according to claim 1 or 2, wherein the absolute value of the coefficient k ($|k|$) fulfils $0.5 < |k| < 2$, preferably $0.6 < |k| < 1.5$ and most preferably $0.8 < |k| < 1.2$.

4. The stack (1) according to claim 3, wherein the coefficient k is essentially equal to +1.

5. The stack (1) according to any of the preceding claims, wherein n is an integer from 1 to 20, preferably from 1 to 10, and most preferably from 1 to 5.

6. The stack (1) according to any of the preceding claims, wherein the first visible pattern (20) comprises distinct decorative elements (22).

7. The stack (1) according to any of the preceding claims, wherein substantially all folds (16, 17) are substantially perpendicular to the web extension direction (19).

8. The stack (1) according to any of the preceding claims, wherein the folds (16, 17) are substantially perpendicular to the machine direction (MD) of the first web-shaped material (12).

9. The stack (1) according to any of the preceding claims, wherein at least some of the edge portions (9, 10, 11; 24, 25) comprise separation lines (18).

10. The stack (1) according to any of the preceding claims, wherein the majority of the visible edge portions are formed by folded web-shaped material of said first web-shaped material.

11. The stack (1) according to any of the preceding claims, wherein the intermediate web (13) comprises two web-shaped materials, said first web-shaped material (12) and a second web-shaped material (23), which are interfolded with each other.

12. The stack (1) according to any of the preceding claims, wherein the intermediate web (13) comprises two web-shaped materials, said first web-shaped material (12) forming a first planar surface of the intermediate web (13) and said second web-shaped material (23) forming an opposing second planar surface of the intermediate web (13), said first planar surface having the first visible pattern (20), said second planar surface having a second visible pattern, and each said planar surface fulfilling $L = n \cdot r + k \cdot t$, as defined in claim 1, independent of the other planar surface.

13. The stack (1) according to any one of claims 1 to 10, wherein the intermediate web (13) comprises separate sheets (14), having three, four or more panels (15), and

wherein two consecutive separate sheets overlap each other by at least essentially one panel.

14. The stack (1) according to any of the preceding claims, wherein said first web-shaped material (12) has a thickness (d) of at least 200 µm, preferably at least 250 µm, and most preferably 300 µm.

15. The stack (1) according to any of the preceding claims, wherein said first web-shaped material (12) is made of through-air-dried paper.

16. A method of forming a stack (1) having a first visible pattern (20) by folding an intermediate web (13), said stack having a first face side (2) and a second face side (3), said first and second face sides facing in opposite directions, each of said face sides comprising a plurality of edge portions (9, 10, 11; 24, 25) formed by folds in said intermediate web, said edge portions having a thickness (t),
said method comprising the steps of
- applying said first visible pattern (20) to a first web-shaped material (12), having a web extension direction (19), said pattern having a repeat length (r) in the web extension direction of said first web-shaped material,
- forming said intermediate web (13) from said first web-shaped material (12),
- folding said intermediate web (13) in an accordion-like manner along a first set (16) and a second set of folds (17) extending in an edge direction (8) being perpendicular to the web extension direction (19), said first set of folds (16) forming said plurality of edge portions of the first face side (2) of said stack and said second set of folds (17) forming said plurality of edge portions of the opposite second face side (3) of the stack, each fold of each set of folds being separated by a distance L in the web extension direction along said first web-shaped material
characterized by
said folding of said intermediate web being carried out such that the distance (L) satisfies the equation:
$L = n \cdot r + k \cdot t$
where n is a positive integer, r is said repeat length, t is said edge portion thickness and k is a constant, with k being selected such that an edge pattern (21) is formed on at least one of said first and second sides of the stack, which edge pattern (21) approximates said first visible pattern (20) on said first web-shaped

material.

17. The method according to claim 16, wherein both face sides (2, 3) of said stack (1) fulfil $L = n \cdot r + k \cdot t$ as defined in claim 16.

18. The method according to claim 16 or 17, wherein the absolute value of the coefficient ($|k|$) fulfils $0.5 < |k| < 2$, preferably $0.6 < |k| < 1.5$ and most preferably $0.8 < |k| < 1.2$.

19. The method according to claim 18 wherein the coefficient (k) is essentially equal to +1.

20. The method according to any of claims 16 to 19, wherein the method further comprises the steps of
- applying a second visible pattern to a second web-shaped material (23), said second visible pattern being similar to said first visible pattern or different,
- forming a intermediate web (13) of said first (12) and second web-shaped materials (23),
- interfolding said first (12) and second (23) web-shaped materials when folding the intermediate web, the first web-shaped material forming a first planar surface of said intermediate web and the second web-shaped material forming the opposing planar surface of said intermediate web, each of said planar surfaces thus having a visible pattern and fulfilling the equation $L = n \cdot r + k \cdot t$, as defined in claim 16, independent of the other planar surface.

21. The method according any of claims 16 to 20, wherein the method further comprises the step of
- perforating or cutting in the intermediate web at separation lines (18), wherein the distance between separation lines (18) is chosen to provide sheets (14) of a suitable size.

22. The method according to claim 21, wherein the separation lines (18) are localised so that each sheet overlaps the following sheets (14) by at least substantially one panel.

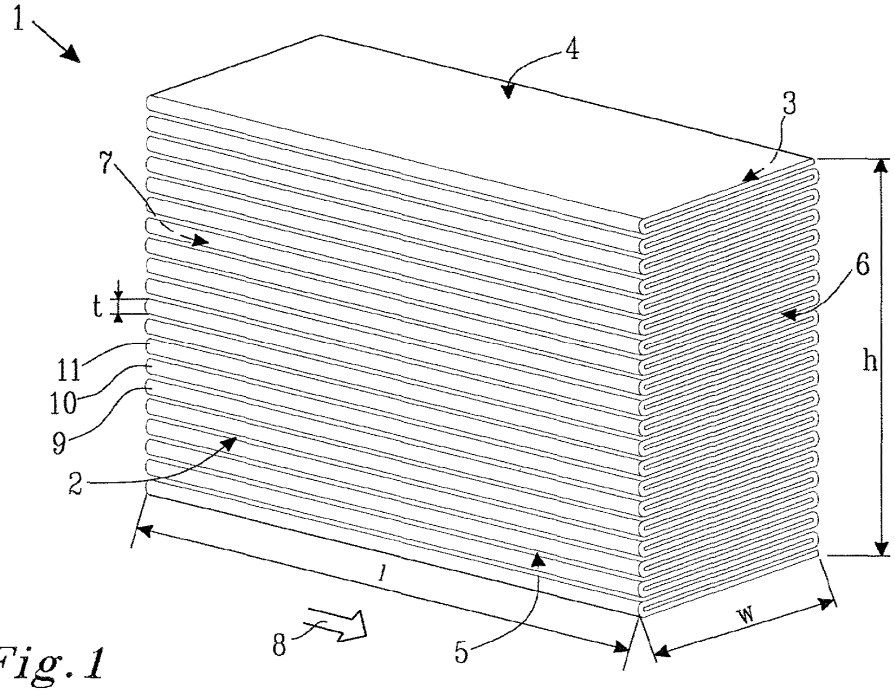

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Fig. 1

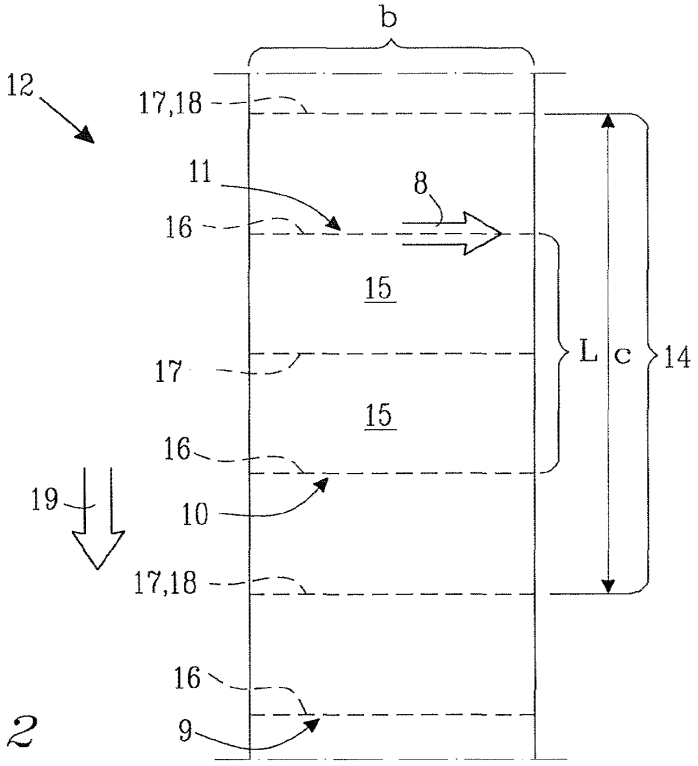

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Fig. 2

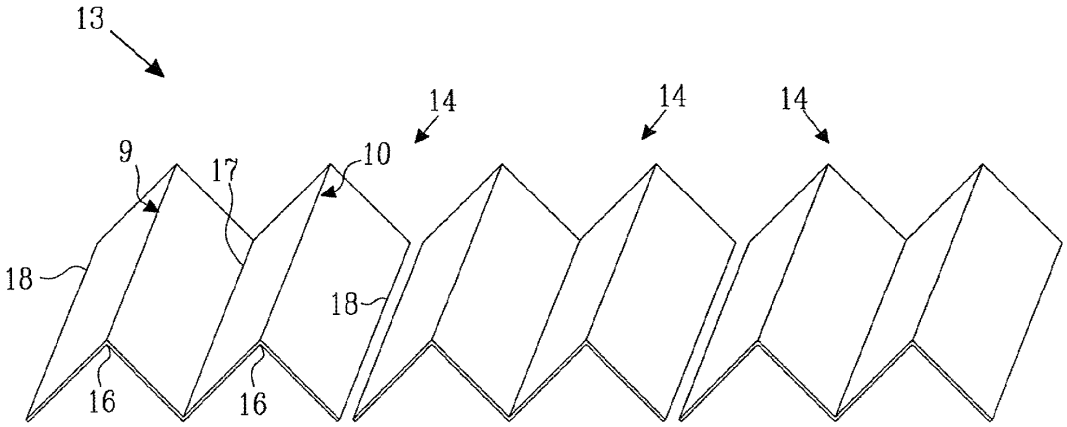


Fig. 3

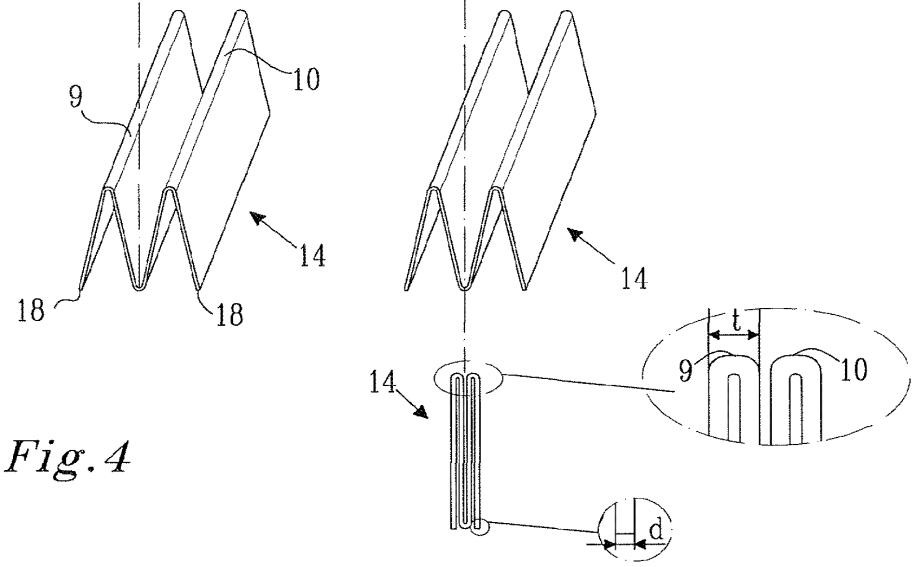


Fig. 4

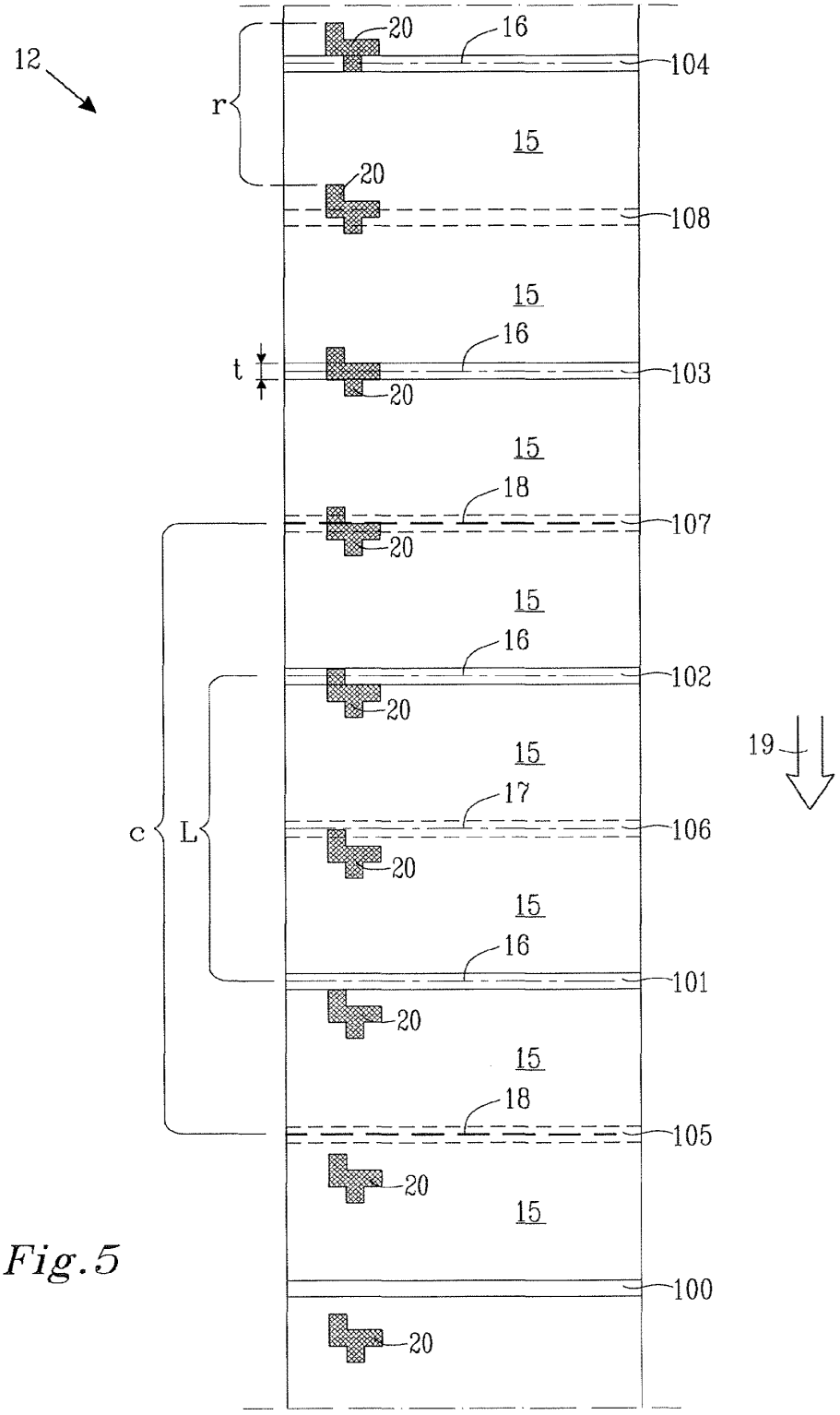


Fig.5

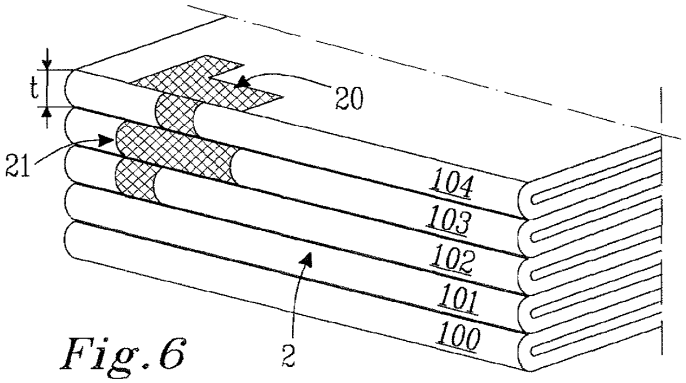


Fig. 6

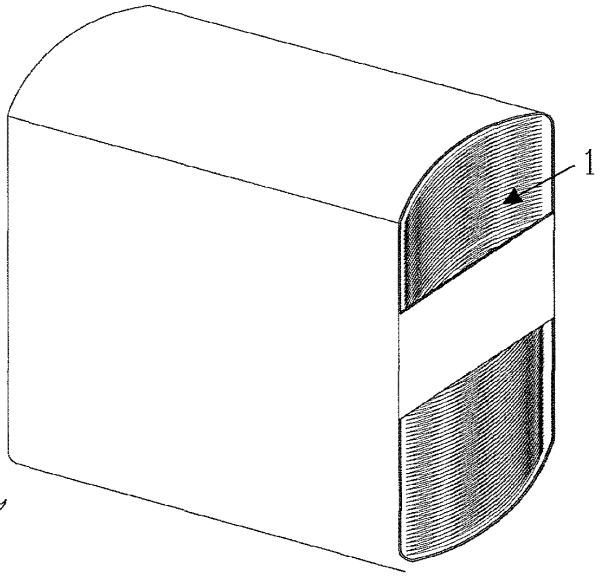


Fig. 7

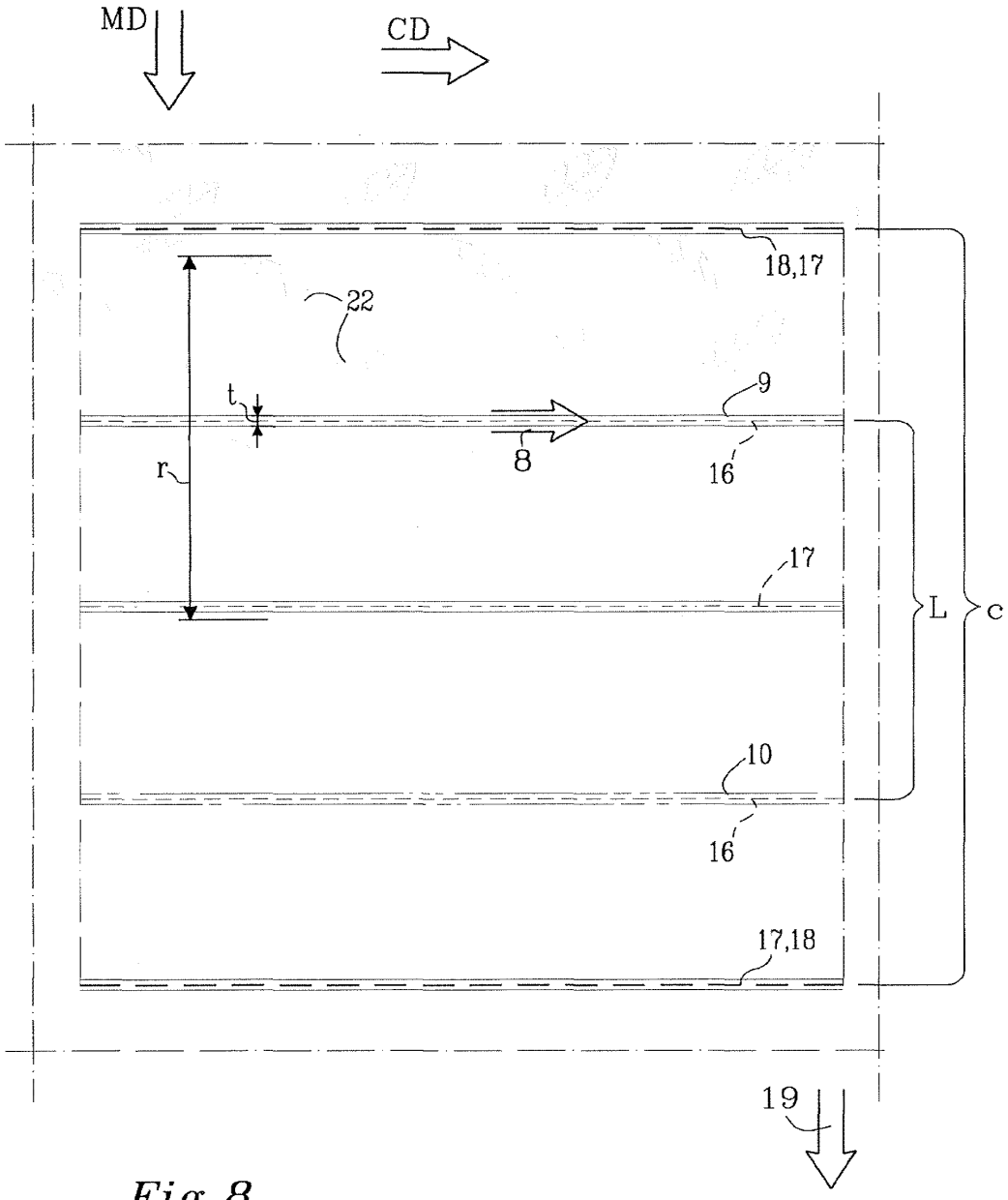


Fig. 8

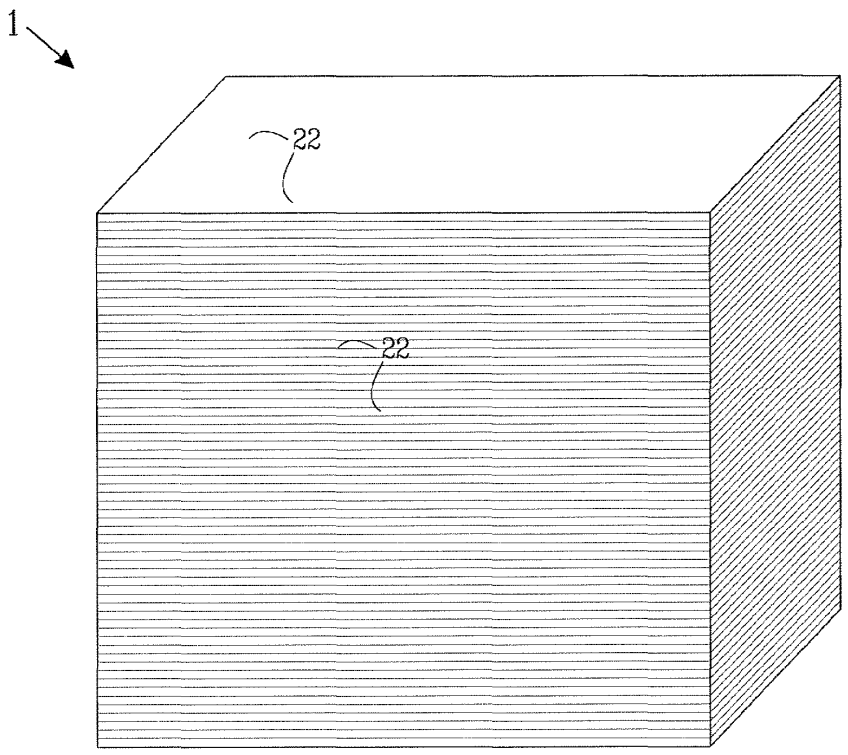


Fig. 9

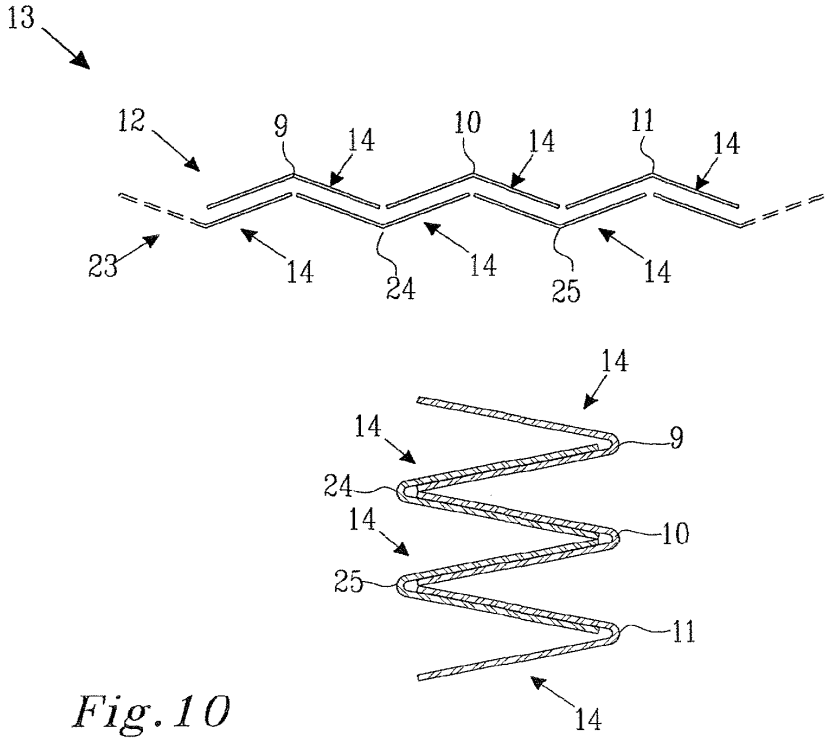

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Fig. 10

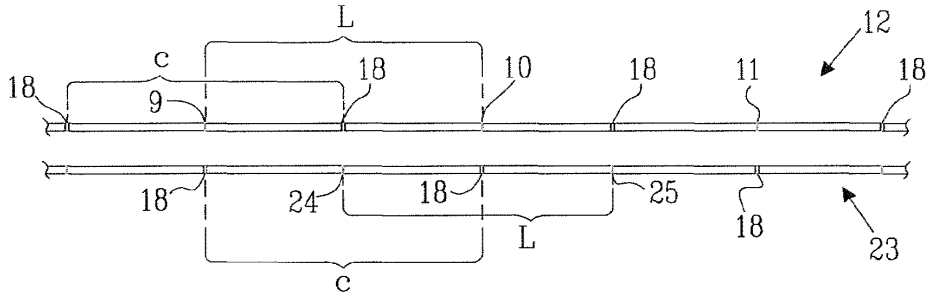

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Fig. 11

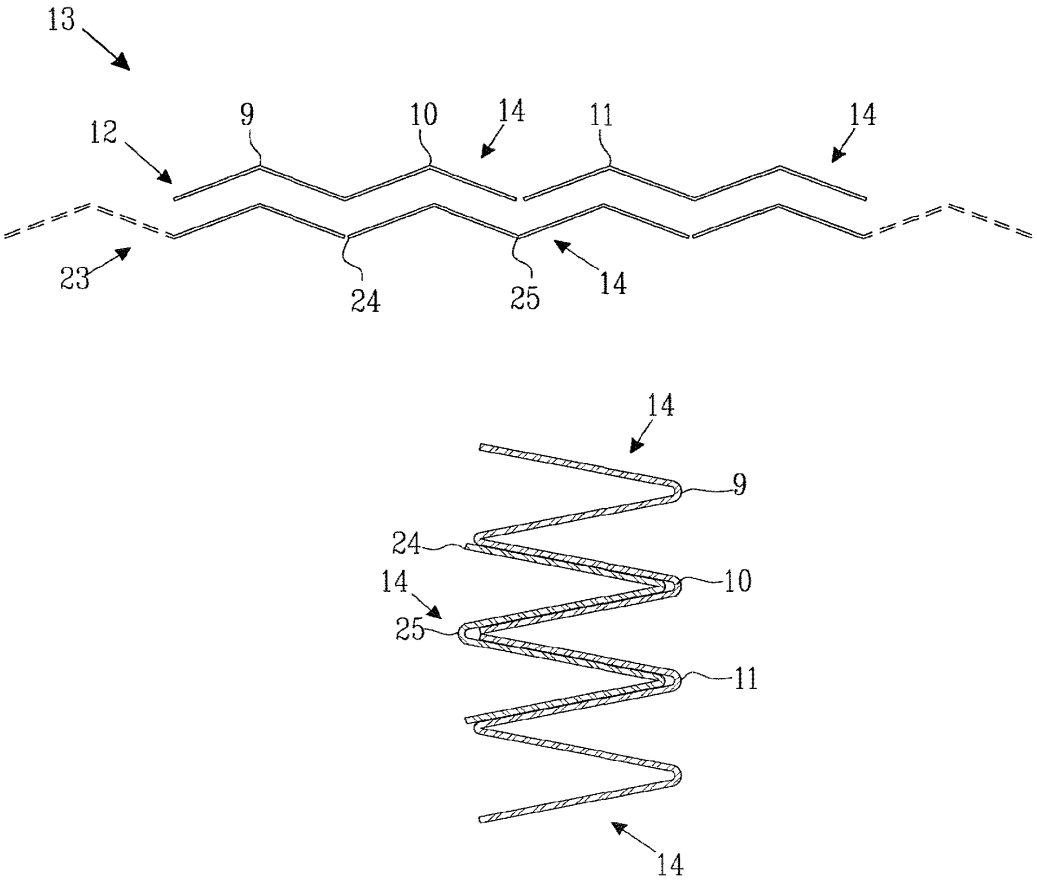

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Fig. 12

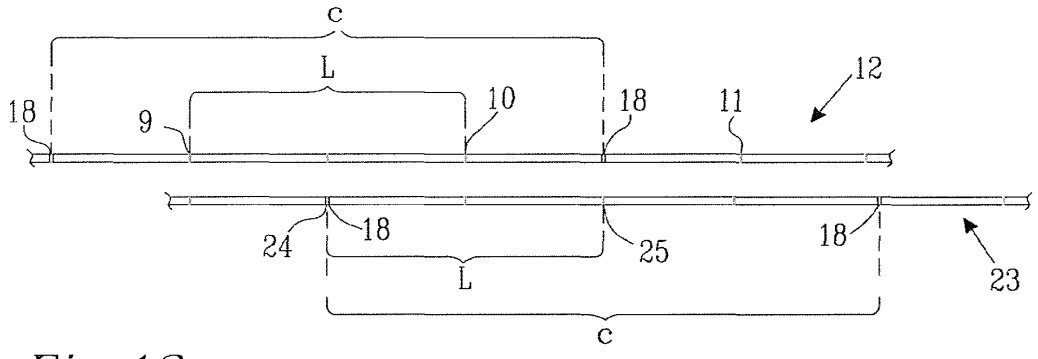

C
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L
C

Fig. 13

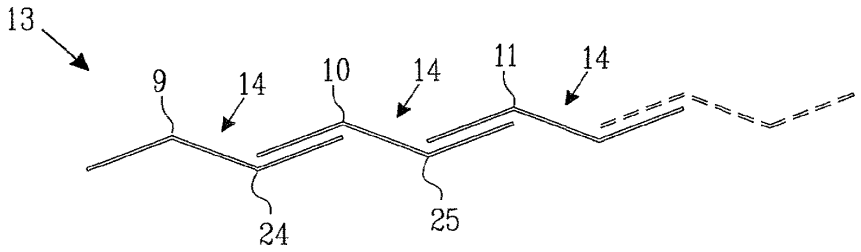


Fig. 14

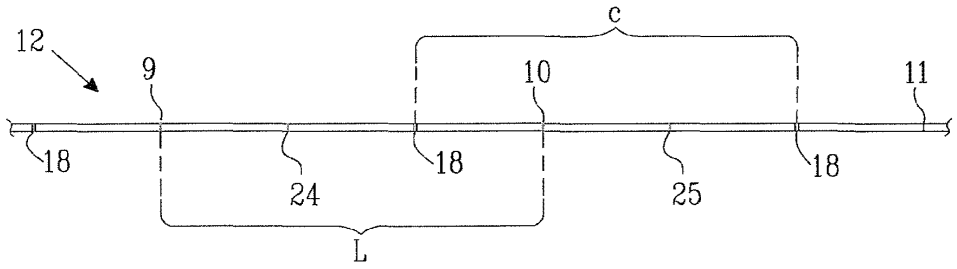


Fig. 15

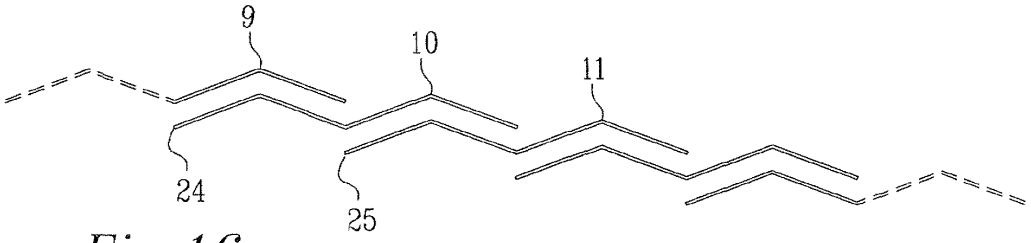


Fig. 16

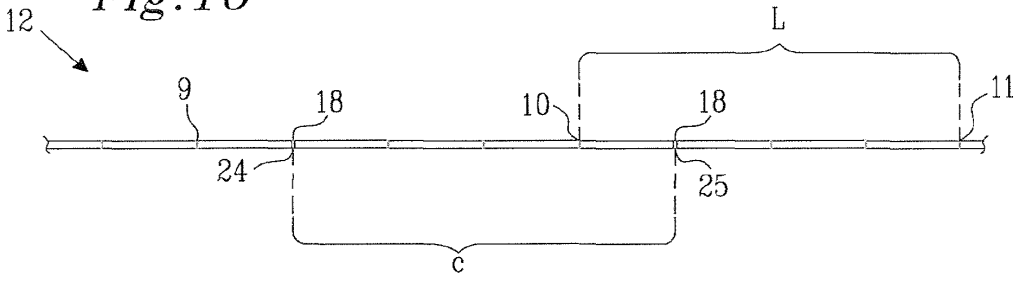


Fig. 17

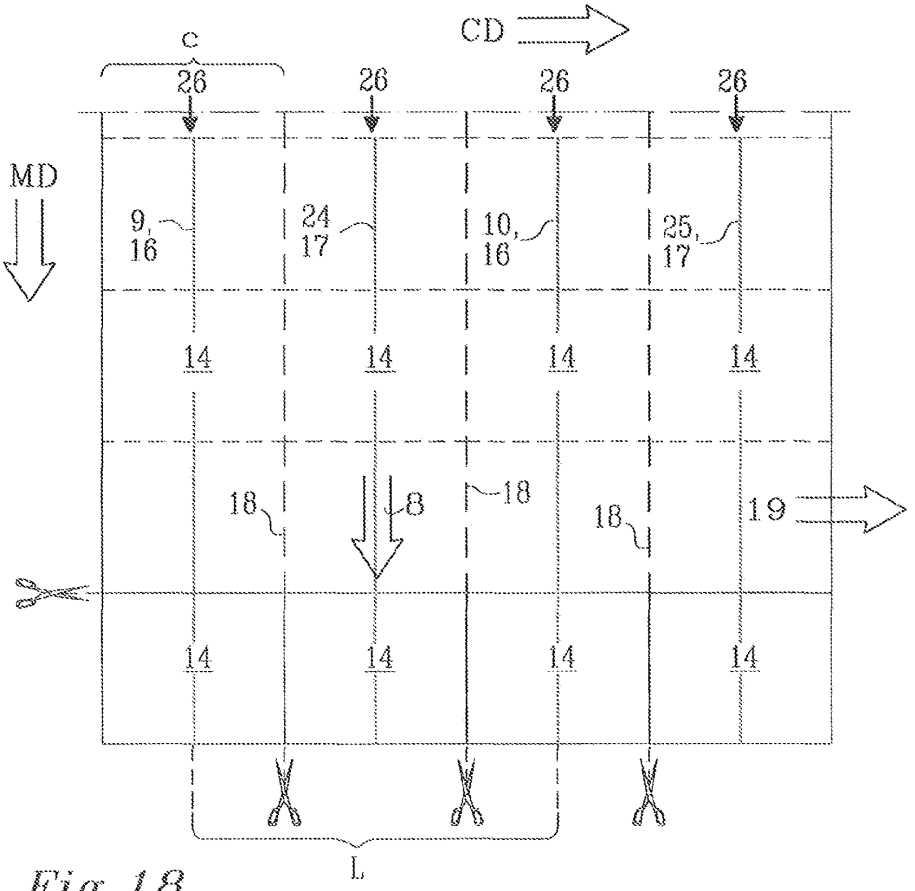

C
CD
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Fig. 18

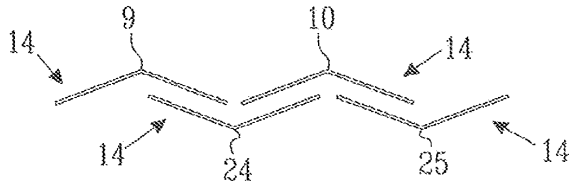

14
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14

Fig. 19

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2008/050881

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: A47K, B65H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2007081244 A1 (SCA HYGIENE PRODUCTS AB), 19 July 2007 (19.07.2007), page 24, line 17 - line 25, figure 7, abstract ---	1-22
A	US 6257410 B1 (C.C. ULMANN ET AL), 10 July 2001 (10.07.2001), figure 2, abstract --- --------	1,16

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

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WO	2007081244	A1	19/07/2007	NONE		
US	6257410	B1	10/07/2001	AU	6390200 A	19/02/2001
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(54) **Title**: SOFT TISSUE COMPRISING NON-WOOD FIBERS

(57) **Abstract**: The present invention provides soft, durable and bulky tissue products comprising non-wood fibers and more particularly hesperaloe fiber. The inventors have discovered that high yield hesperaloe pulp fiber, when incorporated in amounts of at least about 5 percent by weight of the tissue product, produces products having a GMT less than about 1000 g/3" and a GM Slope less than about 7.0 kg. At the foregoing tensile strengths and modulus the tissue products of the present invention are also generally soft, such as having a Stiffness Index less than about 10.0, and more preferably less than about 9.0, such as from about 7.0 to about 9.0.

SOFT TISSUE COMPRISING NON-WOOD FIBERS

BACKGROUND OF THE DISCLOSURE

Tissue products, such as facial tissues, paper towels, bath tissues, napkins, and other similar products, are designed to include several important properties. For example, the products should have good bulk, a soft feel, and should have good strength and durability. Unfortunately, however, when steps are taken to increase one property of the product, other characteristics of the product are often adversely affected.

To achieve the optimum product properties, tissue products are typically formed, at least in part, from pulps containing wood fibers and often a blend of hardwood and softwood fibers to achieve the desired properties. Typically when attempting to optimize surface softness, as is often the case with tissue products, the papermaker will select the fiber furnish based in part on the coarseness of pulp fibers. Pulps having fibers with low coarseness are desirable because tissue paper made from fibers having a low coarseness can be made softer than similar tissue paper made from fibers having a high coarseness. To optimize surface softness even further, premium tissue products usually comprise layered structures where the low coarseness fibers are directed to the outside layer of the tissue sheet with the inner layer of the sheet comprising longer, coarser fibers.

Unfortunately, the need for softness is balanced by the need for durability. Durability in tissue products can be defined in terms of tensile strength, tensile energy absorption (TEA), burst strength and tear strength. Typically tear, burst and TEA will show a positive correlation with tensile strength while tensile strength, and thus durability, and softness are inversely related. Thus the paper maker is continuously challenged with the need to balance the need for softness with a need for durability. Unfortunately, tissue paper durability generally decreases as the fiber length is reduced. Therefore, simply reducing the pulp fiber length can result in an undesirable trade-off between product surface softness and product durability.

Besides durability long fibers also play an important role in overall tissue product softness. While surface softness in tissue products is an important attribute, a second element in the overall softness of a tissue sheet is stiffness. Stiffness can be measured from the tensile slope of stress – strain tensile curve. The lower the slope the lower the stiffness and the better overall softness the product will display. Stiffness and tensile strength are positively correlated, however at a given tensile strength shorter fibers will display a greater stiffness than long fibers. While not wishing to be bound by theory, it is believed that this behavior is due to the higher number of hydrogen bonds required to produce a product of a given tensile strength with short fibers than with long fibers. Thus, easily

collapsible, low coarseness long fibers, such as those provided by northern softwood kraft (NSWK) fibers typically supply the best combination of durability and softness in tissue products when those fibers are used in combination with hardwood Kraft fibers such as Eucalyptus hardwood Kraft fibers. While Northern Softwood Kraft Fibers have a higher coarseness than Eucalyptus fibers their small cell wall thickness relative to lumen diameter combined with their long length makes them the ideal candidate for optimizing durability and softness in tissue.

Unfortunately supply of NSWK is under significant pressure both economically and environmentally. As such, prices of NSWK have escalated significantly creating a need to find alternatives to optimize softness and strength in tissue products. Alternatives, however, are limited. For example, southern softwood kraft (SSWK) may only be used in limited amounts in the manufacture of tissue products because its high coarseness results in stiffer, harsher feeling products than NSWK. Thus, there remains a need for an alternative to NSWK for the manufacture of premium tissue products, which must be both soft and strong.

SUMMARY OF THE DISCLOSURE

The present inventors have successfully used hesperaloe fibers to produce a tissue having satisfactory softness, strength and bulk. To produce the instant tissue products the inventors have successfully moderated the changes in strength and stiffness typically associated with substituting conventional wood papermaking fibers, such as NSWK, with hesperaloe fibers. Not only have the inventors succeeded in moderating changes to strength and stiffness they have done so without negatively effecting bulk. As such, the tissue products of the present invention have properties comparable to or better than those produced using conventional wood papermaking fibers, and more particularly softwood fibers, and still more particularly NSWK fibers. Accordingly, in certain preferred embodiments, the invention provides tissue products in which hesperaloe fibers replace at least about 50 percent of the NSWK, more preferably at least about 75 percent and still more preferably all NSWK without negatively effecting the tissue products strength, stiffness and bulk.

In other embodiments the present invention provides tissue products comprising a multi-layered tissue web where one or more of the layers comprise a blend of hesperaloe fibers and NSWK fibers and/or Southern Softwood Kraft (SSWK) fibers. Blending hesperaloe fibers with NSWK fibers and/or SSWK fibers may improve the physical properties of the tissue product, such as increased softness and durability while reducing the cost of manufacture. In particularly preferred embodiments the multi-layered tissue structure comprises two outer layers and a middle layer, where the outer layers are substantially free from hesperaloe fiber and the middle layer consists essentially of hesperaloe fiber.

In yet other embodiments the present invention provides a tissue product comprising from about 20 to about 50 weight percent hesperaloe fiber and substantially free from long average fiber length kraft fibers, such as NSWK and SSWK, the tissue product having a sheet bulk greater than about 10 cc/g, a GMT from about 500 to about 750 g/3", a Stiffness Index less than about 8.0 and a Durability Index greater than about 30.

In still other embodiments the present invention provides a tissue product comprising at least about 20 weight percent hesperaloe fiber, the tissue product having a GMT from about 400 to about 1,000 g/3", a Stiffness Index less than about 10 and more preferably less than about 8.0, and a sheet bulk greater than about 10 cc/g.

In another embodiment the present invention provides a tissue product comprising at least one through-air dried tissue web, the web comprising at least about 20 weight percent hesperaloe fiber, the tissue product having a GMT from about 500 to about 750 g/3", a Stiffness Index less than about 8.0 and a Durability Index greater than about 30.

In yet another embodiment the present invention provides a tissue product comprising from about 20 to about 50 weight percent hesperaloe fiber, the tissue product having a sheet bulk greater than about 10 cc/g, a GMT from about 500 to about 750 g/3", a Stiffness Index less than about 8.0 and a Durability Index greater than about 30.

In other embodiments the present invention provides a tissue product comprising from about 20 to about 50 weight percent hesperaloe fiber and substantially free from NSWK, the tissue product having a basis weight from about 20 to about 50 gsm, a GMT from about 500 to about 750 g/3", a Stiffness Index less than about 8.0 and a Durability Index greater than about 32.

In still other embodiments the present invention provides a product comprising at least one multi-layered through-air dried tissue web comprising a first and a second layer, the first layer being substantially free from high yield hesperaloe pulp fibers and the second layer consisting essentially of high yield hesperaloe pulp fibers, the tissue product having a Durability Index greater than about 28.0 and a Stiffness Index less than about 10.0, wherein the tissue product comprises from about 20 to about 50 weight percent high yield hesperaloe pulp fibers.

In yet other embodiments the present invention provides a single-ply through-air dried tissue product comprising at least about 20 weight percent high yield hesperaloe pulp fibers, the tissue product having a basis weight from about 30 to about 60 gsm, a sheet bulk greater than about 10 cc/g and a Stiffness Index less than about 10.

DEFINITIONS

As used herein, a "tissue product" generally refers to various paper products, such as facial tissue, bath tissue, paper towels, napkins, and the like. Normally, the basis weight of a tissue product of the present invention is less than about 80 grams per square meter (gsm), in some embodiments less than about 60 gsm, and in some embodiments from about 10 to about 60 gsm and more preferably from about 20 to about 50 gsm.

As used herein, the term "layer" refers to a plurality of strata of fibers, chemical treatments, or the like within a ply.

As used herein, the terms "layered tissue web," "multi-layered tissue web," "multi-layered web," and "multi-layered paper sheet," generally refer to sheets of paper prepared from two or more layers of aqueous papermaking furnish which are preferably comprised of different fiber types. The layers are preferably formed from the deposition of separate streams of dilute fiber slurries, upon one or more endless foraminous screens. If the individual layers are initially formed on separate foraminous screens, the layers are subsequently combined (while wet) to form a layered composite web.

The term "ply" refers to a discrete product element. Individual plies may be arranged in juxtaposition to each other. The term may refer to a plurality of web-like components such as in a multi-ply facial tissue, bath tissue, paper towel, wipe, or napkin.

As used herein, the term "basis weight" generally refers to the bone dry weight per unit area of a tissue and is generally expressed as grams per square meter (gsm). Basis weight is measured using TAPPI test method T-220.

As used herein, the term "Burst Index" refers to the dry burst peak load (typically having units of grams) at a relative geometric mean tensile strength (typically having units of grams per three inches) as defined by the equation:

$$Burst\ Index = \frac{Dry\ Burst\ Peak\ Load\ (g)}{GMT\ (g/3")}\ x\ 10$$

While Burst Index may vary tissue products prepared according to the present disclosure generally have a Burst Index greater than about 8.0, more preferably greater than about 8.5 and still more preferably greater than about 9.0.

As used herein, the term "TEA Index" refers the geometric mean tensile energy absorption (typically expressed in g•cm/cm^2) at a given geometric mean tensile strength (typically having units of grams per three inches) as defined by the equation:

$$TEA\ Index = \frac{GM\ TEA\ (\mathrm{g} \bullet \mathrm{cm/cm2})}{GMT\ (g/3")}\ x\ 1{,}000$$

While the TEA Index may vary tissue products prepared according to the present disclosure generally have a TEA Index greater than about 9.0, more preferably greater than about 9.5 and still more preferably greater than about 10.0.

As used herein, the term "Tear Index" refers to the GM Tear Strength (typically expressed in grams) at a relative geometric mean tensile strength (typically having units of grams per three inches) as defined by the equation:

$$Tear\ Index = \frac{GM\ Tear\ (g)}{GMT(g/3")}\ x\ 1{,}000$$

While the Tear Index may vary tissue products prepared according to the present disclosure generally have a Tear Index greater than about 12.0, more preferably greater than about 12.5 and still more preferably greater than about 13.0.

As used herein, the term "Durability Index" refers to the sum of the Tear Index, the Burst Index, and the TEA Index and is an indication of the durability of the product at a given tensile strength.

$$Durability\ Index = Tear\ Index + Burst\ Index + TEA\ Index$$

While the Durability Index may vary tissue products prepared according to the present disclosure generally have a Durability Index value greater than about 28, more preferably greater than about 30 and still more preferably greater than about 32.

As used herein, the term "caliper" is the representative thickness of a single sheet (caliper of tissue products comprising two or more plies is the thickness of a single sheet of tissue product comprising all plies) measured in accordance with TAPPI test method T402 using an EMVECO 200-A Microgage automated micrometer (EMVECO, Inc., Newberg, OR). The micrometer has an anvil diameter of 2.22 inches (56.4 mm) and an anvil pressure of 132 grams per square inch (per 6.45 square centimeters) (2.0 kPa).

As used herein, the term "sheet bulk" refers to the quotient of the caliper (µm) divided by the bone dry basis weight (gsm). The resulting sheet bulk is expressed in cubic centimeters per gram (cc/g). Tissue products prepared according to the present invention generally have a sheet bulk greater than about 10 cc/g, more preferably greater than about 11 cc/g and still more preferably greater than about 12 cc/g.

As used herein, the term "fiber length" refers to the length weighted average length of fibers determined utilizing a Kajaani fiber analyzer model No. FS-100 available from Kajaani Oy Electronics, Kajaani, Finland. According to the test procedure, a pulp sample is treated with a macerating liquid to ensure that no fiber bundles or shives are present. Each pulp sample is disintegrated into hot water and diluted to an approximately 0.001 percent solution. Individual test samples are drawn in approximately 50 to 100 ml portions from the dilute solution when tested using the standard Kajaani fiber analysis test procedure. The weighted average fiber length may be expressed by the following equation:

$$\sum_{x_i=0}^{k} (x_i \times n_i)/n$$

where k = maximum fiber length

x_i = fiber length

n_i = number of fibers having length x_i

n = total number of fibers measured.

As used herein, the term "hesperaloe fiber" refers to a fiber derived from a plant of the genus *Hesperaloe* of the family Asparagaceae including, for example, *Hesperaloe funifera*. The fibers are generally processed into a pulp for use in the manufacture of tissue products according to the present invention. Preferably the pulping process is a high yield pulping process. The high yield hesperaloe pulp fibers generally have a lignin content, measured as Klason lignin, from about 10 to about 15 weight percent. The terms "hesperaloe fiber" and "high yield hesperaloe pulp fiber" may be used interchangeably herein when referring to non-wood fibers incorporated into tissue products, one skilled in the art will appreciate however that when incorporating non-wood fibers into tissue products it is preferred that the fibers be processed, such as by high yield pulping.

As used herein, the term "slope" refers to slope of the line resulting from plotting tensile versus stretch and is an output of the MTS TestWorks™ in the course of determining the tensile strength as described in the Test Methods section herein. Slope is reported in the units of grams (g) per unit of sample width (inches) and is measured as the gradient of the least-squares line fitted to the load-corrected strain points falling between a specimen-generated force of 70 to 157 grams (0.687 to 1.540 N) divided by the specimen width. Slopes are generally reported herein as having units of grams per 3 inch sample width or g/3".

As used herein, the term "geometric mean slope" (GM Slope) generally refers to the square root of the product of machine direction slope and cross-machine direction slope. GM Slop generally is expressed in units of kg.

As used herein, the terms "geometric mean tensile" and "GMT" refer to the square root of the product of the machine direction tensile strength and the cross-machine direction tensile strength of the web. While the GMT may vary tissue products prepared according to the present disclosure generally have a GMT greater than about 400 g/3", more preferably greater than about 500 g/3" and still more preferably greater than about 600 g/3".

As used herein, the term "Stiffness Index" refers to the quotient of the geometric mean tensile slope, defined as the square root of the product of the MD and CD slopes (typically having units of kg), divided by the geometric mean tensile strength (typically having units of grams per three inches).

$$Stiffness\ Index = \frac{\sqrt{MD\ Tensile\ Slope\ (kg) x\ CD\ Tensile\ Slope(kg)}}{GMT\ (g/3")}\ x\ 1{,}000$$

While the Stiffness Index may vary tissue products prepared according to the present disclosure generally have a Stiffness Index less than about 10.0, more preferably less than about 9.0 and still more preferably less than about 8.0.

DETAILED DESCRIPTION OF THE DISLOSURE

Generally the skilled tissue maker is concerned with balancing various tissue properties such as bulk, softness, stiffness and strength. For example, the tissue maker often desires to increase bulk without stiffening the tissue product or reducing softness, while at the same time maintaining a given tensile strength. Previous attempts to manufacture tissue using hesperaloe fibers have not successfully balanced these important tissue properties resulting in reduced bulk with dramatic increases in tensile and stiffness. Despite the failings of the prior art, the present inventors have now succeeded in moderating the changes in strength and stiffness without negatively effecting bulk when manufacturing a tissue product comprising hesperaloe fibers, as illustrated in Table 1, below.

TABLE 1

Example	Furnish	Delta Bulk	Delta GMT	Delta GM Slope
US 5,320,710	50% *H. Funifera* 50% NSWK	-20%	192%	65%
Inventive	40% *H. Funifera* 60% EHWK	2%	1%	8%

Not only were previous attempts to balance bulk, strength, stiffness and softness unsuccessful, the resulting tissue products were not suitable for use as premium bath tissue because

the strengths and modulus were excessively high. For example, when compared to Northern® Bathroom Tissue the inventive code of US 5,320,710 had 11 percent lower bulk, 23 percent greater modulus and 148 percent greater stiffness (measured as the modulus divided by the tensile strength). The present inventors have overcome these failings to provide a tissue product that is comparable or better than commercially available bath tissue products. For example, when compared to a current version of Northern® Bathroom Tissue, products of the present invention have comparable bulks, 31 percent lower modulus and 13 percent lower stiffness.

Without being bound by any particular theory, the high degree of strength and stiffness observed previously in tissue products may be attributed in-part to the morphology of hesperaloe fiber when prepared by chemical pulping, which has a relatively long fiber length, high aspect ratio and high ratio of fiber length to cell wall thickness. A comparison of fiber morphology, as reported in the literature for, hesperaloe kraft pulp fibers, conventional NSWK and SSWK is provided in Table 2, below.

TABLE 2

Fiber	Fiber Length (mm)	Average Fiber Width (μm)	Cell Wall Thickness (μm)	Aspect Ratio	Fiber Length : Cell Wall Thickness
H. Funifera kraft pulp	3.4	16.5	3.5	206	971
NSWK	3.5	36	6	97	583
SSWK	4.0	43	7	93	571

Despite the foregoing properties of hesperaloe kraft pulp fibers and the tendency of such pulps to produce overly strong and stiff tissue products, the present inventors have discovered that hesperaloe fibers processed by high yield pulping means, such as mechanical pulping, may be a suitable replacement for high fiber length wood fibers without decreasing bulk, significantly altering tensile, increasing stiffness or reducing softness. Processing of hesperaloe fibers by high yield pulping means generally yields a fiber having a slightly shorter fiber length and higher coarseness compared to hesperaloe chemical pulp fibers.

Not only have the present inventors discovered that high yield hesperaloe pulp fibers are a suitable replacement for high fiber length wood fibers, such as NSWK, but also that the resulting tissue products have physical properties comparable to or better than those produced using NSWK fibers. Accordingly, in certain embodiments, hesperaloe fibers may replace at least about 50 percent of the NSWK in the tissue product, more preferably at least about 75 percent and still more preferably all NSWK without negatively effecting the tissue products softness and durability.

Thus, in one embodiment the present invention provides a tissue product comprising at least about 5 percent, by weight of the tissue product, high yield hesperaloe pulp fiber, the tissue product having a GMT less than about 1000 g/3" and a GM Slope less than about 7.0 kg. In still other embodiments the present disclosure provides a tissue product having a GMT from about 400 to about 1,000 g/3" and more preferably from about 500 to about 800 g/3", a GM Slope less than about 7.0 kg, such as from about 4.5 to about 7.0 kg, and comprising from about 5 to about 50 percent, by weight of the tissue product, high yield hesperaloe pulp fiber. At the foregoing tensile strengths and modulus the tissue products of the present invention are also generally soft, such as having a Stiffness Index less than about 10.0, and more preferably less than about 9.0, such as from about 7.0 to about 9.0.

The improved properties are further illustrated in the table below which compares the change in various tissue product properties relative to comparable tissue products comprising NSWK. All tissues shown in Table 3 are single-ply products having a basis weight of about 35 grams per square meter (gsm) and comprising either 40 weight percent NSWK or hesperaloe and 60 weight percent EHWK, based upon the total weight of the tissue product. Surprisingly hesperaloe provides comparable levels of durability without stiffening or dramatically increasing tensile strength.

TABLE 3

	NSWK	High Yield Hesperaloe Fiber	Delta (%)
GMT (g/3")	627	635	1.3
Sheet Bulk (cc/g)	11	11.2	1.8
Tear Index	14.04	14.96	6.6
TEA Index	9.09	9.45	4.0
Burst Index	9.38	8.27	-11.8
Durability Index	32.5	32.7	0.6
Stiffness Index	7.66	8.2	6.9

Accordingly, in certain embodiments the present invention provides tissue products that are not only soft, but also highly durable at relatively modest tensile strengths. As such the tissue products generally have a GMT less than about 1000 g/3", such as from about 400 to about 1,000 g/3", and more preferably from about 500 to about 800 g/3", but still have a Durability Index greater than about 25, such as from about 25 to about 35, and more preferably from about 30 to about 35.

In other embodiments the tissue products have a Stiffness Index less than about 10.0 and a Durability Index greater than about 30, such as from about 30 to about 35. In one particularly preferred embodiment the tissue product comprises a through-air dried web comprising less than about 5 weight percent NSWK, and from about 10 to about 40 weight percent hesperaloe fiber, the tissue product a Durability Index from about 30 to about 35 and Stiffness Index from about 8.0 to about 10.0.

In a particularly preferred embodiment the tissue product comprises a multi-layered through-air dried web wherein hesperaloe fiber is selectively disposed in only one of the layers such that the hesperaloe fiber is not brought into contact with the user's skin in-use. For example, in one embodiment the tissue web may comprise a two layered web wherein the first layer consists essentially of hardwood kraft pulp fibers and is substantially free of hesperaloe and the second layer comprises hesperaloe, wherein the hesperaloe comprises at least about 50 percent by weight of the second layer, such as from about 50 to about 100 percent by weight of the second layer. It should be understood that, when referring to a layer that is substantially free of hesperaloe fibers, negligible amounts of the fiber may be present therein, however, such small amounts often arise from the hesperaloe fibers applied to an adjacent layer, and do not typically substantially affect the softness or other physical characteristics of the web.

The tissue webs may be incorporated into tissue products that may be either single- or multi-ply, where one or more of the plies may be formed by a multi-layered tissue web having hesperaloe fibers selectively incorporated in one of its layers. In one embodiment the tissue product is constructed such that the hesperaloe fibers are not brought into contact with the user's skin in-use. For example, the tissue product may comprise two multi-layered through-air dried webs wherein each web comprises a first fibrous layer substantially free from hesperaloe fibers and a second fibrous layer comprising hesperaloe fibers. The webs are plied together such that the outer surface of the tissue product is formed from the first fibrous layer of each web and the second fibrous layer comprising the hesperaloe fibers is not brought into contact with the user's skin in-use.

Generally hesperaloe fibers useful in the present invention are derived from non-woody plants in the genus Hesperaloe in the family Agavaceae. Suitable species within the genus Hesperaloe include, for example *H. funifera*, *H. nocturna*, *H. parviflova*, and *H. changii*, as well as combinations thereof.

In certain embodiments the hesperaloe fibers are processed by a high yield pulping process, such as mechanically treating the fibers. High yield pulping processes include, for example, mechanical pulp (MP), refiner mechanical pulp (RMP), pressurized refiner mechanical pulp (PRMP), thermomechanical pulp (TMP), high temperature TMP (HT-TMP) RTS-TMP, thermopulp, groundwood pulp (GW), stone groundwood pulp (SGW), pressure groundwood pulp (PGW), super pressure groundwood pulp (PGW-S), thermo groundwood pulp (TGW), thermo stone groundwood pulp (TSGW) or any modifications and combinations thereof. Processing of hesperaloe fibers using a high yield pulping process generally results in a pulp having a yield of at least about 85 percent, more preferably at least about 90 percent and still more preferably at least about 95 percent.

The high yield pulping process may comprise heating the hesperaloe fiber above ambient temperatures, such as from about to 100 to about 200°C and more preferably from about 120 to about 190°C while subjecting the fiber to mechanical forces. In other embodiments a caustic or oxidizing agent may be introduced to the process to facilitate fiber separation. For example, in one embodiment a 3-8 percent solution of NaOH may be added to the fiber during mechanical treatment. Although a caustic or oxidizing agent may be added during processing, it is generally preferred that the hesperaloe fiber is not pretreated with a chemical agent prior to processing. For example, high yield hesperaloe pulps are generally prepared without pretreatment of the fiber with an aqueous solution of sodium sulfite or the like, which is commonly employed in the manufacture of chemi-mechanical wood pulps.

Generally the high yield pulping process removes from about 1 to about 3 weight percent of the lignin from the hesperaloe fiber. As such high yield hesperaloe pulp useful in the present invention generally has a lignin content less than about 15 weight percent, preferably less than about 13 weight percent and still more preferably less than about 11 weight percent, such as from about 10 to about 15 weight percent.

In a particularly preferred embodiment hesperaloe fibers are utilized in the tissue web as a replacement for high fiber length wood fibers such as softwood fibers and more specifically NSWK or Southern softwood kraft (SSWK). In one particular embodiment the hesperaloe fibers are substituted for NSWK such that the total amount of NSWK, by weight of the tissue product, is less than about 10 percent and more preferably less than about 5 percent. In other embodiments it may be desirable to replace all of the NSWK with hesperaloe fibers such that the tissue product is substantially free from NSWK. In other embodiments hesperaloe fibers may be blended with SSWK fibers such that the total amount of SSWK, by weight of the tissue product, is less than about 10 percent and more preferably less than about 5 percent.

If desired, various chemical compositions may be applied to one or more layers of the multi-layered tissue web to further enhance softness and/or reduce the generation of lint or slough. For example, in some embodiments, a wet strength agent can be utilized, to further increase the strength of the tissue product. As used herein, a “wet strength agent” is any material that, when added to pulp fibers can provide a resulting web or sheet with a wet geometric tensile strength to dry geometric tensile strength ratio in excess of about 0.1. Typically these materials are termed either “permanent” wet strength agents or “temporary” wet strength agents. As is well known in the art, temporary and permanent wet strength agents may also sometimes function as dry strength agents to enhance the strength of the tissue product when dry.

Wet strength agents may be applied in various amounts, depending on the desired characteristics of the web. For instance, in some embodiments, the total amount of wet strength agents added can be between about 1 to about 60 pounds per ton (lbs/T), in some embodiments, between about 5 to about 30 lbs/T, and in some embodiments, between about 7 to about 13 lbs/T of the dry weight of fibrous material. The wet strength agents can be incorporated into any layer of the multi-layered tissue web.

A chemical debonder can also be applied to soften the web. Specifically, a chemical debonder can reduce the amount of hydrogen bonds within one or more layers of the web, which results in a softer product. Depending on the desired characteristics of the resulting tissue product, the debonder can be utilized in varying amounts. For example, in some embodiments, the debonder can be applied in an amount between about 1 to about 30 lbs/T, in some embodiments between about 3 to about 20 lbs/T, and in some embodiments, between about 6 to about 15 lbs/T of the dry weight of fibrous material. The debonder can be incorporated into any layer of the multi-layered tissue web.

Any material capable of enhancing the soft feel of a web by disrupting hydrogen bonding can generally be used as a debonder in the present invention. In particular, as stated above, it is typically desired that the debonder possess a cationic charge for forming an electrostatic bond with anionic groups present on the pulp. Some examples of suitable cationic debonders can include, but are not limited to, quaternary ammonium compounds, imidazolinium compounds, bis-imidazolinium compounds, diquaternary ammonium compounds, polyquaternary ammonium compounds, ester-functional quaternary ammonium compounds (e.g., quaternized fatty acid trialkanolamine ester salts), phospholipid derivatives, polydimethylsiloxanes and related cationic and non-ionic silicone compounds, fatty and carboxylic acid derivatives, mono and polysaccharide derivatives, polyhydroxy hydrocarbons, etc. For instance, some suitable debonders are described in US Patent Nos. 5,716,498, 5,730,839, 6,211,139, 5,543,067, and WO/0021918, all of which are incorporated herein in a manner consistent with the present disclosure.

Still other suitable debonders are disclosed in US Patent Nos. 5,529,665 and 5,558,873, both of which are incorporated herein in a manner consistent with the present disclosure. In particular, US Patent No. 5,529,665 discloses the use of various cationic silicone compositions as softening agents.

Tissue webs useful in forming tissue products of the present invention can generally be formed by any of a variety of papermaking processes known in the art. For example, a papermaking process of the present disclosure can utilize adhesive creping, wet creping, double creping, embossing, wet-pressing, air pressing, through-air drying, creped through-air drying, uncreped

through-air drying, as well as other steps in forming the paper web. Examples of papermaking processes and techniques useful in forming tissue webs according to the present invention include, for example, those disclosed in US Patent Nos. 5,048,589, 5,399,412, 5,129,988 and 5,494,554 all of which are incorporated herein in a manner consistent with the present disclosure. In one embodiment the tissue web is formed by through-air drying and be either creped or uncreped. When forming multi-ply tissue products, the separate plies can be made from the same process or from different processes as desired.

TEST METHODS

Sheet Bulk

Sheet Bulk is calculated as the quotient of the dry sheet caliper (μm) divided by the basis weight (gsm). Dry sheet caliper is the measurement of the thickness of a single tissue sheet measured in accordance with TAPPI test methods T402 and T411 om-89. The micrometer used for carrying out T411 om-89 is an Emveco 200-A Tissue Caliper Tester (Emveco, Inc., Newberg, OR). The micrometer has a load of 2 kilo-Pascals, a pressure foot area of 2500 square millimeters, a pressure foot diameter of 56.42 millimeters, a dwell time of 3 seconds and a lowering rate of 0.8 millimeters per second.

Tear

Tear testing was carried out in accordance with TAPPI test method T-414 "Internal Tearing Resistance of Paper (Elmendorf-type method)" using a falling pendulum instrument such as Lorentzen & Wettre Model SE 009. Tear strength is directional and MD and CD tear are measured independently.

More particularly, a rectangular test specimen of the sample to be tested is cut out of the tissue product or tissue basesheet such that the test specimen measures 63 mm ± 0.15 mm (2.5 inches ± 0.006") in the direction to be tested (such as the MD or CD direction) and between 73 and 114 millimeters (2.9 and 4.6 inches) in the other direction. The specimen edges must be cut parallel and perpendicular to the testing direction (not skewed). Any suitable cutting device, capable of the proscribed precision and accuracy, can be used. The test specimen should be taken from areas of the sample that are free of folds, wrinkles, crimp lines, perforations or any other distortions that would make the test specimen abnormal from the rest of the material.

The number of plies or sheets to test is determined based on the number of plies or sheets required for the test results to fall between 20 to 80 percent on the linear range scale of the tear tester and more preferably between 20 to 60 percent of the linear range scale of the tear tester. The sample preferably should be cut no closer than 6 mm (0.25 inch) from the edge of the material from which the

specimens will be cut. When testing requires more than one sheet or ply the sheets are placed facing in the same direction.

The test specimen is then placed between the clamps of the falling pendulum apparatus with the edge of the specimen aligned with the front edge of the clamp. The clamps are closed and a 20-millimeter slit is cut into the leading edge of the specimen usually by a cutting knife attached to the instrument. For example, on the Lorentzen & Wettre Model SE 009 the slit is created by pushing down on the cutting knife lever until it reaches its stop. The slit should be clean with no tears or nicks as this slit will serve to start the tear during the subsequent test.

The pendulum is released and the tear value, which is the force required to completely tear the test specimen, is recorded. The test is repeated a total of ten times for each sample and the average of the ten readings reported as the tear strength. Tear strength is reported in units of grams of force (gf). The average tear value is the tear strength for the direction (MD or CD) tested. The "geometric mean tear strength" is the square root of the product of the average MD tear strength and the average CD tear strength. The Lorentzen & Wettre Model SE 009 has a setting for the number of plies tested. Some testers may need to have the reported tear strength multiplied by a factor to give a per ply tear strength. For basesheets intended to be multiple ply products, the tear results are reported as the tear of the multiple ply product and not the single-ply basesheet. This is done by multiplying the single-ply basesheet tear value by the number of plies in the finished product. Similarly, multiple ply finished product data for tear is presented as the tear strength for the finished product sheet and not the individual plies. A variety of means can be used to calculate but in general will be done by inputting the number of sheets to be tested rather than number of plies to be tested into the measuring device. For example, two sheets would be two 1-ply sheets for 1-ply product and two 2-ply sheets (4-plies) for 2-ply products.

Tensile

Tensile testing was done in accordance with TAPPI test method T-576 "Tensile properties of towel and tissue products (using constant rate of elongation)" wherein the testing is conducted on a tensile testing machine maintaining a constant rate of elongation and the width of each specimen tested is 3 inches. More specifically, samples for dry tensile strength testing were prepared by cutting a 3 inches ± 0.05 inches (76.2 mm ± 1.3 mm) wide strip in either the machine direction (MD) or cross-machine direction (CD) orientation using a JDC Precision Sample Cutter (Thwing-Albert Instrument Company, Philadelphia, PA, Model No. JDC 3-10, Serial No. 37333) or equivalent. The instrument used for measuring tensile strengths was an MTS Systems Sintech 11S, Serial No. 6233. The data acquisition software was an MTS TestWorks® for Windows Ver. 3.10 (MTS Systems Corp., Research

Triangle Park, NC). The load cell was selected from either a 50 Newton or 100 Newton maximum, depending on the strength of the sample being tested, such that the majority of peak load values fall between 10 to 90 percent of the load cell's full scale value. The gauge length between jaws was 4 ± 0.04 inches (101.6 ± 1 mm) for facial tissue and towels and 2 ± 0.02 inches (50.8 ± 0.5 mm) for bath tissue. The crosshead speed was 10 ± 0.4 inches/min (254 ± 1 mm/min), and the break sensitivity was set at 65 percent. The sample was placed in the jaws of the instrument, centered both vertically and horizontally. The test was then started and ended when the specimen broke. The peak load was recorded as either the "MD tensile strength" or the "CD tensile strength" of the specimen depending on direction of the sample being tested. Ten representative specimens were tested for each product or sheet and the arithmetic average of all individual specimen tests was recorded as the appropriate MD or CD tensile strength the product or sheet in units of grams of force per 3 inches of sample. The geometric mean tensile (GMT) strength was calculated and is expressed as grams-force per 3 inches of sample width. Tensile energy absorbed (TEA) and slope are also calculated by the tensile tester. TEA is reported in units of gm cm/cm^2. Slope is recorded in units of kg. Both TEA and Slope are directional dependent and thus MD and CD directions are measured independently. Geometric mean TEA and geometric mean slope are defined as the square root of the product of the representative MD and CD values for the given property.

Multi-ply products were tested as multi-ply products and results represent the tensile strength of the total product. For example, a 2-ply product was tested as a 2-ply product and recorded as such. A basesheet intended to be used for a two ply product was tested as two plies and the tensile recorded as such. Alternatively, a single ply may be tested and the result multiplied by the number of plies in the final product to get the tensile strength.

Burst Strength

Burst strength herein is a measure of the ability of a fibrous structure to absorb energy, when subjected to deformation normal to the plane of the fibrous structure. Burst strength may be measured in general accordance with ASTM D-6548 with the exception that the testing is done on a Constant-Rate-of-Extension (MTS Systems Corporation, Eden Prairie, MN) tensile tester with a computer-based data acquisition and frame control system, where the load cell is positioned above the specimen clamp such that the penetration member is lowered into the test specimen causing it to rupture. The arrangement of the load cell and the specimen is opposite that illustrated in FIG. 1 of ASTM D-6548. The penetration assembly consists of a semi spherical anodized aluminum penetration member having a diameter of 1.588 ± 0.005 cm affixed to an adjustable rod having a ball end socket. The test specimen is secured in a specimen clamp consisting of upper and lower concentric rings of aluminum

between which the sample is held firmly by mechanical clamping during testing. The specimen clamping rings has an internal diameter of 8.89 ± 0.03 cm.

The tensile tester is set up such that the crosshead speed is 15.2 cm/min, the probe separation is 104 mm, the break sensitivity is 60 percent and the slack compensation is 10 gf and the instrument is calibrated according to the manufacturer's instructions.

Samples are conditioned under TAPPI conditions and cut into 127 x 127 mm ± 5 mm squares. For each test a total of 3 sheets of product are combined. The sheets are stacked on top of one another in a manner such that the machine direction of the sheets is aligned. Where samples comprise multiple plies, the plies are not separated for testing. In each instance the test sample comprises three sheets of product. For example, if the product is a 2-ply tissue product, three sheets of product, totaling six plies are tested. If the product is a single-ply tissue product, then three sheets of product totaling three plies are tested.

Prior to testing the height of the probe is adjusted as necessary by inserting the burst fixture into the bottom of the tensile tester and lowering the probe until it was positioned approximately 12.7 mm above the alignment plate. The length of the probe is then adjusted until it rests in the recessed area of the alignment plate when lowered.

It is recommended to use a load cell in which the majority of the peak load results fall between 10 and 90 percent of the capacity of the load cell. To determine the most appropriate load cell for testing, samples are initially tested to determine peak load. If peak load is < 450 gf a 10 Newton load cell is used, if peak load is > 450 gf a 50 Newton load cell is used.

Once the apparatus is set-up and a load cell selected, samples are tested by inserting the sample into the specimen clamp and clamping the test sample in place. The test sequence is then activated, causing the penetration assembly to be lowered at the rate and distance specified above. Upon rupture of the test specimen by the penetration assembly the measured resistance to penetration force is displayed and recorded. The specimen clamp is then released to remove the sample and ready the apparatus for the next test.

The peak load (gf) and energy to peak (g-cm) are recorded and the process repeated for all remaining specimens. A minimum of five specimens are tested per sample and the peak load average of five tests is reported as the Dry Burst Strength.

EXAMPLES

Example 1

Single-ply uncreped through-air dried (UCTAD) tissue web were made generally in accordance with US Patent No. 5,607,551. The tissue webs and resulting tissue products were formed from various fiber furnishes including, Eucalyptus Hardwood Kraft (EHWK) pulp, NSWK pulp, and high yield hesperaloe pulp (HYH).

The EHWK furnish was prepared by dispersing about 120 pounds (oven dry basis) EHWK pulp in a pulper for 30 minutes at a consistency of about 3 percent. The fiber was then transferred to a machine chest and diluted to a consistency of 1 percent. In certain instances starch (Redibond 2038 A) was added to the EHWK machine chest as indicated in Table 4.

The NSWK furnish was prepared by dispersing about 50 pounds (oven dry basis) of NSWK pulp in a pulper for 30 minutes at a consistency of about 3 percent. The fiber was then transferred to a machine chest and diluted to a consistency of 1 percent. In certain instances starch (Redibond 2038 A) was added to the NSWK machine chest as indicated in Table 4.

The HYH was prepared by dispersing about 50 pounds (oven dry basis) HYH pulp in a pulper for 30 minutes at a consistency of about 3 percent. The fiber was then transferred to a machine chest and diluted to a consistency of 1 percent. HYH was produced by processing *H. Funifera* using a three stage non-wood pulping process commercially available from Taizen America (Macon, GA). The hesperaloe was not refined. The hesperaloe had an average fiber length of about 1.85 mm and a fiber coarseness of about 5.47 mg/100 m.

TABLE 4

Sample	Furnish Layering	Redibond 2038 A (kg/ton)/Layer	Refining (min)
Control 1	EHWK/NSWK/EHWK	3/All	1
Control 2	EHWK/NSWK/EHWK	3/All	1
Inventive 1	EHWK/Hesperaloe/EHWK	0	-
Inventive 2	EHWK/Hesperaloe/EHWK	6/EWHK	-

The stock solutions were pumped to a 3-layer headbox after dilution to 0.75 percent consistency to form a three layered tissue web. EHWK fibers were disposed on the two outer layers and either NSWK or HYH was disposed in the middle layer. The relative weight percentage of the layers was 30% / 40% / 30%. The formed web was non-compressively dewatered and rush transferred to a transfer fabric traveling at a speed about 28 percent slower than the forming fabric. The transfer vacuum at the transfer to the TAD fabric was maintained at approximately 6 inches of mercury vacuum to control molding to a constant level. The web was then transferred to a T-1205-2 TAD fabric

(commercially available from Voith Fabrics, Appleton, WI and previously disclosed in US Patent No. 8,500,955, the contents of which are incorporated herein in a manner consistent with the present disclosure). The web was then dried and wound into a parent roll. The parent rolls were then converted into 1-ply bath tissue rolls. Calendering was done with a steel-on-rubber setup. The rubber roll using in the converting process had a hardness of 40 P&J. The rolls were converted to a diameter of about 117 mm with Kershaw firmness target of about 6 mm and a target roll weight of about 400 grams. Samples were produced as described in Table 5, below.

TABLE 5

Sample	Basis Weight (gsm)	Target GMT (g/3")	Plies	EHWK (wt%)	NSWK (wt%)	Hesperaloe (wt%)
Control 1	31.0	650	1	60	40	-
Control 2	31.2	900	1	60	40	-
Inventive 1	31.3	650	1	60	-	40
Inventive 2	31.9	900	1	60	-	40

The effect of hesperaloe fibers on various tissue properties, including tensile, durability and softness, is summarized in the tables below.

TABLE 6

Sample	Basis Weight (gsm)	Sheet Bulk (cc/g)	GMT (g/3")	GM TEA (g•cm/cm^2)	GM Slope (kg)	GM Tear (g)	Dry Burst (g)
Control 1	31.0	11.0	627	5.7	4.8	8.8	588
Control 2	31.2	12.0	883	8.6	5.4	12.9	764
Inventive 1	31.3	11.2	635	6.0	5.2	9.5	525
Inventive 2	31.9	11.5	920	9.7	6.2	13.3	736

TABLE 7

Sample	Tear Index	TEA Index	Burst Index
Control 1	14.04	9.09	9.38
Control 2	14.6	9.74	8.65
Inventive 1	14.96	9.45	8.27
Inventive 2	14.46	10.54	8.00

TABLE 8

Sample	Stiffness Index	Delta Stiffness Index (%)	Durability Index	Delta Durability
Control 1	7.66	-	32.50	-
Control 2	6.11	-	33.00	-
Inventive 1	8.19	7	32.68	1
Inventive 2	6.74	10	33.00	0

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Example 2

Additional single-ply uncreped through-air dried (UCTAD) tissue web were made generally in accordance with US Patent No. 5,607,551 at differing basis weights and tensile strengths compared to the tissue products of Example 1. The tissue webs and resulting tissue products were formed from various fiber furnishes including, Eucalyptus Hardwood Kraft (EHWK) pulp, NSWK pulp, and hesperaloe pulp. Fiber furnishes were prepared as described in Example 1 and the following samples were prepared.

TABLE 9

Sample	Furnish	Redibond 2038 A (kg/ton)	Refining (min)
Control 3	EHWK/NSWK/EHWK	0	-
Control 4	EHWK/NSWK/EHWK	2	-
Inventive 3	EHWK/Hesperaloe/EHWK	4	-
Inventive 4	EHWK/Hesperaloe/EHWK	0	2

The stock solutions were pumped to a 3-layer headbox after dilution to 0.75 percent consistency to form a three layered tissue web. EHWK fibers were disposed on the two outer layers and either NSWK or HYH was disposed in the middle layer. The relative weight percentage of the layers was 30% / 40% / 30%. The formed web was non-compressively dewatered and rush transferred to a transfer fabric traveling at a speed about 28 percent slower than the forming fabric. The transfer vacuum at the transfer to the TAD fabric was maintained at approximately 6 inches of mercury vacuum to control molding to a constant level. The web was then transferred to a either T-1205-2 or T2407-13 (commercially available from Voith Fabrics, Appleton, WI and previously disclosed in US Patent No. 8,702,905, the contents of which are incorporated herein in a manner consistent with the present disclosure) TAD fabric. The web was then dried and wound into a parent roll. The parent rolls were then converted into 1-ply bath tissue rolls. Calendering was done with a steel-on-rubber setup. The rubber roll using in the converting process had a hardness of 40 P&J. The rolls were converted to a diameter of about 117 mm with Kershaw firmness target of about 6 mm and a target roll weight of about 400 grams. Samples were produced as described in Table 10, below.

TABLE 10

Sample	Vacuum (Inches of Hg)	TAD Fabric	EHWK (wt%)	NSWK (wt%)	Hesperaloe (wt%)
Control 3	9	T-1205-2	60	40	-
Control 4	9	T2407-13	60	40	-
Inventive 3	9	T-1205-2	60	-	40
Inventive 4	9	T2407-13	60	-	40

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TABLE 11

Sample	GMT	Basis Weight (gsm)	Bulk (cc/g)	CD Stretch (%)	GM Slope (kg)	Stiffness Index	GM Stretch (%)	GM TEA (g•cm/cm^2)	TEA Index
Control 3	441	26.9	15.3	8.7	4.08	9.25	11.3	4.58	10.39
Control 4	492	27.9	15.5	8.5	4.57	9.30	11.3	4.96	10.09
Inventive 3	459	27.3	17.2	9.3	3.85	8.38	11.9	5.03	10.95
Inventive 4	460	25.8	16.6	9.5	4.21	9.16	11.7	5.06	11.01

While tissue webs, and tissue products comprising the same, have been described in detail with respect to the specific embodiments thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing, may readily conceive of alterations to, variations of, and equivalents to these embodiments. Accordingly, the scope of the present invention should be assessed as that of the appended claims and any equivalents thereto and the foregoing embodiments:

In a first embodiment the present invention provides a tissue product comprising at least about 20 weight percent high yield hesperaloe pulp fibers, the tissue product having a GMT from about 400 to about 1,000 g/3", a Stiffness Index less than about 10 and a sheet bulk greater than about 10 cc/g.

In a second embodiment the present invention provides the tissue product of the first embodiment having a Burst Index greater than about 8.0.

In a third embodiment the present invention provides the tissue product of the first or the second embodiments having a TEA Index greater than about 8.0.

In a fourth embodiment the present invention provides the tissue product of any one of the first through the third embodiments having a Durability Index greater than about 28.

In a fifth embodiment the present invention provides the tissue product of any one of the first through the fourth embodiments wherein the GM Slope is less than about 6.0 kg.

In a sixth embodiment the present invention provides the tissue product of any one of the first through the fifth embodiments having a GMT from about 700 to about 1,000 g/3 and still more preferably from about 750 to about 900 g/3".

In a seventh embodiment the present invention provides the tissue product of any one of the first through the sixth embodiments wherein the tissue product is substantially free from softwood kraft pulp fibers.

In an eighth embodiment the present invention provides the tissue product of any one of the first through the seventh embodiments comprising from about 25 to about 50 weight percent high yield hesperaloe pulp fibers.

In a ninth embodiment the present invention provides the tissue product of any one of the first through the eighth embodiments wherein the high yield hesperaloe pulp fibers have a lignin content from about 10 to about 15 weight percent.

In a tenth embodiment the present invention provides the tissue product of any one of the first through the ninth embodiments wherein the tissue product is substantially free from NSWK fibers.

In a eleventh embodiment the present invention provides a tissue product comprising at least one multi-layered through-air dried tissue web comprising a first and a second layer, the first layer being substantially free from high yield hesperaloe pulp fibers and the second layer consisting essentially of high yield hesperaloe pulp fibers, the tissue product having a Durability Index greater than about 28.0, such as from about 28.0 to about 32.0 and more preferably from about 29.0 to about 31.0, and a Stiffness Index less than about 10.0.

WHAT IS CLAIMED IS:

1. A tissue product comprising at least about 20 weight percent high yield hesperaloe pulp fibers, the tissue product having a GMT from about 400 to about 1,000 g/3" and a Stiffness Index less than about 10.0.
2. The tissue product of claim 1 having a sheet bulk greater than about 10 cc/g.
3. The tissue product of claim 1 having a Burst Index greater than about 8.0.
4. The tissue product of claim 1 having a TEA Index greater than about 8.0.
5. The tissue product of claim 1 having a Durability Index greater than about 28.
6. The tissue product of claim 1 having a GM Slope less than about 6.0 kg.
7. The tissue product of claim 1 having a basis weight from about 30 to about 60 gsm and a sheet bulk from about 10 to about 15 cc/g.
8. The tissue product of claim 1 wherein the tissue product is substantially free from softwood kraft pulp fibers.
9. The tissue product of claim 1 wherein the tissue product comprises from about 25 to about 50 weight percent high yield hesperaloe pulp fibers.
10. The tissue product of claim 1 wherein the high yield hesperaloe pulp fibers have a lignin content from about 10 to about 15 weight percent.
11. The tissue product of claim 1 wherein the tissue product comprises two plies and each ply is a through-air dried tissue web.
12. A tissue product comprising at least one multi-layered through-air dried tissue web comprising a first and a second layer, the first layer being substantially free from high yield hesperaloe pulp fibers and the second layer consisting essentially of high yield hesperaloe pulp fibers, the tissue product having a Durability Index greater than about 28.0 and a Stiffness Index less than about 10.0, wherein the tissue product comprises from about 20 to about 50 weight percent high yield hesperaloe pulp fibers.
13. The tissue product of claim 12 having a Burst Index greater than about 8.0.

14. The tissue product of claim 12 having a TEA Index greater than about 8.0.

15. The tissue product of claim 12 having a GM Slope less than about 6.0 kg.

16. The tissue product of claim 12 having a basis weight from about 30 to about 60 gsm and a sheet bulk from about 10 to about 15 cc/g.

17. The tissue product of claim 12 wherein the tissue product is substantially free from softwood kraft pulp fibers.

18. The tissue product of claim 12 wherein the high yield hesperaloe pulp fibers have a lignin content from about 10 to about 15 weight percent.

19. A single-ply through-air dried tissue product comprising at least about 20 weight percent high yield hesperaloe pulp fibers, the tissue product having a basis weight from about 30 to about 60 gsm, a sheet bulk greater than about 10 cc/g and a Stiffness Index less than about 10.

20. The single-ply through-air dried tissue product of claim 19 having a GM Slope less than about 6.0 kg.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/033168

A. CLASSIFICATION OF SUBJECT MATTER

A47K 10/16(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A47K 10/16; D21H 27/38; D21H 11/12; D21H 27/00; B65H 18/28; D21H 27/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: tissue, hesperaloe, geometric mean tensile, stiffness index, durability, basis weight, and bulk

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014-0284010 A1 (KIMBERLY-CLARK WORLDWIDE, INC.) 25 September 2014 See paragraphs [0014], [0020], [0022], [0027], [0077], [0081], [0089] and claims 1, 10-12.	1-20
Y	US 5320710 A (REEVES et al.) 14 June 1994 See column 2, lines 61-68; claims 1-2, 7 and figure 2.	1-20
A	US 2013-0199741 A1 (STAGE et al.) 08 August 2013 See paragraph [0030] and claims 1-2, 7-8, 11, 17.	1-20
A	US 2004-0140076 A1 (HERMANS et al.) 22 July 2004 See paragraphs [0063], [0164] and claims 1-2.	1-20
A	US 2013-0068868 A1 (HERMANS et al.) 21 March 2013 See claims 1-3, 10, 14.	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 February 2016 (26.02.2016)	**26 February 2016 (26.02.2016)**

Name and mailing address of the ISA/KR
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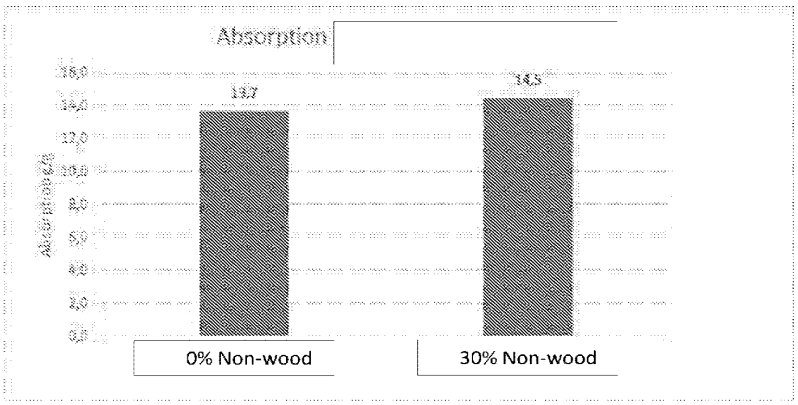


Fig. 1

(57) Abstract: A single-ply tissue paper material having a basis weight less than 40 gsm and an absorbency of at least 3 g/g, comprising a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the non-wood tissue ply. The disclosure further relates to a single-ply tissue paper product, and a multi-ply tissue paper product.

[Continued on next page]

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TISSUE PAPER MATERIAL AND TISSUE PAPER PRODUCT COMPRISING NON-WOOD FIBRES

TECHNICAL FIELD

The present disclosure relates to a tissue paper material, a single-ply tissue paper product and a multi-ply tissue paper product comprising non-wood cellulose pulp fibres.

BACKGROUND

Tissue paper materials find extensive use in modern society. Toilet paper, and paper towels such as hand towels or household (kitchen) towels, facial tissues, tissue handkerchiefs, napkins, and industrial wipes are staple items of commerce. These products are typically made from papermaking pulp comprising wood fibres, such as hardwood and softwood fibres.

In the following, a "tissue paper product" relates to an absorbent paper product based on cellulose wadding which is also called tissue paper material or tissue paper base-sheet in this field of technology.

Tissue paper material is defined as a soft absorbent paper material having a low basis weight, of for example 8 to 45 g/m^2, preferably 10 to 35 g/m^2 per ply. The total basis weight of multi-ply tissue paper products may preferably be up to a maximum of 110 g/m^2, more preferably to a maximum of 80 g/m^2. Its density is typically below 0.6 g/cm^3, preferably below 0.30 g/cm^3 and more preferably in the range of 0.02 g/cm^3 and 0.20 g/cm^3. The production of tissue paper material is distinguished from conventional paper production, e.g. printing paper production, by its relatively low basis weight and relatively high tensile energy absorption index (see ISO 12625-4). Conventional paper and tissue paper also differ in general with regard to the modulus of elasticity that characterises the stress/strain properties of these generally planar products as a material parameter.

The fibres contained in the tissue paper are mainly cellulosic fibres, such as pulp fibres from chemical pulp (e.g. Kraft or sulphite), or mechanical pulp (e.g. ground wood, thermo mechanical pulp, chemo-mechanical pulp and/or chemo- thermo-mechanical pulp /CTMP). Pulps derived from both deciduous (hardwood) and coniferous (softwood) can be used. Fibres may also come from non-wood plants e.g. cereal, bamboo, jute, or sisal. The fibres or a portion of the fibres may be recycled fibres, which may belong to any or all of

the above categories. The fibres can be treated with additives, e.g. fillers, softeners, such as, but not limited to, quaternary ammonium compounds and binders, conventional dry-strength agents, temporary wet strength agents or wet-strength agents, in order to facilitate the original paper making or to adjust the properties thereof.

Tissue paper products in particular for use as hygiene- or wiping products primarily include all kinds of tissue paper materials including dry-creped tissue paper material, wet-creped tissue paper material, NTT (flat), TAD-paper material (Through Air Drying), tissue paper material based on structured or textured technologies such as ATMOS, NTT (textured), UCTAD, eTAD, QRT, PrimeLineTEX etc. and cellulose or pulp-wadding, or combinations, laminates or mixtures thereof. Typical properties of these hygiene- and wiping products include the ability to absorb tensile stress energy, their drapability, good textile-like flexibility, properties which are frequently referred to as bulk softness, a high surface softness and a high specific volume with a perceptible thickness. A liquid absorbency as high as possible and, depending on the application, a suitable wet and dry strength as well as an appealable visual appearance of the outer product's surfaces are desired. These properties, among others, allow these hygiene and wiping products to be used, for example, as cleaning wipes such as windscreen cleaning wipes, industrial wipes, kitchen paper or the like; as sanitary products such as for example bathroom tissue, handkerchiefs, household towels, towels and the like; as cosmetic wipes such as for example facials and as serviettes or napkins, just to mention some of the products that can be used. Furthermore, the hygiene- and wiping products can be dry, moist, wet, printed or pre-treated in any manner. In addition, the hygiene- and wiping products may be folded, interleaved or individually placed, stacked or rolled, connected or not, in any suitable manner.

The products described above can be used for personal and household use as well as commercial and industrial use. They are adapted to absorb fluids, remove dust, and for other cleaning purposes.

If tissue paper material is to be made out of pulp, the process essentially comprises a forming step that includes a headbox- and a forming wire section, and a drying section, e.g. including through air drying or conventional drying on a Yankee cylinder. The production process can also include a crepe process for tissue paper and, finally, typically a monitoring and winding area.

Tissue paper material can be formed by placing the fibres, in an oriented or random manner, on one or between two endless continuously rotating wires or felts of a paper making machine while simultaneously removing water.

Further dewatering and drying the formed primary fibrous web occur in one or more steps by mechanical and thermal means until a final dry-solid content of usually about 90 to 99% has been reached.

In case of creped tissue paper material making, this stage is followed by the crepe process which influences the properties of the finished tissue paper product in conventional processes. The conventional dry crepe process involves creping on a usually 3.0 to 6.5 m diameter drying cylinder, the so-called Yankee cylinder, by means of a crepe doctor blade with the aforementioned final dry-solids content of the raw tissue paper. Wet creping can be used as well, if lower demands are made of the tissue quality. The creped, finally dry raw tissue paper material, the so-called base tissue, is then available for further processing into the tissue paper product.

Instead of the conventional tissue making process described above, the use of a modified technique is possible in which an improvement in specific volume is achieved by a special kind of drying which leads to an improvement in the e.g. caliper, bulk, softness, etc. of the tissue paper material. This process, which exists in a variety of subtypes, is herein generally termed the structured tissue technique. Examples of structured tissue techniques are TAD, ATMOS®, NTT(textured), UCTAD, eTAD, QRT, PrimeLineTex etc.

The processing step from the tissue paper material to the finished tissue paper product occurs in processing machines (converting machines) which include operations such as unwinding the tissue paper material (base tissue), calendering of the tissue, laminating, printing or embossing.

Several plies may be combined together by a combining operation of a chemical nature (e.g. by adhesive bonding), or of a mechanical nature (e.g. by knurling or so-called edge-embossing), or a combination of both. Examples of such process steps for combining plies together will be described in more detail in the below.

Further, the processing to finished tissue paper product may involve e.g. longitudinal cut, folding, cross cut etc. Moreover, individual tissue paper products may be positioned and brought together to form stacks, which may be individually packaged. Such processing

steps may also include application of substances like scents, lotions, softeners or other chemical additives.

When several plies are combined together using adhesive bonding, a film of adhesive is deposited over some or all of the surface of at least one of the plies, then the adhesive-treated surface is placed in contact with the surface of at least one other ply.

When several plies are combined together using mechanical bonding, the plies may be combined by knurling, by compression, by edge-embossing, union embossing and/or ultrasonic.

Mechanical and adhesive bonding may also be combined to combine several plies together to form a multi-ply product.

Embossing is to change the shape of a sheet from flat to shaped, so that there are areas that are raised and/or recessed from the rest of the surface. It therefore constitutes a deformation of the previously relatively flat sheet, and results in a ply having a particular relief. The thickness of the ply or of the multiple plies is in most cases increased after embossing compared with its initial thickness.

An embossing process is carried out between an embossing roll and an anvil roll. The embossing roll can have protrusions or depressions on its circumferential surface leading to embossed protrusions/depressions in the paper web. Anvil rolls may be softer than the corresponding embossing roll and may consist of rubber, such as natural rubber, or plastic materials, paper or steel. If the anvil roll is made of a softer material like rubber, a contact area/nip can be formed between the embossing roll (e.g. steel roll) and the anvil roll by the deformation of the softer roll.

By embossing, a pattern can be applied to a tissue paper fulfilling a decorative and/or functional purpose.

A functional purpose may be to improve the properties of the hygiene paper product, that is, the embossment may improve the product thickness, absorbency, bulk, softness etc.

A functional purpose may also be to provide a joint to another ply in a multi-ply product.

Tissue paper products display a number of physical properties which are of importance for their use for example as toilet paper, hand towels, kitchen towels, facial tissues, handkerchiefs, napkins, wipe or the like. Examples of such properties are their strength, softness, and absorbency (primarily for aqueous systems). These physical properties are

generally tuned for addressing common consumer demand in view of the intended use of the tissue paper product.

For example, it is desired that tissue paper products have an absorbency so as to be suitable for their purpose such as for wiping liquids or moisture, cleaning etc.

For example, tissue paper products need to retain their strength at least for a time period of use e.g. for wiping liquids or moisture.

At the same time, there are requirements regarding tactile properties such as softness as tissue paper products may be intended to come in intimate contact with the body and skin. Accordingly, it is desired that tissue paper products shall exhibit sufficient softness in order to ensure consumer's comfort.

Hence, it is desired to provide a tissue paper product providing a good balance between required properties. For example, it is desired to provide a tissue paper product achieving a satisfactory absorption, strength and/or softness.

Further, there is a desire to reduce the consumption of wood fibre to produce tissue paper products. This desire is advocated by e.g. rising costs for wood fibre, concerns involving sustainable forest management, and other environmental reasons such as carbon foot print.

To this end, attempts have been made to replace some or all of the wood fibre in tissue paper products with for example recycled fibres and/or with non-wood fibres. However, since the fibre content in the pulp will naturally impact the above-mentioned physical properties of the resulting tissue paper material, the replacement of virgin wood fibres with other fibres in the pulp is not uncomplicated.

Thus, there is a need for improvement and/or alternatives for tissue paper products in view of one or more of the above-mentioned desires.

SUMMARY

An object of the present invention is to fulfill said need for improvement and/or alternatives.

To this end, it is proposed herein to use non-wood cellulose pulp fibres in tissue paper materials and tissue paper products.

The non-wood cellulose pulp fibres may be chemical pulp fibres.

Optionally, the non-wood cellulose pulp fibres may be never-dried fibres. "Never-dried" means herein that the fibres have not been subject to drying before use in the tissue making process. It is believed that the non-wood cellulose pulp fibres being never-dried may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

Optionally, the non-wood cellulose pulp fibres contain at least 15% hemicellulose. It is believed that such a hemicellulose content may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

Optionally, the non-wood cellulose pulp fibres contain no more than 15 % lignin. For example, the non-wood cellulose pulp fibres may contain no more than 12 % lignin. In yet another example, the non-wood cellulose pulp fibres may contain no more than 10% lignin. It is believed that such a lignin content may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

For example, the non-wood cellulose pulp fibres may contain at least 15% hemicellulose and no more than 15 % lignin, such as no more than 12 % lignin or no more than 10% lignin.

Optionally, the non-wood cellulose pulp fibres are pre-treated, to obtain the desired amounts of lignin and/or hemicellulose.

Further, the non-wood cellulose pulp fibres may have a relatively low average fibre length.

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1700 µm.

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1200 µm.

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 1000 µm.

Optionally, the non-wood cellulose pulp fibres have an average fibre length of less than 900 µm.

Further, it is believed that the non-wood cellulose pulp fibres having a relatively high breaking length may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products. The breaking length is the initial breaking length of the non-wood cellulose pulp fibres as measured on the non-wood cellulose pulp fibres after the pulping process.

Optionally, the non-wood cellulose fibres have a breaking length of more than 3000 m.

For example, the non-wood cellulose fibres may have a breaking length of more than 3000 m and an average fibre length of less than 1700 µm, such as less than 1200 µm or less than 900 µm.

Also, it is believed that the non-wood cellulose pulp fibres having a relatively high ratio between breaking length and average fibre length may contribute to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products.

Optionally, the non-wood cellulose fibres have a breaking length/average fibre length of more than 3.7.

Optionally, the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.0.

Optionally, the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.5.

For example, the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 5 such as more than 5.5.

For example, the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 3.7 such as more than 4 and an average fibre length of less than 1700 µm, such as less than 1200 µm, less than 1000 µm, or less than 900 µm.

For comparison, it may be mentioned that different types of conventional hardwood and softwood pulps display lower breaking length/average fibre length ratios than those suggested in the above for the non-wood cellulose fibres. This applies also to examples of never-dried hardwood and softwood pulps. Average ratios as calculated for different types of hardwood and softwood pulps are indicated in the table in the below.

Type of pulps	Average ratio
BEK	2.4
BHK	2.0
BSK	1.0
BSS	0.6
NBHK	2.3
NBSK	1.2
Never-dried HW	0.9
Never-dried SW	1.0

(BEK – Bleached Eucalyptus Pulp, BHK – Bleached Hardwood Kraft, BSK – Bleached Softwood Kraft, BSS – Bleached Softwood Sulfite, Northern Bleached Hardwood Kraft, Northern Bleached Softwood Kraft. The never-dried Hardwood (HW) and Softwood (SW) are sulfite.)

Also, several types of previously used non-wood cellulose pulp fibres have been found to display lower breaking length/average fibre length ratio than what is proposed in the above. For example, tested samples of dried bagasse fibre pulp was found to have an average ratio of 2.6, dried bamboo fibre pulp an average ratio of 1.2 and dried wheat fibre pulp an average ratio of 3.5.

For example, the non-wood cellulose fibres may be never-dried non-wood cellulose pulp fibres and the non-wood cellulose fibres may have a breaking length/average fibre length ratio of more than 3.7, such as more than 4.0 or more than 4.5.

The non-wood cellulose pulp fibres as proposed herein may be used together with hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

As mentioned in the above, optionally, a portion or all non-wood cellulose pulp fibres are never-dried non-wood cellulose pulp fibres.

Optionally, the non-wood cellulose fibres are used with softwood cellulose pulp fibres. In this case, a portion of or all softwood cellulose fibres may be never-dried softwood cellulose pulp fibres.

For example, the softwood cellulose pulp fibres may comprise never-dried hardwood cellulose pulp fibres and/or dried softwood cellulose pulp fibres.

Optionally, the non-wood cellulose fibres are used with hardwood cellulose pulp fibres. In this case, a portion of or all hardwood cellulose fibres may be never-dried hardwood cellulose pulp fibres.

For example, the hardwood cellulose pulp fibres may comprise never-dried hardwood cellulose pulp fibres and/or dried hardwood cellulose pulp fibres.

Optionally, the non-wood cellulose pulp fibres as proposed herein may be achieved by treatment by a non-pressurised process.

Optionally, the non-wood cellulose pulp fibres as proposed herein may be achieved by treatment by a process with no use of sulfur.

For example, the non-wood cellulose pulp fibres may be achieved by treatment using methods similar to the methods described EP 2 048281 A1, EP 2 247781 B1, US20130129573 A1, EP 2 034 090 A1, US20110281298 A1, and/or US20130129573 A1.

Additionally or alternatively, the non-wood cellulose pulp fibres may be achieved by treatment using methods similar to the methods described in WO2020264311 A1, WO2020264322 A1, US20190091643 A1, US2592983.

For example, the non-wood cellulose pulp fibres may be achieved by the Phoenix Process TM, of Sustainable Fiber Technologies Inc.

It will be understood that the features as discussed in the above as being contributing to the non-wood cellulose pulp fibres being suitable for use in tissue paper materials and tissue paper products may be used separately or in different combinations.

Optionally, the non-wood cellulose pulp fibres are derived from agricultural waste or byproduct.

Optionally, the non-wood cellulose pulp fibres are derived from a member of the Pocacea family. For example, the non-wood cellulose pulp fibres may be derived from wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, and/or sorghum. Another example of a member of the Pocacea family is sugar cane, from which non-wood cellulose pulp fibres may be derived, for example from sugar cane bagasse.

Optionally, the non-wood cellulose pulp fibres are derived from a member of the Cannabaceae family. For example, the non-wood cellulose pulp fibres may be derived from hemp and/or hop.

Optionally, the non-wood cellulose pulp fibres are derived from agricultural waste or byproducts. For example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts of the members of the Pocacea family and/or Cannabaceae family such as exemplified in the above, i.e. including agricultural waste or byproducts from wheat straw, rice straw, barley straw, oat straw, rye grass, sugar cane bagasse, hemp or hop. In another example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts such as banana harvest residue (belongs to the family Musaceae), pineapple residue (belongs to the family Bromeliaceae), bagasse from agave, nut shell waste, hop residue and/or corn stover.

Optionally, the non-wood cellulose pulp fibres are derived from kenaf (belongs to the family Malvaceae), switchgrass, succulents, alfalfa (belongs to the family Fabaceae), flax straw (belongs to the family Linaceae), palm fruits (Elaeis or Arecaceae), and/or avocado (Lauraceae).

Optionally, the non-wood cellulose pulp fibres are derived from one or more of wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, sorghum, banana harvest residue, pineapple residue, nut shell waste, sugar-cane bagasse, industrial hemp, and/or members of the Cannabaceae family, kenaf, switchgrass, succulents, alfalfa, corn stover, and flax straw.

Optionally, the non-wood cellulose pulp fibres are derived from wheat straw, oat straw, barley straw, and/or rye grass. For example, the non-wood cellulose pulp fibres may be derived from agricultural waste or byproducts of wheat straw, oat straw, barley straw, and/or rye grass.

For example, the non-wood cellulose pulp fibres may be derived from wheat straw, such as from agricultural waste or byproducts of wheat.

Optionally, the non-wood cellulose pulp fibres are derived from residues from sugar production. For example, the non-wood cellulose pulp fibres may be residues from beet.

Optionally, the non-wood cellulose pulp fibres are derived from sugarcane bagasse.

Optionally, the non-wood cellulose pulp fibres are derived from agave. For example, the non-wood cellulose pulp fibres may be derived from resides from agave syrup production or derived from agave bagasse.

Although the present disclosure relates primarily to tissue paper made of non-wood fibres, it is understood that the non-wood cellulose pulp fibres as described herein may also find use in other applications e.g. in wound care, in absorbent articles, for example diapers, sanitary napkins, and incontinence articles, in beauty care, and/or in nonwoven materials and products.

Herein, the non-wood cellulose pulp fibres as described in the above are proposed to be used to form a non-wood tissue ply, comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 30% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of at least 40% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount from 20 to 50% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount from 25 to 35% by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of less than 70 % by dry weight of the non-wood tissue ply.

Optionally, said non-wood tissue ply comprises non-wood cellulose pulp fibres in an amount of less than 60 % by dry weight of the non-wood tissue ply.

Optionally, the non-wood tissue ply further comprises wood pulp fibres, such as hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

Optionally, the non-wood tissue ply further comprises wood pulp fibres in an amount such that the wood pulp fibre amount plus the non-wood fibre amount constitutes 100% dry weight of the tissue paper ply.

Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 95/5.

Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 90/10.

Optionally, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply is less than 80/20.

For example, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply may be greater than or equal to 0/100.

For example, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply may be in the range of 70/30 to 30/70.

For example, the hardwood/softwood dry weight proportion of the wood pulp fibres in the non-wood tissue ply may be in the range of 60/40 to 40/60.

Optionally, said non-wood cellulose pulp fibres are present throughout the non-wood tissue ply. In other words, at least some non-wood cellulose pulp fibres may be found in all parts of the ply, e.g. in all layers of the ply. The non-wood cellulose pulp fibres need not be uniformly distributed, but may be a result of e.g. stratified distribution of the non-wood cellulose pulp fibres. For example, the non-wood cellulose pulp fibres may be homogenously distributed in the ply. In another example, the non-wood cellulose pulp fibres may be heterogeneously distributed in the ply.

Optionally, when said non-wood tissue ply comprises two or more layers, at least one layer of the non-wood tissue ply comprises non-wood fibres. For example, said at least one layer maybe an outer layer of the non-wood tissue ply.

Optionally, when said non-wood tissue ply comprises two or more layers, each out of said two or more layers may comprise non-wood fibres.

Optionally, the non-wood tissue ply is produced by conventional wet press technology (CWP). By “is produced” means that the tissue paper material has been manufactured using conventional wet press technology, i.e. the tissue paper material is a CWP tissue paper material. For example, the tissue paper material may be a dry crepe tissue paper material.

Optionally, the non-wood tissue ply is produced by structured tissue technology. By "is produced" means that the tissue paper material has been manufactured using structured tissue technology, i.e. the tissue paper material is a structured tissue paper material.

Optionally, the non-wood tissue ply is produced by TAD (Through Air Drying) technology.
Optionally, the non-wood tissue ply is produced by ATMOS technology.
Optionally, the non-wood tissue ply is produced by UCTAD technology.
Optionally, the non-wood tissue ply is produced by NTT technology (textured).
Optionally, the non-wood tissue ply is produced by eTAD technology, such as Advantage eTAD technology from Valmet.
Optionally, the non-wood tissue ply is produced by QRT technology.
Optionally, the non-wood tissue ply is produced by PrimeLine TEX technology.

In accordance with the invention, there is provided tissue paper materials and tissue paper products including the non-wood tissue ply as described in the above with the non-wood cellulose pulp fibres as described in the above.

Thus, in a first aspect, there is provided a single-ply tissue paper material according to claim 1. Thus, there is provided a single-ply tissue paper material having a basis weight less than 40 gsm and an absorbency of at least 3 g/g, comprising a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

Optionally, the tissue paper material has an absorbency of at least 4 g/g.

Optionally, the tissue paper material has an absorbency of at least 5 g/g.

Optionally, the tissue paper material is produced by CWP (Conventional Wet Pressed) technology.

Optionally, the tissue paper material is produced by structured tissue technology.

Optionally, the tissue paper material is produced by structured tissue technology and have an absorbency of at least 6 g/g.

Optionally, the tissue paper material is produced by structured tissue technology and have an absorbency of at least 7 g/g.

Optionally, the tissue paper material is produced by structured tissue technology and have an absorbency of at least 8 g/g.

Optionally, the structured tissue technology is TAD technology.

Optionally, the tissue paper material has a GMT tensile strength of at least 60 N/m.

Optionally, the tissue paper material has a GMT tensile strength of at least 70 N/m.

Optionally, the tissue paper material has a GMT tensile strength of at least 80 N/m.

For example, the tissue paper material may have a GMT tensile strength of at least 100 N/m.

For example, the tissue paper material may have a GMT tensile strength of at least 150 N/m.

Optionally, the tissue paper material has a basis weight of less than 30 gsm.

Optionally, the tissue paper material has a basis weight of less than 25 gsm.

Optionally, the tissue paper material has a basis weight of more than 10 gsm.

Optionally, the tissue paper material has a basis weight of more than 15 gsm.

For example, the tissue paper material may be produced by CWP technology, and have a basis weight from 15 to 20 gsm and an absorption of at least 5 g/g.

For example, the tissue paper material may be produced by CWP technology, and have a basis weight from 20 to 30 gsm and an absorption of at least 4 g/g.

For example, the tissue paper material may be produced by CWP technology, and have a basis weight above from 30 gsm and an absorption of at least 3 g/g.

For example, the tissue paper material may be produced by CWP technology, and the basis weight (gsm) x the absorption (g/g) may be at least 75 (g/m2).

For example, the tissue paper material may be produced by CWP technology, and the basis weight (gsm) x the absorption (g/g) may be at least 80 (g/m2).

For example, the tissue paper material may be produced by CWP technology, and the basis weight (gsm) x the absorption (g/g) may be at least 90 (g/m2).

For example, the tissue paper material may be produced by structured tissue technology, and have a basis weight from 15 to 20 gsm and an absorption of at least 8 g/g.

For example, the tissue paper material may be produced by structured tissue technology, and have a basis weight from 20 to 30 gsm and an absorption of at least 7 g/g.

For example, the tissue paper material may be produced by structured tissue technology, and have a basis weight above from 30 gsm and an absorption of at least 6 g/g.

For example, the tissue paper material may be produced by structured tissue technology, and the basis weight (gsm) x the absorption (g/g) may be at least 120 (g/m2).

For example, the tissue paper material may be produced by structured tissue technology, and the basis weight (gsm) x the absorption (g/g) may be at least 140 (g/m2).

For example, the tissue paper material may be produced by (g/m2) technology, and the basis weight (gsm) x the absorption (g/g) may be at least 180 (g/m2).

Optionally, the tissue paper material may have a thickness of above 0.08 mm.

Optionally, the tissue paper material may have a thickness below 0.5 mm.

In a second aspect, there is provided a single-ply tissue paper product according to claim 15. Thus, there is provided a single-ply tissue paper product comprising a single-ply tissue paper material according to the first aspect in the above.

In a third aspect, there is provided a multi-ply tissue paper product according to claim 16. Thus, there is provided a multi-ply tissue paper product comprising two or more plies, wherein an average basis weight of the plies is less than 40 gsm, and the multi-ply tissue paper product having an absorption of at least 4 g/g, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

Optionally, the multi-ply tissue paper product has an absorbency of at least 5 g/g.

Optionally, the multi-ply tissue paper product has an absorbency of at least 6 g/g.

Optionally, at least one ply of the multi-ply tissue paper product is produced by CWP (Conventional Wet Pressed) technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology. For example, the structured tissue technology may be TAD technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 7 g/g. For example, the ply may be produced by TAD technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 8 g/g. For example, the ply may be produced by TAD technology.

Optionally, at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 9 g/g. For example, the ply may be produced by TAD technology.

Optionally all plies of the multi-ply tissue paper product are produced by structured tissue technology. For example, all of the plies may be produced by TAD technology.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 100 N/m.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m.

Optionally, the multi-ply tissue paper product has a GMT tensile strength of at least 150 N/m.

For example, the multi-ply tissue paper product has a GMT tensile strength of at least 200 N/m.

For example, the multi-ply tissue paper product has a GMT tensile strength of at least 300 N/m.

For example, the multi-ply tissue paper product has a GMT tensile strength of at least 400 N/m.

Optionally, a majority of the plies of the multi-ply tissue paper material are non-wood tissue plies.

Optionally, all of the plies of the multi-ply tissue paper material are non-wood tissue plies.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 30% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of at least 40% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of no more than 70% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount of no more than 60% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range between from 15 % to 50% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range between from 15 % to 40% by dry weight the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises non-wood cellulose pulp fibres in an amount in a range between from 25 % to 35% by dry weight of the multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises two to five plies.

Optionally, each of the plies of the multi-ply tissue paper product comprises the same amount of non-wood cellulose pulp fibres.

Optionally, at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 5% dry weight.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 10% dry weight.

Optionally, when at least two plies in said multi-ply tissue paper product comprise different amounts of non-wood cellulose pulp fibres, the amounts differ by at least 20% dry weight.

Optionally, the multi-ply tissue paper product comprises one or more plies with no non-wood cellulose pulp fibres.

Optionally, said at least one non-wood tissue ply is an outer ply of said multi-ply tissue paper product.

Optionally, the multi-ply tissue paper product comprises at least two non-wood tissue plies, wherein the non-wood tissue plies form a first and a second outer ply of the multi-ply tissue paper product.

Optionally, for each of the alternatives relating to a multi-ply tissue paper product in the above, the non-wood ply may be such as defined in the above in any one of the options relating to the first aspect.

Optionally, the at least one non-wood tissue ply of the multi-ply tissue paper product comprises a single-ply tissue paper material in accordance with the first aspect as described in the above.

The single-ply tissue paper product and the multi-ply tissue paper product as disclosed herein may for example be a tissue paper product for personal hygiene.

Optionally, the single-ply tissue paper product and the multi-ply tissue paper product disclosed herein may for example be toilet paper, hand wipes, paper napkins, facial tissue, handkerchiefs, or a kitchen towel or an industrial wipe.

The single-ply tissue paper product and the multi-ply tissue paper product may be embossed and/or calendared as is known in the art.

Optionally, the plies of the multi-ply product may be joined by ply bonding, such as for example embossing or knurling. For example, the multi-ply product may be joined by nesting.

Optionally, the plies of the multi-ply product may be joined by Goffra-Incolla technology.

Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

In the drawings:

Fig. 1 is a diagram of absorbency values obtained for tissue paper materials obtained in Example 1;

Fig. 2a is a diagram of absorbency values obtained for tissue paper materials obtained in Example 2;

Fig. 2b is a diagram of absorbency values obtained for tissue paper products obtained in Example 2;

Fig. 3 is a diagram of absorbency values obtained for tissue paper products obtained in Example 3;

Fig. 4 is a diagram of absorbency values obtained for tissue paper products obtained in Example 4; and

Fig. 5 is a diagram of absorbency values obtained for the tissue paper products obtained in Example 5, including variants of the tissue paper products obtained in Example 2.

DETAILED DESCRIPTION

EXAMPLE 1 (TAD Tissue paper material)

One-ply tissue paper materials intended for use as kitchen towels were produced using TAD technology with different dry content of non-wood fibre.

Two versions of the tissue paper materials were made, one comprising 0% dry weight non-wood fibres, and one comprising 30% by dry weight non-wood fibres.

The non-wood fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp of this type generally has a lignin content of less than 15 % and a hemicellulose content of more than 15 %.

The breaking length, average fibre length, and ratio breaking length/average fibre length of the non-wood cellulose fibre pulp are indicated in the table below:

	Non-wood fibre
Breaking length [m]	5338
Average fibre length[µm]	854
BL/av fibre length	6.25

The conventional short fibre content was made out of dried hardwood cellulose fibre pulp. The dried hardwood cellulose fibre pulp was dried Eucalyptus fibre pulp, BEK (Bleached Eucalyptus Kraft).

The conventional long fibre content was made out of dried softwood cellulose fibre pulp. In this example, the dried softwood cellulose fibre pulp was NBSK (Northern Bleached Softwood Kraft).

The breaking length/average fibre length ratio of BEK in general has been found to be about 2.4, and the breaking length/average fibre length ratio of NBSK has been found to be about 1.2, as indicated in the table in the Summary section in the above.

The machine was a stratified machine with 3 layers headbox, fed with 2 fibre lines:

- The long fibre line is feeding the Hood and Yankee layers of the headbox
- the short fibre line is feeding the middle layer of the headbox

The overall furnish of the reference and the trial were the following

- Reference: 42% BEK – 58% NBSK
- Trial: 12% BEK– 58% NBSK – 30% straw

The different fibres were split and treated as follow:

Trial	Trial	reference	trial
Overall furnish	NBSK	58%	58%
	BEK	42%	12%
	Non-wood	0	30%
Long fibre line	NBSK	83%	83%
	Non-wood	17%	17%
	Refining	160 kwh/T	160 kwh/T
Short fibre line	BEK	100%	0%
	Non-Wood	0%	100%
	Refining	30 kwh/T	none
Headbox	Configuration	stratified	stratified
	Yankee layer	41.5% NBSK + 8.5% BEK	41.5% NBSK + 8.5% BEK
	Middle layer	100% BEK	100% Non-wood
	Hood layer	41.5% NBSK + 8.5% BEK	41.5% NBSK + 8.5% BEK

Chemistry was added to provide dry and wet tensile strength, and was kept constant for the different qualities.

The average base sheet properties are as follows

	Basis weight (g/m²)	Thickness (1 sheet) mm	Dry tensile MD (N/m)	Dry tensile CD (N/m)	Stretch MD (%)	GMT (N/m)	Wet tensile MD (N/m)	Wet tensile CD (N/m)	ABSORPTION (g/g)
Reference	22.1	0.43	257	189	15.0	220	87.1	68.4	13.7
Trial 30% Non-wood	22.4	0.45	276	205	13.9	237	87.5	63.4	14.5

Despite no refining on the short fibre line, the tissue paper material containing non-wood fibres tends to be stronger than the reference paper material without non-wood.

As seen from the values in the table in the above, and as illustrated by the diagrams in Fig. 1, the trial with non-wood is significantly more absorbent than the reference tissue paper material without non-wood.

Thus, the tissue paper material including 30% non-wood fibres was even more absorbent than the tissue paper material including 0% non-wood fibre.

EXAMPLE 2 TAD tissue paper material and 2-ply TAD tissue paper product

Two-ply tissue paper products intended for use as kitchen towels were produced using TAD technology. The two-ply tissue paper products were produced from tissue paper materials (base sheets) produced using TAD technology and with different dry content of non-wood fibre.

The non-wood fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp of this type generally has a lignin content of less than 15 % and a hemicellulose content of more than 15 %.

The breaking length, average fibre length, and ratio breaking length/average fibre length of the non-wood cellulose fibre pulp are indicated in the table below:

	Non-wood fibre
Breaking length [m]	5493

Average fibre length[µm]	861
BL/av fibre length	6.38

The softwood cellulose fibre pulp and the hardwood cellulose pulp were similar to those used in Example 1 in the above.

Tissue paper material 1 (TP1) was made using 0% dry content of non-wood fibres.

Tissue paper material 2 (TP2) was made using 20% dry content of non-wood fibres.

Tissue paper material 3 (TP3) was made using 30% dry content of non-wood fibres.

The proportions between the conventional short fibre i.e. the Eucalyptus fibre pulp BEK (Bleached Eucalyptus Kraft), the conventional long fibre content, i.e. the Softwood fibre pulp NBSK (Northern bleached softwood kraft), and the non-wood fibres are indicated in the table in the below.

Conditions		TP1 (0%)	TP2 (20%)	TP3 (30%)
Overall furnish	BEK	25%	5%	
	NBSK	75%	75%	70%
	Non-wood		20%	30%
Refining kwh/T	Long fibres	160	150	150
Refining kwh/T	Short fibres	32	Off	Off

The machine was a stratified machine. Long fibre line was feeding Hood and Yankee layers of the headbox; the short fibre line feeding the middle layer.

For TP1, Long fibre line was 100% NBSK, and Short fibre line was eucalyptus BEK .

For TP2 and TP3, non-wood fibre substituted or all of the eucalyptus (BEK). The non-wood fibre was not refined.

Chemistry was added to provide dry and wet tensile strength, and was kept constant for the 3 qualities TP1, TP2 and TP3.

Chemical flows were equally split between both fibre lines.

Basis weight, thickness, dry tensile strength and absorption were measured for the resulting tissue paper materials. The results are indicated in the table in the below.

	Non-wood content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT	Absorption (g/g)
TP1	0%	21.2	0.4	334	245	286	14.0
TP2	20%	21.3	0.4	265	232	248	13.9
TP3	30%	21.4	0.4	279	234	255	14.7

Fig. 2a is a diagram illustrating the absorption of the tissue paper material comprising 0 % non-wood cellulose pulp fibres as compared to the absorption of the tissue paper material comprising 30% non-wood cellulose pulp fibre.

As seen in Fig. 2a and indicated in the table, the tissue paper material comprising 30% non-wood fibre displayed better absorption than the tissue paper material comprising 0% non-wood fibre. The tissue paper material comprising 20% non-wood cellulose pulp fibre displayed similar absorption as the tissue paper material comprising 0% non-wood cellulose pulp fibre.

The tensile strength of the tissue materials comprising non-wood cellulose pulp fibre is slightly less than the tensile strength of the tissue material with no non-wood cellulose pulp fibre. However, the deviation in tensile strength is not very significant and the tensile strength is still within acceptable limits.

Two-ply products were formed using the reference tissue paper material TP1 comprising 0% non-wood fibre and the tissue paper material TP3 comprising 30% non-wood fibre as described in the above.

2-ply product 1 (2P-1): 2 plies of the TP1, meaning that the 2-ply product comprises 0% non-wood fibres.

2-ply product 2 (2P-2): 2 plies of TP3, meaning that the 2-ply product comprises 30% dry weight non-wood fibres.

The 2-ply tissue paper products were produced by assembling the tissue paper materials (base sheets) using nested 2-ply technology.

Basis weight, thickness, tensile strength, softness panel and absorption was measured for the three multi-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT (N/m)	Softness panel	Absorption (g/g)
2P-1	0%	41.5	0.72	647	457	544	5.6	13.5
2P-2	30%	41.1	0.74	581	431	500	5.5	14.4

Fig. 2b illustrates the absorption of the two-ply tissue paper products. As seen in Fig. 2b and in the table above, the two-ply tissue paper product comprising 30% by dry weight non-wood fibres (2P-2) displayed a higher absorption at a comparable basis weight and thickness than the two-ply tissue paper product comprising no non-wood fibres.

The dry tensile strength results of the two-ply tissue paper product comprising 30% by dry weight of non-wood fibres (2P-2) were satisfactory to the intended use of the two-ply tissue paper product as a kitchen towel. Further, the softness of the two-ply tissue paper product comprising 30% by dry weight non-wood fibres (2P-2) displayed a similar softness to the two-ply tissue paper product comprising no non-wood fibres.

In all, the results indicate that the two-ply tissue paper products comprising non-wood fibres will display at least a similar absorption as the multi-ply tissue paper product comprising no non-wood fibre. Also, dry tensile strength and softness of the two-ply tissue

products are satisfactory. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

Example 3 (CWP Tissue paper product)

Three-ply tissue paper products intended for use as kitchen towels were produced using CWP technology. The three-ply tissue paper products were produced from tissue paper materials (base sheets) produced using CWP technology and with different dry content of non-wood fibre.

The pilot machine used was a Crescent former with suction presser roll configuration, with a 2 layers Headbox: 50% Top Layer, 50% Bottom Layer.

The machine was run in homogenous mode (same recipe on both layers of the base paper), but 2 fibre lines were used and treated differently.

The amount of non-wood fibre introduced ranged from 0 to 50% of the total blend for producing the tissue paper materials (base sheets).

The non-wood fibre pulp was derived from wheat straw, being treated according to the Phoenix TM process by Sustainable Fiber Solutions Inc. The non-wood fibre pulp was never-dried pulp. The non-wood fibre pulp had a lignin content of 12.8 and a hemicellulose content of 18.0.

The conventional short fibre content was made out of Hardwood. The Hardwood fibre pulp was never-dried pulp.

The conventional long fibre content was made out of Softwood. In this example, the Softwood fibre pulp was also never-dried pulp. The breaking length and morphology of the hardwood and softwood fibre pulp were as indicated in the table below:

	Non-wood (never-dried)	Softwood (never-dried)	Hardwood (never-dried)
Breaking length (m)	3775	1755	882
Average fibre length (microm)	748	2165	929
Fibre width (microm)	20	29	21

Fibre coarseness (mg/m)	0.13	0.20	0.13
Ration breaking length/fibre length (-/micro)	5.05	0.81	0.95

The composition of the different tissue paper materials (base sheets) and the refining level used is indicted in the below

Trial reference	Non-wood content	Long fibre content	Short fibre content	Long fibre line refining	Short fibre line refining
		%	%	kwh/T	kwh/T
G3-A	0%	85%	15%	150	0
G3-B	20%	65%	15%	120	10
G3-C	50%	45%	5%	80	10

The different fibres were split in the different layers of the stock preparation as follows:

Trial	Trial	G3-A	G3-B	G3-C
Overall furnish	softwood (never dried pulp)	85%	65%	45%
	hardwood (never dried pulp)	15%	15%	5%
	Straw	0%	20%	50%
Long fibre line	softwood (never dried pulp)	100%	100%	100%
	Straw	0%	0%	0%
	Refining kwh/T	150	120	80
Short fibre line	hardwood (never dried pulp)	100%	43%	9%
	Straw		57%	91%
	Refining	No	10	10
Headbox	Configuration	Homogenous	Homogenous	Homogenous
	Yankee layer	85% LF + 15% SF	65% LF + 35% SF	45% LF + 55% SF
	Hood layer	85% LF + 15% SF	65% LF + 35% SF	45% LF + 55% SF

Chemistry was added to provide dry and wet tensile strength, and was kept constant for the different qualities.

Average base sheet properties

Trial reference			BW	Caliper	MD	Strech MD	CD	MD wet	CD Wet	Dry/Wet
			g/m2	mm/10-ply	N/m	%	N/m	N/m	N/m	%
	Non-wood content	Target	18	1.2	290	17	145	90	30	25
		Min	17.5	0.9	280	15	130	65	25	21
		Max	18.5	1.4	350	19	170	100	35	
G3-A	0%	Average	17.9	0.97	299	18.3	136	77	27	26
		std	0.3	0.11	14	1.4	8	2	3	2
G3-B	20%	Average	18.5	0.95	327	17.9	141	85	28	26
		std	0.5	0.08	38	3.0	15	10	4	4
G3-C	50%	Average	18.7	1.00	293	16.7	139	67	23	23
		std	0.6	0.03	17	1.7	10	11	1	3

Trial reference	Non-wood content	Long fibre content	Short fibre content	Long fibre line refining	Short fibre line refining	GMT	Absorption g/g
		%	%	kwh/T	kwh/T		
G3-A	0%	85%	15%	150	0	201	6.7
G3-B	20%	65%	15%	120	10	215	6.5
G3-C	50%	45%	5%	80	10	202	6.3

Despite the lower long fibre content and the lower refining level, the tissue paper materials with non-wood cellulose pulp fibre had similar or higher tensile strength than the tissue paper material without non-wood cellulose pulp fibre.

As for absorption, the tissue paper materials with non-wood cellulose pulp fibre did not differ significantly from the tissue paper materials without non-wood cellulose pulp fibre.

Multi-ply products were formed out of the tissue paper materials (basesheets with)the different non-wood fibre contents. The multi-ply products where three-ply products formed by nesting.

Multi-ply product 1: G3A+ G3A+ G3A – i.e. 3 plies with 0% non-wood fibre, and fibre content by dry weight of the entire multi-ply product 1 is 0%.

Multi-ply product 2: G3B+G3B+ G3B – I.e. 3 plies with 20% non-wood fibre, and fibre content by dry weight of the entire multi-ply product 2 is 20%.

Multi-ply product 3: G3B+G3C+G3b – i.e. 2 plies with 20% non-wood fibre and 1 ply with 50% non-wood fibre, giving a fibre content by dry weight of the entire multi-ply product 3 being 30%.

Basis weight, thickness, tensile strength, softness panel and absorption were measured for the three multi-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT (N/m)	Softness panel	Absorption (g/g)
MP1	0%	55.2	0.71	623	234	382	4.4	9.2
MP2	20%	55.6	0.69	799	309	497	4.2	9.6
MP3	30%	56.5	0.73	695	252	418	4.3	9.6

Fig. 3 is a diagram over the absorption values of the three different multi-ply products MP1, MP2, and MP3. As seen from the table and in Fig. 3, the absorption of the multi-ply tissue paper products comprising 20% or 30% by dry weight of the non-wood fibres were even better than the absorption of the multi-ply tissue paper product comprising no non-wood further. Also, as indicated in the table in the above, the multi-ply tissue paper products comprising non-wood fibres displayed values for dry tensile strength and softness which were comparable to that of the multi-ply tissue paper product comprising no non-wood fibre.

In all, the results indicate that the multi-ply tissue paper products comprising non-wood fibres will display at least similar properties as the multi-ply tissue paper product comprising no non-wood fibre. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

Example 4 HYBRID tissue paper product

Two-ply tissue paper products intended for use as kitchen towels were formed comprising one ply being produced with structured tissue technology and one ply being produced with CWP (Conventional Wet Pressed) technology.

A reference two-ply tissue paper product (HYB1) comprising 0% non-wood fibres was formed from one tissue paper material ply produced by TAD technology being TP1 as described in Example 2 in the above, and one tissue paper material ply produced by CWP technology being G3-A as described in Example 3 in the above.

A two-ply tissue paper product (HYB2) comprising 25% non-wood fibres was formed from one tissue paper material ply produced by TAD technology and comprising 30% by dry weight non-wood fibre being TP3 as described in example 2 in the above, and one tissue paper material ply produced by CWP technology comprising 20% by dry weight non-wood fibre, being G3-B as described in example 3 in the above.

The two-ply tissue paper products were assembled by nesting.

Basis weight, thickness, tensile strength, softness panel and absorption were measured for the three multi-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	GMT (N/m)	Softness panel	Absorption (g/g)
HYB1	0%	40.4	0.73	503	270	368	4.6	13.3
HYB2	25%	39.0	0.75	456	309	375	4.4	13.9

Fig. 4 is a diagram over the absorption values of the two two-ply tissue paper products HYB 1 and HYB2. As seen from the table above and in Fig. 4, the absorption of the multi-ply tissue paper product comprising 25% by dry weight of the non-wood fibres was even better than the absorption of the multi-ply tissue paper product comprising no non-wood. Also, as indicated in the table in the above, the multi-ply tissue paper product comprising non-wood fibres displayed values for dry tensile strength and softness which were comparable to that of the multi-ply tissue paper product comprising no non-wood fibre.

In all, the results indicate that the multi-ply tissue paper products comprising non-wood fibres will display at least similar properties as the multi-ply tissue paper product comprising no non-wood fibre. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

EXAMPLE 5 – varying thickness

Two-ply tissue paper products comprising two plies made by TAD technology and similar to 2P-1 and 2P-2, as obtained in the above Example 2, were used as a starting point.

To vary the thickness of the two-ply products, the assembly of the two plies in each product was varied by varying the nip used when nesting the two plies together. Thus, one two-ply product with original thickness, one two-ply product with increased thickness, and one two-ply product with decreased thickness was formed for each of the qualities 2P-1 and 2P-2, as indicated in the above.

Basis weight, thickness, tensile strength, softness panel and absorption were measured for the two two-ply products. The results are indicated in the table in the below.

	Straw content	Basis weight (g/m2)	Thickness 1 sheet (mm)	Dry tensile MD (N/m)	Dry tensile CD (N/m)	Softness panel	Absorption (g/g)
2P-1 Decreased thickness	0	42.5	0.71	707	507	5.0	13.3
2P-1 original	0	41.9	0.75	613	467	5.2	13.2
2P-1 Increased thickness	0	43.3	0.79	608	430	5.2	13.0
2P-2	30	40.5	0.73	513	488	4.6	14.3

Decreased thickness							
2P-2 original	30	40.4	0.76	518	478	4.7	14.7
2P-2 Increased thickness	30	40.2	0.82	462	421	4.5	14.7

The absorption over thickness achieved for the two qualities 2P-1 and 2P-2 are illustrated in Fig. 5.

As may be seen in Fig. 5 and as indicated in the table above, the absorption of the two-ply paper tissue product 2P-2 comprising non-wood fibres is higher than the absorption the two-ply paper tissue product 2P-1 comprising no non-wood fibres for all of the various thicknesses.

Further, the results indicate that the absorption results are stable to thickness variations.

In all, the results indicate that the multi-ply tissue paper products comprising non-wood fibres will display at least similar properties as the multi-ply tissue paper product comprising no non-wood fibre. Accordingly, the benefits obtained by using non-wood fibres may be obtained while still achieving a satisfactory tissue paper product.

Although the results in the above were achieved for specific examples of tissue paper materials and tissue paper products, the finding that the non-wood cellulose pulp fibres and the non-wood plies as described herein are indeed suitable for forming tissue paper materials and tissue paper products may be applied to a wide range of such materials and products.

DEFINITIONS

Tissue paper material: As tissue paper material we understand herein the one-ply base tissue as obtained from a tissue machine.

Layer: The tissue paper material may comprise one or more layers, i.e. it may be a single-layered or a multi-layered web. The term "layer" refers to a stratum within the web having a defined fibre composition. The one or more layers is/are formed by depositing one or more streams of pulp furnishes onto a wire with a pressurized single-or multi-layered headbox.

Ply: The term "ply" as used herein refers to the one or more plies of tissue paper material in the final tissue paper product as are obtained after processes, i.e. converting, one or more base tissue webs. Each individual ply consists of a tissue paper material comprising one or more layers, e.g. one, two, or three layers.

Hardwood: As hardwood we understand herein fibrous pulp derived from the woody substance of deciduous trees (angiosperms). For example, hardwood includes eucalyptus. Typically, hardwood fibres are relatively short fibres. For example, the hardwood fibres may have an average fibre length less than 1700 µm. The hardwood fibres may for example have a diameter of 15 to 40 µm and a wall thickness of 3 to 5 µm.

Softwood: as softwood we understand fibrous pulp derived from the woody substance of coniferous trees (Gymnosperms). Typically, softwood fibres are relatively long fibres. For example, the softwood fibres may have an average fibre length above 1700 µm, such as above 1950 micron, for example the soft wood fibres may have an average fibre length in a range from 1700 to 2500. µm. The softwood fibres may for example have a diameter of from 30 to 80 µm, and a wall thickness of from 2 to 8 µm.

Conventional short fibres: As conventional short fibres we understand herein hardwood fibres as described in the above. Generally, the conventional short fibres may have an average fibre length less than 1700 µm.

Conventional long fibres: As conventional long fibres we understand herein softwood fibres as described in the above. Generally, the conventional long fibres may have an average fibre length greater than 1700 µm.

CWP & structured tissue technology:

As described in the above, paper tissue webs can be produced in several ways. Conventional paper machines have been used for many years for that purpose, to produce such conventional webs at a relatively low cost.

An example of a conventional paper tissue web process is the dry crepe process which involves creping on a drying cylinder, the so-called yankee cylinder, by means of a crepe doctor. Wet creping can be used as well, if there are lower demands on the tissue quality. The creped, finally dry raw tissue paper, the so-called base tissue, is then available for further processing into the paper product for a tissue paper product.

Recently, more advanced methods have been developed, such as e.g. Through Air Drying (TAD), Advanced Tissue Molding System (ATMOS) and similar methods for producing structured tissue webs. A common feature for these latter methods is that they result in a more structured web with a lower density than a web produced on a conventional paper machine.

As used herein the term CWP technology (Conventional Wet Pressed technology) refers to conventional paper web processes, in which the tissue is formed on a forming fabric and dewatered by pressing with one or more pressure roll nips. The process may involve transfer of the sheet to a Yankee dryer and removing the sheet from the Yankee surface by a doctor blade in a creping process. CWP technology as used herein includes for example dry crepe technology, wet crepe technology, and flat NTT (New Tissue Technology).

As used herein, the term structured tissue technology relates to the newer technologies for producing a structured tissue web. Such methods will not employ the high pressure used to dewater the web in the CWP process. Therefore, structured tissue technology is sometimes referred to as non-compressing de-watering technology. The structured tissue technology may for example be TAD (Thru-Air-Dried), UCTAD (Uncreped-Through-Air-Dried) or ATMOS (Advanced-Tissue- Molding-System), textured NTT, QRT, PrimeLineTEX technology and eTAD technology.

The structured tissue technology methods are known from prior art, for example TAD is known from US5853547; and ATMOS from US 7744726, US7550061 and US7527709; and UCTAD from EP 1 156925 and WO 02/40774.

TAD technology has been developed since the 1960's and is well known to a person skilled in the art. It generally involves developing functional properties of the tissue by moulding the fibre mat on a structured fabric. This results in the fibre mat forming a structured tissue which may acquire high bulk and absorption due to air passing through the web while drying the web when still on the structured fabric.

ATMOS technology is a production method developed by Voith and which is also well known to a person skilled in the art.

Another example is textured NTT (New Tissue Technology). Textured NTT was designed to overcome some of the limitations of ATMOS by pressing at even higher pressures before transferring to the Yankee. A shoe press is used in the first pressing section between the former felt and a belt with cells designed to provide absorptive capacity and increase strength. The textured NTT technology may reduce the Yankee Hood drying load as compared to ATMOS.

Yet other examples are Prime Line Tex technology as rendered available by Andritz for production of textured tissue, and eTAD technology as rendered available by Valmet.

METHODS

Lignin content:

The measurement of residual lignin content in the pulp fibres has been carried out according to the draft standard ISO/DIS 21436: Pulps-Determination of lignin content – Method of acid hydrolysis 1), which includes:

i) the gravimetric measurement of the residue after acid hydrolysis (AIL : Acid Insoluble Lignin or Klason Lignin), also described in the Tappi T222 om-02 method 2 ; and

ii) the measurement of soluble lignin (ASL : Acid Soluble Lignin), also described in the technical note Tappi UM2503 .

3.1) Sample preparation: The samples were desintegrated with a grinder/mixer. Their dry matter contents were determined before analysis, by drying in an oven of an aliquot of 2-3 g at 105°C, according to the ISO 638 standard 4 .

3.2) Measurement of acid insoluble lignin (AIL or Klason lignin) after acid hydrolysis An aliquot of ~1 g was hydrolysed with a solution of sulfuric acid, firstly at ambient temperature (2 h) and then under reflux during 4 h (Procedure B of the future standard). After cooling, the suspension was filtered and washed and the solid residue was collected, dried and weighted. The acid insoluble lignin content in the sample was determined by difference between the dry hydrolysis residue weight and the ash weight, reported to the dry mass content of the initial sample. Note 1 : Detection limit (DL) ~0.1% ; Quantification limit (QL) ~0.5%.

3.3) Measurement of acid soluble lignin. The absorbance at 205 nm of the hydrolysate (i.e. the filtrate collected during the filtration of the suspension, cf 3.2), were measured. The acid soluble lignin content (ASL) was determined according to the predefined extinction coefficient of the lignin (i.e. 110 L/g.cm). Note 2 : : Detection limit (DL) ~0.1% ; Quantification Limit (QL) ~0.5% Remark: This quantification method is sensitive to the contaminants being present into the sample. Each compound other than hemicelluloses and cellulose and the acid insoluble minerals are susceptible to interfere with the measurement of the hydrolysis residue and with the acid soluble lignin.

Hemicellulose

The determination of the contents of the main polysaccharides in the pulp (arabinane, galactane, glucane, xylene, and mannane) has been made by using high performance anion exchange chromatography with a pulsed amerometric detector, HPAE/PAD-Dionex® analysis of free monosaccharides (arabinose, galactose, glucose, xylose and mannose) after sulphuric acid hydrolysis of the sample pulp. The cellulose and the hemicellulose content in the pulp sample is determined according to standard method ISO / DIS21437 – Pulps: Determination of carbohydrate (under publication) after calibration. The samples studied are chemical pulp which has not required extraction of aceton beforehand. In contrast, the samples have been dried. However, considering the pulp state (wet lap sheets), samples were grinded before analysis. Dry content of the grinded samples was measured according to NF EN ISO 638:2008.

Basically the method is quantifying the amounts of sugars (monosaccharides) after hydrolysis of cellulose and hemi using the ISO / DIS 21437 – Pulps: Determination of

carbohydrate. Then, calculation is made backwards to estimate level of hemicelluloses (knowing proportion of sugars in hemi and cellulose)

Basis weight

Basis weight is determined in accordance with ISO 12625-6: 2016.

The basis weight is determined in g/m^2.

Thickness per sheet:

Thickness is determined in accordance with ISO 12625-3.

GMT strength:

GMT strength (Geometric Mean Tensile strength) refers to the square root of the product of the machine direction dry tensile strength and the cross-direction dry tensile strength of a tissue web/product.

The GMT strength is determined in accordance with ISO 12625-4.

A load cell of 100N was used.

Absorption:

Absorption is herein the water absorption capacity of the tissue paper. Water absorption capacity is the amount of water the sample is able to absorb, reported in g/g (i.e. g water / g material in sample).

Absorption was measured according to ISO12625-8:2011.

The water is deionized water, conductivity ≤ 0.25 mS/m at 25ºC, in accordance with ISO14487.

Softness panel:

Panel softness is determined by evaluation made by panel members. The panelists rank products in terms of softness. The Softness Panel values are therefore comparative values enabling a comparison between the samples tested, rather than an absolute parameter.

The softer the product/tissue base sheet is rated the higher the value will be.

Softness values of tissue paper products (finished goods) and tissue base sheets are not directly comparable as there are different scales/reference products.

Each sample is composed of one product, i.e. a multi-ply tissue paper product.

The dimensions of the samples are therefore the dimensions of the finished products.

Samples are placed in MD before the panelists.

Samples are conditioned for minimum 2 hours in a controlled area at 23ºC and 50% relative humidity.

The different samples are comfort rated by ten panelists, and an average comfort rating for each product is determined over the panelists.

Hence, softness panel values are comparative values within a test and indicate the perceived softness of a product.

For the purpose of this application, softness panel values given in one and the same table are comparable and indicate the perceived relative softness of the products tested. The higher the value of the rating, the more comfortable is the product.

Average fibre length measurement:

Fibre length measurement was made using the standard for fibre analyser: ISO 16065-2:2014: Pulps – Determination of fibre length by automated optical analysis – Part 1: Unpolarized light method.

Length-weighted mean length was used and the average of the length – weighted fibre-length distribution.

Breaking length measurement

The breaking length is the calculated upper limit of length of a uniform paper strip that would support its own weight if it were suspended at one end. Breaking length (m) = 102 x T/R, where T = Tensile strength, N/m, and R = basis weight, g/m2.

The breaking length is a pulp characteristic obtained by tensile strength and basis weight measurements as measured on lab handsheets produced in accordance with EN ISO 5269-2. (Tensile strength: ISO 12625-4; basis weight: ISO 12625-6: 2016)

Ratio of breaking length measurement/average fibre length measurement

The ratio of breaking length/average fibre length is herein using the values of the fibre length measurement and the breaking length measurements as achieved according to the methods in the above, the average fibre length measurement being reported in µm, and the breaking length being reported in m.

It may be noted that the breaking length, as well as the average fibre length, are pulp characteristics. Thus the measurements are to be performed on the pulp as received from the pulping process, before reaching the papermaking process, such as before entering the stock preparation in a paper machine. Thus, the measurements are done prior to any mechanical and/or chemical and/or enzymatic treatment for strength adjustment which may occur during the paper making process.

CLAIMS.

1. A single-ply tissue paper material having a basis weight less than 40 gsm and an absorbency of at least 3 g/g, comprising a non-wood tissue ply, said non-wood tissue ply
comprising non-wood cellulose pulp fibres being present in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

2. A single-ply tissue paper material according to claim 1, wherein the tissue paper material has an absorbency of at least 4 g/g.

3. A single-ply tissue paper material according to any one of the previous claims, wherein the tissue paper material has an absorbency of at least 5 g/g.

4. A single-ply tissue paper material according to any one of the previous claims being produced by CWP (Conventional Wet Pressed) technology.

5. A single-ply tissue paper material according to any one of the claims 1 to 3, being produced by structured tissue technology and having an absorbency of at least 6 g/g.

6. A single-ply tissue paper material according to any one of the claims 1 to 3, being produced by structured tissue technology and having an absorbency of at least 7 g/g.

7. A single-ply tissue paper material according to any one of the claims 1 to 3, being produced by structured tissue technology and having an absorbency of at least 8 g/g.

8. A single-ply tissue paper material according to any one of the previous claims, wherein the tissue paper material has a GMT tensile strength of at least 60 N/m.

9. A single-ply tissue paper material according to any one of the previous claims, wherein the tissue paper material has a GMT tensile strength of at least 70 N/m.

10. A single-ply tissue paper material according to any one of the previous claims, wherein the tissue paper material has a GMT tensile strength of at least 80 N/m.

11. A single-ply tissue paper material according to any one of the preceding claims, having a basis weight of less than 30 gsm.

12. A single-ply tissue paper material according to any one of the preceding claims, having a basis weight of less than 25 gsm.

13. A single-ply tissue paper material according to any one of the preceding claims, having a basis weight of more than 10 gsm.

14. A single-ply tissue paper material according to any one of the preceding claims, having a basis weight of more than 15 gsm.

15. A single-ply tissue paper product comprising a single-ply tissue paper material according to any one of the claims 1 to 14.

16. A multi-ply tissue paper product comprising two or more plies, wherein an average basis weight of the plies is less than 40 gsm, and the multi-ply tissue paper product having an absorption of at least 4 g/g, wherein at least one ply is a non-wood tissue ply, said non-wood tissue ply comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

17. A multi-ply tissue paper product according to claim 16, wherein the multi-ply tissue paper product has an absorbency of at least 5 g/g.

18. A multi-ply tissue paper product according to claim 16 or 17, wherein multi-ply tissue paper product has an absorbency of at least 6 g/g.

19. A multi-ply tissue paper product according to any one of the claims 16 to 18, wherein at least one ply of the multi-ply tissue paper product is produced by CWP (Conventional Wet Pressed) technology.

20. A multi-ply tissue paper product according to any one of the previous claims, wherein at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 7 g/g.

21. A multi-ply tissue paper product according to any one of the previous claims, wherein at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 8 g/g.

22. A multi-ply tissue paper product according to any one of the previous claims, wherein at least one ply of the multi-ply tissue paper product is produced by structured tissue technology, and the multi-ply tissue paper product has an absorbency of at least 9 g/g.

23. A multi-ply tissue paper product according to any one of the previous claims but claim 19, wherein all plies of the multi-ply tissue paper product are produced by structured tissue technology.

24. A multi-ply tissue paper product according to any one of the claims 16 to 23, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 100 N/m.

25. A multi-ply tissue paper product according to any one of the claims 16 to 24, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 120 N/m.

26. A multi-ply tissue paper product according to any one of the claims 16 to 25, wherein the multi-ply tissue paper product has a GMT tensile strength of at least 150 N/m.

27. A multi-ply tissue paper product according to any one of the claims 16 to 26, wherein at least 50 % of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply

comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

28. A multi-ply tissue paper product according to any one of the claims 16 to 27, wherein all of the plies in said multi-ply tissue paper products are non-wood tissue plies, each non-wood tissue ply
comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the of the non-wood tissue ply.

29. A multi-ply tissue paper product according to any one of the claims 16 to 28, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 10% by dry weight of the multi-ply tissue paper product.

30. A multi-ply tissue paper product according to any one of the claims 16 to 29, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 15% by dry weight of the multi-ply tissue paper product.

31. A multi-ply tissue paper product according to any one of the claims 16 to 30, the multi-ply tissue paper product comprising non-wood cellulose pulp fibres in an amount of at least 20% by dry weight of the multi-ply tissue paper product.

32. A multi-ply tissue paper product according to any one of the claims 16 to 31, wherein said multi-ply tissue paper material or product comprises two to five plies.

33. A multi-ply tissue paper product according to any one of the claims 16 to 32, wherein each ply of the multi-ply product comprises the same amount of non-wood cellulose pulp fibres.

34. A multi-ply tissue paper product according to any one of the claims 16 to 33, wherein at least two plies comprise different amounts of non-wood cellulose pulp fibres.

35. A multi-ply tissue paper product according to any one of the claims 16 to 34, wherein said at least one non-wood tissue ply is an outer ply of said multi-ply tissue paper material.

36. A multi-ply tissue paper product according to claim 35, wherein the multi-ply tissue paper material comprises at least two non-wood tissue plies, the non-wood tissue plies forming a first and a second outer ply of the multi-ply tissue paper product.

37. A multi-ply tissue paper product according to any one of the claims 16 to 36, wherein said non-wood tissue ply is formed by a single-ply tissue paper material in accordance with any one of claims 1 to 14.

38. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres contains at least 15% hemicellulose.

39. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres contains no more than 15 % lignin.

40. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1700 µm.

41. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 1200 µm.

42. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres have an average fibre length of less than 900 µm.

43. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length of more than 3000 m.

44. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 3.7.

45. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.0.

46. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose fibres have a breaking length/average fibre length ratio of more than 4.5.

47. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from a member of the Pocacea family, such as from wheat straw, rice straw, barley straw, oat straw, rye grass, costal Bermuda grass, Arundo donax, miscanthus, bamboo, sugar cane bagasse and/or sorghum.

48. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from a member of the Cannabaceae family, such as from hemp and/or hop.

49. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are agricultural waste or byproduct, such as derived from agricultural waste or byproduct of the Pocacea family and/or Cannabaceae family such as exemplified in the above, including agricultural waste or byproduct from wheat straw, rice straw, barley straw, oat straw, rye grass, sugar cane bagasse, hemp or hop and/or wherein the non-wood cellulose pulp fibres are derived from agricultural waste or byproduct such as

banana harvest residue (belongs to the family Musaceae), pineapple residue (belongs to the family Bromeliaceae), nut shell waste, bagasse from agave, hop residue and/or corn stover.

50. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein the non-wood cellulose pulp fibres are derived from kenaf (belongs to the family Malvaceae), switchgrass , succulents, alfalfa (belongs to the family Fabaceae), flax straw (belongs to the family Linaceae), palm fruits (Elaeis or Arecaceae), and/or avocado (Lauraceae).

51. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 15%.

52. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of at least 20%.

53. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 70 % by dry weight.

54. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply or plies comprises said non-wood cellulose pulp fibres in an amount of less than 60 % by dry weight.

55. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein said non-wood tissue ply further comprises wood pulp fibres, such as hardwood cellulose pulp fibres and/or softwood cellulose pulp fibres.

56. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to claim 55, wherein said non-wood tissue ply comprises wood pulp fibres in an amount such that the wood pulp fibre amount plus the non-wood fibre amount constitutes 100% dry weight of the non-wood tissue ply.

57. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to claim 55 or 56, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 95/5.

58. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 55 to 57, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 90/10.

59. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the claims 55 to 58, wherein the hardwood/softwood dry weight proportion of the wood pulp fibres in said non-wood tissue ply is less than 80/20.

60. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the previous claims, wherein said non-wood cellulose pulp fibres are present throughout the non-wood tissue ply or plies.

61. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the previous claims, wherein said non-wood tissue ply or plies comprises two or more layers, and at least one layer comprises non-wood cellulose pulp fibres.

62. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, said non-wood tissue ply or plies being produced by conventional wet press technology (CWP).

63. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, said non-wood tissue ply or plies being produced by structured tissue technology, for example TAD (Through Air Drying), ATMOS, textured NTT, UCTAD, eTAD, QRT or PrimeLineTEX.

64. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, wherein a portion or all non-wood cellulose pulp fibres are never-dried non-wood cellulose pulp fibre.

65. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, comprising softwood cellulose pulp fibres and wherein a portion or all softwood cellulose fibres are never-dried softwood cellulose pulp fibre.

66. A single-ply tissue paper material, a single-ply tissue paper product or a multi-ply tissue paper product according to any one of the preceding claims, comprising hardwood cellulose pulp fibres and wherein a portion or all hardwood cellulose fibres are never-dried hardwood cellulose pulp fibre.

67. Single-ply tissue paper product or multi-ply tissue paper product according to any one of the claims 15 to 66, the tissue paper product being for personal hygiene, such as toilet paper, hand wipes, paper napkins, facial wipes, handkerchiefs or the tissue paper product being a kitchen towel or industrial wipe.

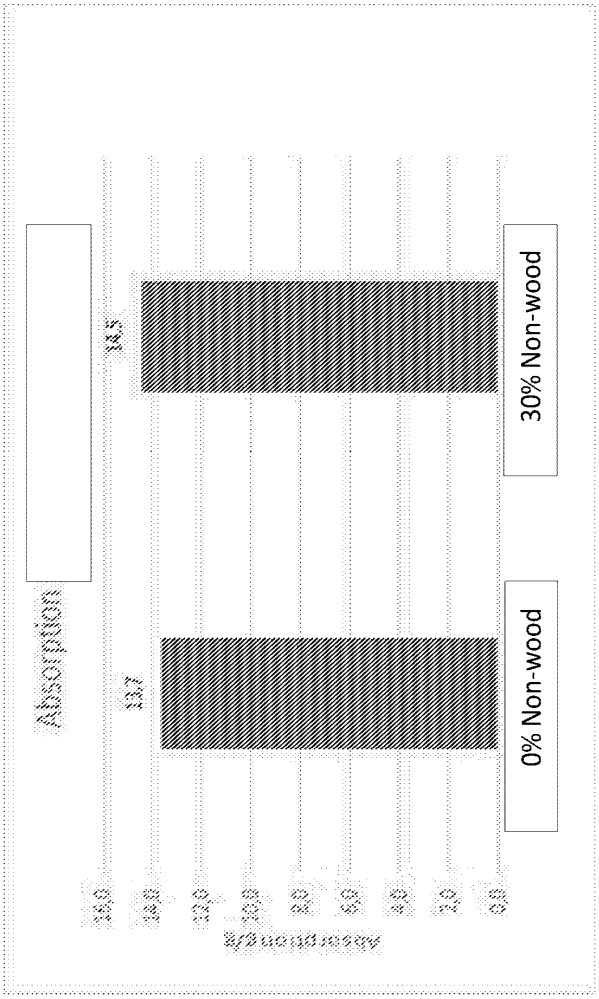

Absorption
14.5
13.7
30% Non-wood
0% Non-wood
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
g/g wood mass

Fig. 1

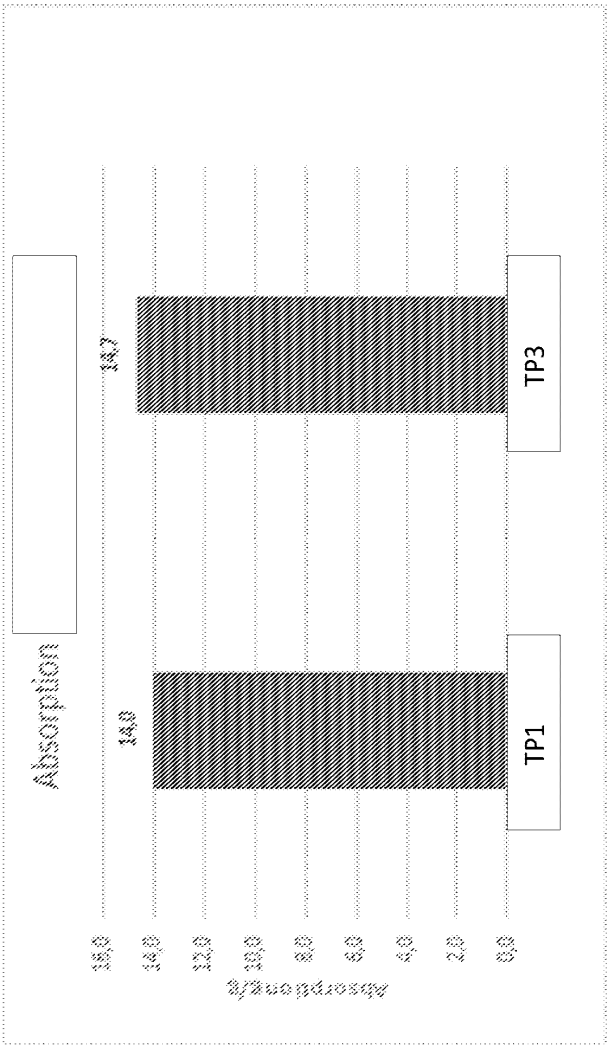

Absorption
14,7
14,0
TP3
TP1
16,0
14,0
12,0
10,0
8,0
6,0
4,0
2,0
0,0
Wavelength

Fig. 2a

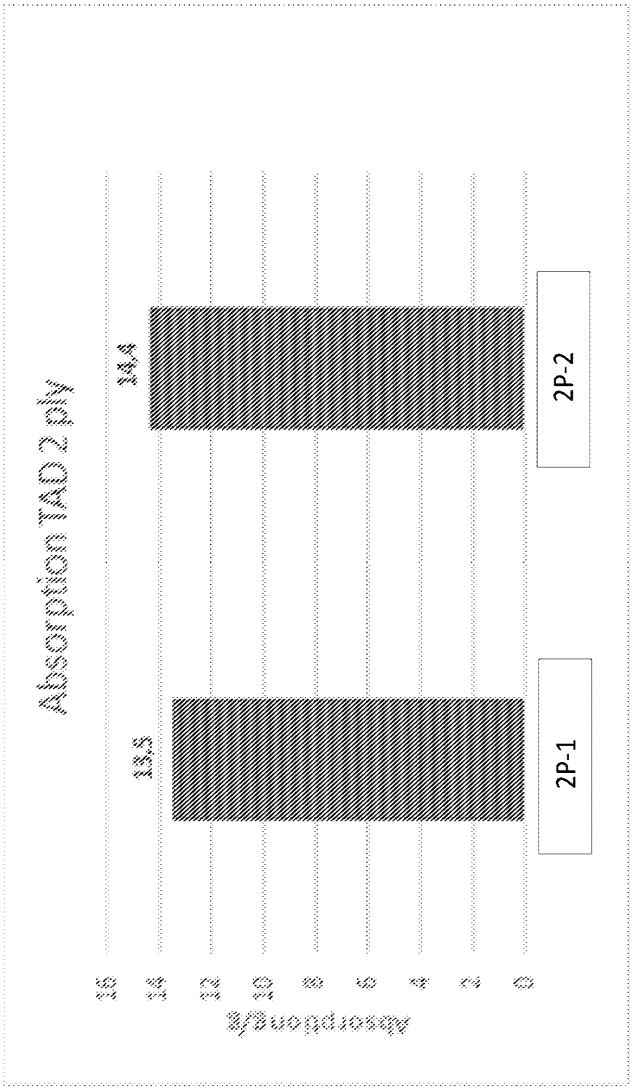

Absorption TAD 2 ply
14,4
13,5
2P-2
2P-1
Absorption g/g
18
16
14
12
10
8
6
4
2
0

Fig. 2b

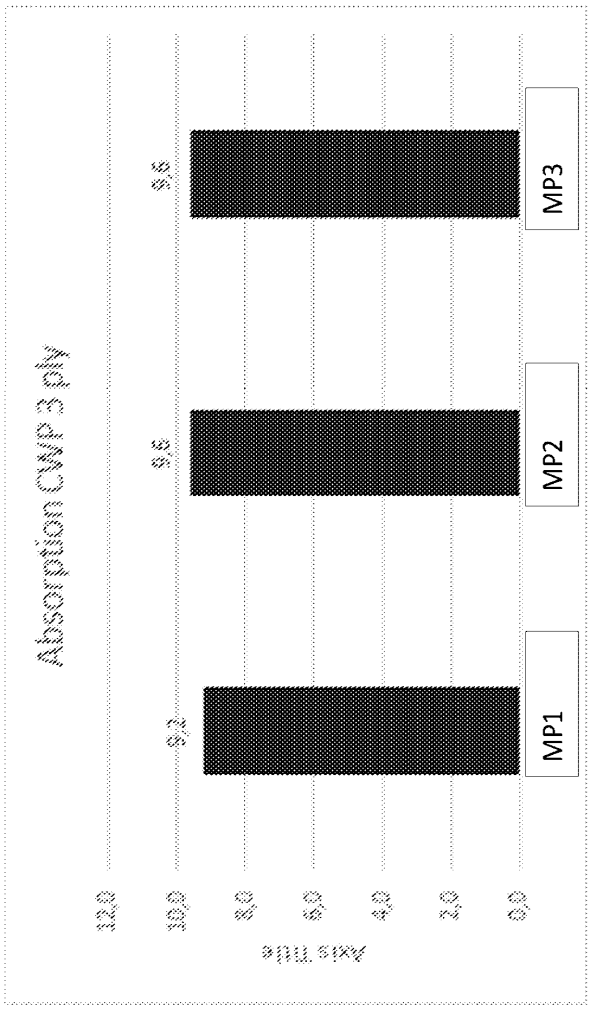

Absorption CWP 3 dly
MP1
MP2
MP3
9,2
9,8
9,8
120
100
80
60
40
20
0,0
Axis Title

Fig. 3

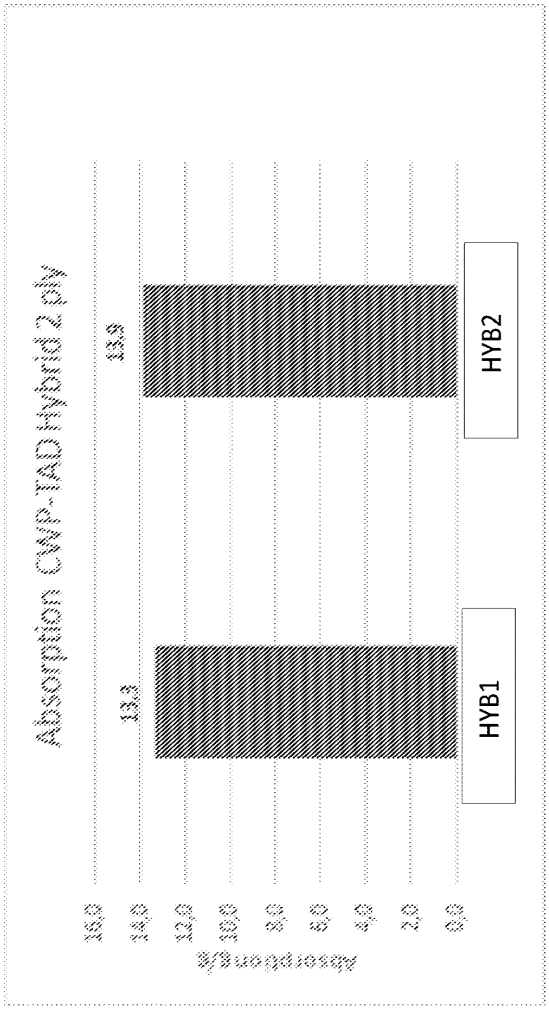

Absorption CWP-TAD hybrid 2 ply
13.3
13.8
HYB1
HYB2
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
g/g Absorption

Fig. 4

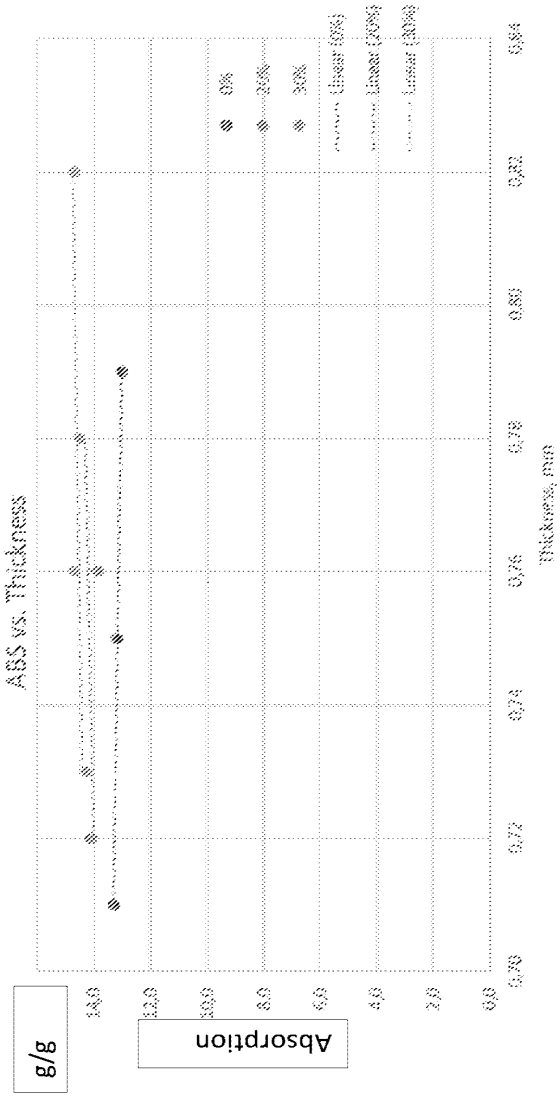

ABS vs. Thickness
Absorption
g/g
Thickness, mm
0.70
0.72
0.74
0.76
0.78
0.80
0.82
0.84
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
0%
20%
30%

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2021/050717

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: A47K, A61K, D04H, D21H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2016195627 A1 (KIMBERLY CLARK CO), 8 December 2016 (2016-12-08); page 1, line 1 - line 20; page 2, line 5 - line 15; page 3, line 1 - line 4; page 5, line 23 - line 28; page 10, line 20 - line 24; page 11, line 9 - line 17; claim 3; Tables 3-4	1-63, 67
Y	--	64-66
X	WO 2016173641 A1 (SCA HYGIENE PROD AB), 3 November 2016 (2016-11-03); page 9, line 31 - line 35; page 15, line 1 - line 6; page 15, line 31 - line 37; page 17, line 16 - line 20; page 22, line 3 - line 4; page 24, line 11 - line 34; page 25, line 18 - line 27; Table 3	1-63, 67
Y	--	64-66

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23-03-2022	23-03-2022

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	John Sjöberg Telephone No. + 46 8 782 28 00

Form PCT/ISA/210 (second sheet) (July 2019)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2021/050717

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2016048943 A1 (GEORGIA PACIFIC CONSUMER PROD), 31 March 2016 (2016-03-31); claims 1,8-9 --	1-67
X	CN 108755241 A (UNIV TIANJIN SCIENCE & TECH), 6 November 2018 (2018-11-06); paragraphs [0018]-[0026] --	1-67
X	US 20200024803 A1 (ZIEGENBEIN TOBIAS), 23 January 2020 (2020-01-23); paragraphs [0030], [0050]-[0051] --	1-67
X	WO 2018156109 A1 (KIMBERLY CLARK CO), 30 August 2018 (2018-08-30); claims 1,3,12 --	1-67
X	WO 2013041986 A2 (KIMBERLY CLARK CO ET AL), 28 March 2013 (2013-03-28); page 31, line 16 - line 18; Table 3 --	1-67
Y	WO 2013016311 A1 (GEORGIA PACIFIC CONSUMER PROD ET AL), 31 January 2013 (2013-01-31); claim 35 -- --------	64-66

Continuation of: second sheet

International Patent Classification (IPC)

D21H 27/00 (2006.01)
D21H 11/12 (2006.01)
A47K 10/16 (2006.01)
A61K 8/02 (2006.01)
D04H 1/425 (2012.01)
D04H 1/732 (2012.01)
D21H 27/30 (2006.01)

Kimberly Clark EX1002, p. 2268
PGR2026-00078

WO	2016195627	A1	08/12/2016	AU	2015397128	B2	16/07/2020
				BR	112017024038	A2	24/07/2018
				EP	3302200	B1	07/10/2020
				ES	2838799	T3	02/07/2021
				KR	20180013965	A	07/02/2018
				MX	2017014274	A	20/04/2018
				US	10145066	B2	04/12/2018
				US	10519601	B2	31/12/2019
				US	20190100878	A1	04/04/2019
				US	20180135249	A1	17/05/2018
WO	2016173641	A1	03/11/2016	AU	2015393147	A1	09/11/2017
				CN	107532385	A	02/01/2018
				CO	2017010865	A2	16/01/2018
				EC	SP17078850	A	28/02/2018
				EP	3289139	A1	07/03/2018
				HK	1246833	A1	14/09/2018
				MA	41084	A1	30/11/2018
				MX	2017013851	A	21/03/2018
				RU	2670867	C9	11/12/2018
				SG	11201708100	A	29/11/2017
				TN	2017000446	A1	12/04/2019
				US	10577748	B2	03/03/2020
				US	20180127920	A1	10/05/2018
WO	2016048943	A1	31/03/2016	CA	2962420	A1	31/03/2016
				US	10351998	B2	16/07/2019
				US	20170211234	A1	27/07/2017
CN	108755241	A	06/11/2018	NONE			
US	20200024803	A1	23/01/2020	US	10731295	B2	04/08/2020
WO	2018156109	A1	30/08/2018	AU	2017400674	A1	05/09/2019
				BR	112019014276	A2	03/03/2020
				GB	2574744	A	18/12/2019
				KR	20190116335	A	14/10/2019
				MX	2019008742	A	02/10/2019
				US	20210292973	A1	23/09/2021
				US	11053643	B2	06/07/2021
				US	20200232166	A1	23/07/2020

WO	2013041986	A2	28/03/2013	AU	2012311164	B2 22/01/2015
				BR	112014005592	A2 21/03/2017
				CA	2847064	A1 28/03/2013
				CN	103814173	B 02/03/2016
				CO	6910179	A2 31/03/2014
				EP	2758593	B1 20/03/2019
				KR	101497884	B1 02/03/2015
				KR	20140068073	A 05/06/2014
				MX	2014002400	A 05/06/2014
				MX	337233	B 18/02/2016
				SA	112330828	B1 06/12/2015
				TW	I577855	B 11/04/2017
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				US	8524374	B2 03/09/2013
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				US	20130071678	A1 21/03/2013
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				EP	2940210	B1 30/08/2017
				EP	2737131	B1 13/01/2016
				HK	1194444	A1 17/10/2014
				HK	1210630	A1 29/04/2016
				RU	2014107739	A 10/09/2015
				RU	2602155	C2 10/11/2016
				US	9476162	B2 25/10/2016
				US	10196780	B2 05/02/2019
				US	20170328012	A1 16/11/2017
				US	9708774	B2 18/07/2017
				US	20160340835	A1 24/11/2016
				US	20160115648	A1 28/04/2016
				US	9267240	B2 23/02/2016
				US	20130029106	A1 31/01/2013

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	18/131,383	YOUNG et al.
	Examiner	**Art Unit**
	JOSE A FORTUNA	1748

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

CLAIMS										
☐ Claims renumbered in the same order as presented by applicant			☐ CPA		☐ T.D.		☐ R.1.47			
CLAIM		**DATE**								
Final	Original	01/25/2025								
	1	÷								
	2	÷								
	3	÷								
	4	÷								
	5	÷								
	6	÷								
	7	÷								
	8	÷								
	9	÷								
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	18	÷								
	19	÷								
	20	÷								
	21	÷								

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PGR2026-00078

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/131,383	04/06/2023	Christopher Michael YOUNG	16255M3	7685

27752 7590 01/30/2025

THE PROCTER & GAMBLE COMPANY
GLOBAL IP SERVICES
CENTRAL BUILDING, C9
ONE PROCTER AND GAMBLE PLAZA
CINCINNATI, OH 45202

EXAMINER	
FORTUNA, JOSE A	

ART UNIT	PAPER NUMBER
1748	

NOTIFICATION DATE	DELIVERY MODE
01/30/2025	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

centraldocket.im@pg.com
mayer.jk@pg.com
pair_pg@firsttofile.com

Office Action Summary	**Application No.** 18/131,383	**Applicant(s)** YOUNG et al.	
	Examiner JOSE A FORTUNA	**Art Unit** 1748	**AIA (FITF) Status** Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 2 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 6/26/2023.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-21 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☐ Claim(s) _____ is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☑ Claim(s) 1-21 are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Election/Restriction

Restriction to one of the following inventions is required under 35 U.S.C. 121:

I. Claims 1-14, drawn to a "Sanitary Tissue Product," classified in D21H.

II. Claims 15-21, drawn to a "Sanitary Tissue Product," classified in D21H.

The inventions are independent or distinct, each from the other because:

Inventions I and II are directed to related products. The related inventions are distinct if: (1) the inventions as claimed are either not capable of use together or can have a materially different design, mode of operation, function, or effect; (2) the inventions do not overlap in scope, i.e., are mutually exclusive; and (3) the inventions as claimed are not obvious variants. See MPEP § 806.05(j). In the instant case, the inventions as claimed have materially different design since they have different properties, softness TS7, TS750 for group I and Slip Stick for group II. Furthermore, the inventions as claimed do not encompass overlapping subject matter and there is nothing of record to show them to be obvious variants.

Restriction for examination purposes as indicated is proper because all the inventions listed in this action are independent or distinct for the reasons given above and there would be a serious search and/or examination burden if restriction were not required because one or more of the following reasons apply:

The inventions have acquired a separate status in the art in view of their different classification;

The inventions have acquired a separate status in the art due to their recognized divergent subject matter; and

The inventions require a different field of search (e.g., searching different classes/subclasses or electronic resources, or employing different search strategies or search queries).

Applicant is advised that the reply to this requirement to be complete must include (i) an election of an invention to be examined even though the requirement may be traversed (37 CFR 1.143) **and (ii) identification of the claims encompassing the elected invention**.

The election of an invention may be made with or without traverse. To reserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the restriction requirement, the election shall be treated as an election without traverse. Traversal must be presented at the time of election in order to be considered timely. Failure to timely traverse the requirement will result in the loss of right to petition under 37 CFR 1.144. If claims are added after the election, applicant must indicate which of these claims are readable upon the elected invention.

Should applicant traverse on the ground that the inventions are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the inventions to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103 or pre-AIA 35 U.S.C. 103(a) of the other invention.

Applicant is reminded that upon the cancelation of claims to a non-elected invention, the inventorship must be corrected in compliance with 37 CFR 1.48(a) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. A request to correct inventorship under 37 CFR 1.48(a) must be accompanied by an application data sheet in accordance with 37 CFR 1.76 that identifies each inventor by his or her legal name and by the processing fee required under 37 CFR 1.17(i).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to JOSE A FORTUNA whose telephone number is (571)272-1188. The examiner can normally be reached MONDAY- FRIDAY 11:30 PM- 9:00 PM.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Abbas Rashid can be reached on 571-270-7457. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: https://patentcenter.uspto.gov. Visit https://www.uspto.gov/patents/apply/patent-center for more information about Patent Center and https://www.uspto.gov/patents/docx for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC)

at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service

Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/JOSE A FORTUNA/
Primary Examiner, Art Unit 1748

JAF

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 929 261 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
29.12.2021 Bulletin 2021/52

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(22) Date of filing: **21.01.2016**

(51) Int Cl.:
C09J 129/04 *(2006.01)* ***C09J 11/08*** *(2006.01)*
B32B 29/00 *(2006.01)* ***B31F 5/04*** *(2006.01)*
D21H 27/32 *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **28.01.2015 US 201562108594 P**
19.01.2016 US 201615000071

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
16743873.8 / 3 250 654

(71) Applicant: **GPCP IP Holdings LLC**
Atlanta, Georgia 30303 (US)

(72) Inventors:
- **Sumnicht, Daniel W.**
Hobart, 54313 (US)
- **Yu, Zhiying**
Oshkosh, 54904 (US)
- **Vaijapurkar, Siddharth S.**
Appleton, 54913 (US)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

Remarks:
This application was filed on 18-08-2021 as a divisional application to the application mentioned under INID code 62.

(54) GLUE-BONDED MULTI-PLY ABSORBENT SHEET AND POLYVINYL ALCOHOL PLY BONDING ADHESIVE

(57) A multi-ply absorbent sheet includes a first absorbent ply of cellulosic sheet; a second absorbent ply of cellulosic sheet; and a ply bonding adhesive interposed between the first absorbent ply and the second absorbent ply, the ply-bonding adhesive thereby adhering said absorbent plies together. The ply-bonding adhesive comprises polyvinyl alcohol and nanofibrillated cellulose. In a particularly preferred embodiment the adhesive is applied as a dilute aqueous composition to tissue plies and the nanofibrillated cellulose has a Characteristic Breaking Length of 6.5 km or above.

EP 3 929 261 A1

Printed by Jouve, 75001 PARIS (FR)

Description

Claim for Priority

[0001] This application is based on United States Non-Provisional Application No. 15/000,071, filed January 19, 2016, of the same title. Application No. 15/000,071 is based on United States Provisional Application No. 62/108,594, filed January 28,2015, also of the same title. The priorities of the foregoing applications are hereby claimed and their disclosures incorporated herein by reference.

Technical Field

[0002] The present invention relates generally to glue-bonded, multi-ply absorbent sheet. The present invention is directed, in part, to multi-ply tissue wherein the plies are bonded to one another with a pseudoplastic polyvinyl alcohol adhesive containing nanofibrillated cellulose. The invention also extends to a method of making the sheet as well as the adhesive.

Background

[0003] Multi-ply absorbent sheet such as towel and tissue sometimes conventionally include a plurality of glue-bonded layers or plies. Adhesives employed include aqueous polyvinyl alcohol (PVOH) solutions as is disclosed in United States Patent no. 3,414,459. Such solutions are relatively low solids, less than 10% by weight PVOH and exhibit Newtonian Fluid viscosity characteristics; that is, wherein viscosity is substantially independent of shear. Tissue/towel ply bonding is typically carried out in the following steps: 1) embossing one or more plies; 2) applying glue to the web on the raised emboss pattern elements; 3) bringing one or more plies into contact with the glued surface and applying sufficient pressure to the mated web to provide enduring plybond once the glue has dried. This process places several demands on the glue. It must penetrate the first web, but not too much. Enough tackiness must remain to stick to the non-glued web. The remaining glue must preferably penetrate the nonglued web to improve the integrity of the bond. *See, also,* United States Patent No. 5,858,554 to Neal et al., entitled *Paper Product Comprising Adhesively Joined Plies* which describes ply-bonded absorbent sheet provided with polyvinyl alcohol or starch adhesive compositions, note Col. 4, lines 20-55.

[0004] A paper/glue bond can be considered a fiber/polymer composite structure with a . tendency to fracture at the interface of the plies. The process and product requirements present a difficult balancing act. If the glue is too viscous, it may not penetrate either ply sufficiently. If the glue is too thin, excess glue is required to overcome the excess wicking of glue into the web. Sometimes increased marrying roll pressure is used in an attempt to overcome the performance of the glue; however, bulk, softness and emboss quality suffer when too much pressure is used.

[0005] There is a need for a better ply bonding adhesive that overcomes the mentioned deficiencies.

[0006] Nanofibrillated cellulose (NFC) or sometimes referred to as microfibrillated cellulose (MFC) is known in the art to be useful for a variety of purposes, including for use as a structural material in sheet and related articles. For example, in United States Patent No. 6,734,335 it is mentioned that NFC is useful for use in absorbent structures. Col. 22, lines 13+. *See, also,* United States Patent No. 7,614,110, Col. 13, lines 38+. United States Patent Application Publication No. US 2012/0219816 discloses use of NFC as a layer in a multilayer paperboard structure, Abstract *See,* generally, United States Patent Application Publication No. US 2012/0058536, ¶ [0151], which discloses NFC as a structural material. NFC is used in molded structures, as seen in United States Patent Application Publication No. US 2009/0308552, ¶ [0001], as well as United States Patent Application Publication No. US 2011/0263756, Abstract. NFC is, likewise, known for use in adhesives. JP 60250079 discloses a liquid adhesive made by blending a polyvinyl acetate emulsion, sodium carboxymethyl cellulose and above 3-4% NFC based on the weight of the liquid composition. *See, also,* United States Patent Application Publication No. US 2010/0285295, ¶ [0023], where NFC is mentioned as a filler for an adhesive resin; United States Patent Application Publication No. US 2011/0052881, ¶ [0062], having similar discussion, as well as United States Patent Application Publication No. US 2009/0042003, ¶ [0057].

Summary of Invention

[0007] Nanofibrillated cellulose has been found useful as a glue additive that results in an unexpectedly better fiber/polymer matrix by reinforcing the interface between the plies, providing for softer products with less glue. The NFC modifies the glue viscosity while strengthening the interface. NFC is a shear-thinning material, so it flows more as shear is applied, and recovers viscosity as shear decreases; that is, a stationary film of glue with NFC will be initially more viscous as it sits on the web surface and thin as the plies are married to enable penetration into each paper web. The glue will thicken after marrying to retain the wet bond with less pressure. NFC has the additional benefit that it can

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reinforce the interface between plies after drying.

[0008] Advantages of the invention are appreciated with references to Figures 1 and 2. **Figure 1** is a plot of trained panel softness (arbitrary scale) versus plybond for two-ply conventional wet press (CWP) tissue with the emboss pattern shown in Figure 4. The invention sheet had 18.7 panel softness when a glue containing nanofibrillated cellulose (NFC) was used to laminate the plies with converting speeds at industrial speeds of 1000, 1500 and 2000 fpm (5, 7.6 and 10 mps) **(Figure 1).** The same basesheet, laminated with the control glue, was converted to 18.2 softness as described hereinafter.

[0009] **Figure 2** is a plot of Peel Test Plybond of TAD towel basesheet adhered with glues of the invention and control glues having the same composition without NFC. It is appreciated from Figure 2 that glues of the invention provide increases in bonding strength, enabling lower glue add-ons for providing unexpectedly softer products at comparable levels of adhesion.

[0010] Still further features and advantages of the invention will become apparent from the discussion which follows.

Brief Description of Drawings

[0011] The invention is described in detail below with reference to the drawings wherein like numerals designate similar parts and wherein:

Figure 1 is a plot of panel softness versus plybond for CWP tissue;

Figure 2 is a histogram detailing Peel Test Plybond for various glue formulations applied to TAD towel;.

Figure 3 is a schematic diagram of an embossing and laminating apparatus for preparing multi-ply absorbent sheet;

Figure 4 is a diagram showing the pattern of raised embossments provided to the tissue basesheet by the apparatus of **Figure 3;**

Figure 5 is a diagram showing the pattern of raised embossments provided to a towel basesheet by the apparatus of **Figure 3;**

Figure 6 is a histogram showing Plybond values for various two-ply TAD towels with different glues;

Figure 7 is a plot of trained panel softness (arbitrary scale) versus Plybond for two-ply TAD towels laminated with different glues;

Figure 8 is a plot of trained panel softness (arbitrary scale) versus CD Wet Tensile for commercial towel and towels of the invention;

Figure 9 is a plot of viscosity versus shear rate for PVOH/NFC adhesive and a PVOH/xanthan gum adhesive having a comparable viscosity profile;

Figure 10 is a histogram showing Plybond for various two-ply CWP tissue products at various converting speeds;

Figure 11 is a histogram showing Plybond for 2-ply structured tissue products at various converting speeds;

Figure 12A is a perspective view of a three-ply product;

Figure 12B is a schematic diagram showing an embossing and laminating process for preparing 3-ply absorbent sheet;

Figure 12C is a diagram showing a pattern for a top sheet of a 3-ply absorbent sheet;

Figure 12D is a diagram showing a pattern for a top sheet of another 3-ply absorbent sheet;

Figure 13 is a scanning electron microscope image of NFC;

Figure 14 is a plot of Characteristic Nanofiber Viscosity versus shear rate for 4 grades of NFC at 1% solids;

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Figure 15 is a histogram detailing breaking length for 4 grades of NFC formed into handsheets or films;

Figure 16 is a histogram detailing maximum stretch, or stretch at break for 4 grades of NFC, formed into handsheets or film;

Figure 17 is a histogram detailing Specific Young's modulus for 4 grades of NFC formed into handsheets or film;

Figures 18 and 19 are plots of Adhesive Viscosity versus shear rate for various adhesives;

Figure 20 is a histogram showing Peel Test Plybond for various glues;

Figure 21 is a plot showing Peel Test Plybond values for various glues as applied to TAD towel basesheet versus PVOH concentration in weight %; and

Figure 22 is a plot of Peel Test Plybond versus NFC concentration in weight % based on PVOH content of the aqueous adhesive; and

Figure 23 is a plot of Glue Absorbency Rate versus PVOH content for various glues.

Detailed Description

[0012] The invention is described in detail below in connection with the Figures for purposes of illustration, only. The invention is defined in the appended claims. Terminology used herein is given its ordinary meaning consistent with the exemplary definitions set forth immediately below; mg refers to milligrams and m^2 refers to square meters, fpm refers to feet per minute and so forth.

[0013] Adhesive Viscosity is measured at room temperature using a cone and plate geometry.

[0014] Characteristic Breaking Length of NFC material is determined by testing a strip cut from a handsheet of the subject NFC fiber as described herein.

[0015] Characteristic Nanofiber Viscosity is measured on a 1 wt% suspension of the NFC in water as further described herein.

[0016] Characteristic PVOH Viscosity is measured on a 4 wt% solution of the polyvinyl alcohol in water at a temperature of 20°C.

[0017] Relative Peel Test Plybond value refers to the ratio of the Peel Test Plybond of an NFC containing glue to that of the same glue without NFC X 100%. The glues are tested with the same absorbent sheet by the same equipment and procedure and have the same composition except that one glue has no NFC. Thus, an NFC glue having 4.5% PVOH and 5% NFC having a Peel Test Plybond value of 50g as compared with a PVOH glue of 4.5% PVOH having a Peel Test Plybond value of 20 g has a Relative Peel Test Plybond value of 50/20 X 100% or 250%.

[0018] A Relative Plybond value is the ratio of the Plybond of a product made with NFC/PVOH adhesive to that of an identical product made without NFC X 100%. That is, the products are identical in composition, processing and the same Plybond measurement is made on the product Thus, a product made with 5% NFC in the glue having a Plybond of 5g as compared with an identical product made without NFC in the glue having a Plybond value of 4g has a Relative Plybond value of 5/4 X 100% or 125%.

Cellulosic Sheet and Related Terminology

[0019] The term "cellulosic", "cellulosic sheet" and the like are meant to include any product incorporating papermaking fiber having cellulose as a major constituent. "Papermaking fibers" include virgin pulps or recycle (secondary) cellulosic fibers or fiber mixes comprising cellulosic fibers. Fibers suitable for making the webs of this invention include: nonwood fibers, such as cotton fibers or cotton derivatives, abaca, kenaf, sabai grass, flax, esparto grass, straw, jute hemp, bagasse, milkweed floss fibers, and pineapple leaf fibers; and wood fibers such as those obtained from deciduous and coniferous trees, including softwood fibers, such as northern and southern softwood Kraft fibers; hardwood fibers, such as eucalyptus, maple, birch, aspen, or the like. Papermaking fibers used in connection with the invention are typically naturally occurring pulp-derived fibers (as opposed to reconstituted fibers such as lyocell or rayon) which are liberated from their source material by any one of a number of pulping processes familiar to one experienced in the art including sulfate, sulfite, polysulfide, soda pulping, etc. The pulp can be bleached if desired by chemical means including the use of chlorine dioxide, oxygen, alkaline peroxide and so forth. The products of the present invention may comprise a blend of conventional fibers (whether derived from virgin pulp or recycle sources) and high coarseness lignin-rich tubular fibers, such as bleached chemical thermomechanical pulp (BCTMP). Pulp-derived fibers thus also include high yield fibers

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such as BCTMP as well as thermomechanical pulp (TMP), chemithermomechanical pulp (CTMP) and alkaline peroxide mechanical pulp (APMP). "Furnishes" and like terminology refers to aqueous compositions including papermaking fibers, optionally wet strength resins, debonders and the like for making paper products.

[0020] Kraft softwood fiber is low yield fiber made by the well known Kraft (sulfate) pulping process from coniferous material and includes northern and southern softwood Kraft fiber, Douglas fir Kraft fiber and so forth. Kraft softwood fibers generally have a lignin content of less than 5 percent by weight, a length weighted average fiber length of greater than 2 mm, as well as an arithmetic average fiber length of greater than 0.6 mm.

[0021] Kraft hardwood fiber is made by the Kraft process from hardwood sources, i.e., eucalyptus and also has generally a lignin content of less than 5 percent by weight. Kraft hardwood fibers are shorter than softwood fibers, typically having a length weighted average fiber length of less than 1 mm and an arithmetic average length of less than 0.5 mm or less than 0.4 mm.

[0022] Recycle fiber may be added to the papermaking furnish in any amount. While any suitable recycle fiber may be used, recycle fiber with relatively low levels of ground wood is preferred in many cases, for example recycle fiber with less than 15% by weight lignin content, or less than 10% by weight lignin content may be preferred depending on the furnish mixture employed and the application. Recycle fiber is in many cases 80% hardwood fiber.

[0023] "Basesheet" refers to a unitary cellulosic sheet as manufactured by a paper machine. Basesheets may be layered; however, they have a unitary structure not readily delaminated. A "ply" of a finished product refers to basesheet incorporated into the product.

[0024] Products of the invention are made with a cellulosic fiber basesheet and have an absorbency or SAT value as well as tensiles and densities suitable for tissue and towel products. Typical SAT values are greater than about 3 g/g in most cases. *See* United States Patent No. 8,778,138.

[0025] "CWP" refers to absorbent products made by a conventional wet-press process; that is, wet-pressing a furnish to a drying cylinder with a papermaking felt followed by creping the web from the cylinder. See United States Patent No. 7,951,266, **Figure 7** thereof.

[0026] "Structured" basesheet refers to product that is wet creped (fabric creped) from a cylinder prior to final drying. See United States Patent Nos.: 7,850,823; 7,585,388; 7,585,389; and 7,662,257.

[0027] "TAD" refers to through-air dried absorbent products. Throughdried, creped products are disclosed in the following patents: United States Patent No. 3,994,771 to Morgan, Jr. et al.; United States Patent No. 4,102,737 to Morton; and United States Patent No. 4,529,480 to Trokhan. The processes described in these patents comprise, very generally, forming a web on a foraminous support, thermally pre-drying the web, applying the web to a Yankee dryer with a nip defined, in part, by an impression fabric, and creping the product from the Yankee dryer.

[0028] The absorbent characteristics of a product can be affected by the furnish, basis weight, strength, papermaking technology, and so forth. The sheet absorbency and converting technology for a specific product will impact the selection of glue characteristics. CWP sheets are more consolidated than TAD sheets and therefore may have a lower wicking rate. Towel sheets commonly contain more softwood than tissue sheets, which may impact the pore size distribution of the web. It can be appreciated that an optimal glue formula for one product may not be optimal for another.

[0029] A towel product is typically characterized by having predominantly (more than 50% by weight based on fiber content) softwood fiber.

[0030] A tissue product is typically characterized by having predominantly (more than 50% by weight based on fiber content) hardwood fiber.

[0031] Laminating glue is commonly described in terms of PVOH solids. 3% PVOH glue should be understood as 3 grams of PVOH per 100 grams solution. The NFC addition is described in most cases as a percentage of the PVOH in the formula. Thus, "3% PVOH + 5% NFC" means that the glue has 3 grams PVOH and 3 * 0.05 = 0.15 g NFC per 100 grams solution. In some cases, notably Embodiments 108 and following, NFC content is expressed as a weight percentage of the aqueous composition.

Embossing and Laminating Multi-ply Absorbent Sheet

[0032] Referring to **Figure 3,** there is shown a converting apparatus **10** for embossing and plying basesheet into a multi-ply product. Apparatus **10** includes a glue chamber **12** an anilox roll **14,** an applicator roll **16,** an embossing roll **18,** a marrying roll **20** and an upper rubber roll **22** which is softer than marrying roll **20** which is made of hard rubber.

[0033] In operation, a first basesheet **24** is fed to the nip between upper roll **22** and embossing roll **18** where sheet **24** is provided with a plurality of raised embossments having the pattern shown in **Figure 4.** The pattern of **Figure 4** provides an embossed area of raised embossments of 5.2% of the sheet area, which corresponds to the bonding area as will be appreciated from the discussion which follows. Glue, including the PVOH/NFC adhesives of this invention is provided as an aqueous composition to glue chamber **12** and is picked up by anilox roll **14** and transferred to applicator roll 16. From applicator **roll 16,** the glue is applied to the raised embossments of basesheet **24.**

[0034] Concurrently with processing basesheet **24,** a second basesheet **26** is fed through the nip defined by marrying

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roll **20** and embossing roll **18** such that basesheet **26** is pressed to basesheet **24,** including the adhesive disposed on the raised embossments on basesheet **24,** to produce multi-ply web **30.**

[0035] Apparatus **10** was operated as described above to produce a variety of multi-ply tissue products, including the products described in **Figure 1.** The apparatus was operated at converting speeds of 1000 fpm, 1500 fpm and 2000 fpm (5, 7.6 and 10 mps) with basesheet of the type described in **Table 1** which was prepared by a CWP process using tissue fiber furnish (75% slush southern HW / 25% slush southern SW). Details as to tissue products made from these basesheets appear in **Table 2.**

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Table 1 - Physical Properties of CWP Base Web

Description	Basis Weight, lb/3000 ft^2	Caliper 8 sheet, Mils/8 sht	MD Tensile, g/3 in	CD Tensile, g/3 in	GM Tensile, g/3 in	MD Stretch. %	CD Stretch, %	MD T.E.A., mm-g/mm^2	GM Break Modulus, g/%	CD T.E.A., mm-g/mm^2	CD Break Modulus, g/%	Break Modulus MD g/%	Basis Weight Raw Wt, g
Basesheet 1	15.7	48.8	506	232	342	29.3	7.8	1.0	22.1	0.1	28.9	17.0	1.2
Basesheet 2	15.7	46.8	555	258	378	29.4	8.2	1.1	24.4	02	31.6	18.9	1.2

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Values are given SI units in Table 1A

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Table 1A - Physical Properties of CWP Base Web

Description	Basis Weight, g/m^2	Caliper 8 sheet, mm/8 sht	MD Tensile, g/mm	CD Tensile, g/mm	GM Tensile, g/mm	MD Stretch, %	CD Stretch, %	MD T.E.A., mm-g/ mm^2	GM Break Modulus, g/%	CD T.E.A., mm-g/ mm^2	CD Break Modulus, g/%	Break Modulus MD g/%	Basis Weight Raw Wt, g
Basesheet 1	25.6	1.24	6.64	3.04	4.49	29.3	7.8	1.0	22.1	0.1	28.9	17.0	1.2
Basesheet 2	25.6	1.19	7.28	3.39	4.96	29.4	8.2	1.1	24.4	0.2	31.6	18.9	1.2

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Table 2 - Physical Properties of Converted CWP Samples

Sample	Glue	Converting speed, fpm	Basis Weight lb/3000 ft^2	Caliper 8 Sheet mils/ 8 sht	Tensile MD g/3 in	Tensile CD g/3 in	Tensile GM g/3 in	Stretch MD %	Stretch CD %	Wet Tens Finch CD g/3 in	Break Mod-ulus GM g/%	Brtness MacBeth UV-C %	Color Mac-Beth b*-UV C Unitless	Opacity MacBeth Opacity Units
a1	3% PVOH	1000	31.86	121.38	1,008.51	489.07	701.67	28.08	8.82	64.27	44.53	83.12	6.12	72.99
		1500	32.04	122.83	960.07	500.75	693.10	27.11	9.05	63.89	44.36	83.44	6.06	73.62
		2000	32.03	120.71	935.43	468.76	661.62	27.79	9.11	59.56	41.20	83.51	5.98	73.09
a2	3% PVOH + 5% NFC III	1000	32.24	120.41	999.99	496.06	703.82	28.76	9.01	63.08	43.55	83.29	6.15	73.89
		1500	32.33	119.95	965.75	518.94	707.70	28.18	9.03	64.46	43.93	83.39	6.07	73.70
		2000	32.07	120.56	956.24	487.08	682.03	28.05	8.95	62.14	43.20	83.38	606	73.71
a3	2.5% PVOH + 5% NFC III	1000	32.39	120.83	1,013.03	512.50	720.25	29.20	8.82	65.13	44.79	83.60	6.00	73.45
		1500	32.06	119.91	940.26	502.39	687.02	27.82	9.10	63.56	42.70	83.45	6.04	73.76
		2000	32.10	120.17	948.41	486.86	679.13	28.21	9.67	60.45	41.12	83.65	5.98	73.73

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Values are given SI units in Table 2A.

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Table 2 - Physical Properties of Converted CWP Samples (cont'd)

Sample	Glue	Converting speed, fpm	TMI Ply-bond g	Roll Diame-ter in	Roll Com-press Value %	Break Modulus MDg/%	Break Modulus CDg/%	Color Mac-Beth a*-UV CUnitless	Color Mac-Beth L*-UV CUnitless	T.E.A. MD mm-g/ mm^2	T.EA. CD mm-g mm^2	Basis Weight Raw Wtg	Roll Comp in	Softness
a1	3% PVOH	1000	6.35	4.50	27.24	35.91	55.29	-1.23	96.40	1.98	0.32	2.41	3.28	18.1
		1500	5.65	4.34	29.13	35.53	55.43	-1.25	96.50	1.85	0.34	2.42	3.22	18.2
		2000	3.58	4.53	27.20	33.31	51.01	-1.22	96.50	1.86	0.32	2.42	3.30	18.2
a2	3% PVOH + 5% NFC III	1000	4.91	4.57	28.47	34.65	54.78	-1.24	96.50	2.01	034	2.44	3.27	18.1
		1500	4.01	4.57	28.52	33.76	57.19	-1.25	96.50	1.91	0.36	2.44	3.27	18.2
		2000	4.01	4.57	28.87	34.26	54.50	-1.23	96.49	1.88	0.33	2.42	3.25	18.2
a3	2.5% PVOH + 5% NFC III	1000	3.27	4.55	28.33	34.36	58.43	-1.24	96.55	2.03	0.34	2.45	3.26	18.6
		1500	3.44	4.57	29.93	33.71	54.14	-1.25	96.50	1.85	0.35	2.42	3.20	18.7
		2000	321	4.58	29.55	33.33	50.78	-1.21	96.56	1.88	0.36	2.43	3.23	18.7

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Values are given SI units in Table 2A.

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Table 2A - Physical Properties of Converted CWP Samples

Sample	Glue	Converting speed, mps	Basis Weight g/m^2	Caliper 8 Sheet rom/8 sht	Tensile MD g/mm	Tensile CD g/mm	Tensile GM g/mm	Stretch MD %	Stretch CD %	Wet Tens Finch CD g/mm	Break Modulus GM, g/%	Brtness MacBeth UV-C, %	Color MacBeth b*-UVC Unitless	Opacity MacBeth Opacity Units
a1	3% PVOH	5.1	51.85	3.083	13.2347	6.4181	9.2080	28.08	8.82	0.8434	44.53	83.12	6.12	72.99
		7.6	52.14	3120	12.5990	6.5713	9.0956	27.11	9.05	0.8384	44.36	83.44	6.06	73.62
		10.2	52.13	3.066	12.2756	6.1515	8.6824	27.79	9.11	0.7816	41.20	83.51	5.98	73.09
a2	3% PVOH +. 5% NFC III 111	5.1	52.47	3058	13.1229	6.5098	9.2362	28.76	9.01	0.8278	43.55	83.29	6.15	73.89
		7.6	52.62	3.047	12.6735	6.8100	9.2871	28.18	9.03	0.8459	43.93	83.39	6.07	73.70
		10.2	52.19	3.062	12.5487	6.3920	8.9503	28.05	8.95	0.8155	43.20	83.38	6.06	73.71
a3	2.5% PVOH + 5% NFC III	5.1	52.71	3.069	13.2940	6.7255	9.4518	29.20	8.82	0.8547	44.79	83.60	6.00	73.45
		7.6	52.18	3.046	12.3390	6.5929	9.0158	27.82	9.10	0.8341	42.70	83.45	6.04	73.76
		10.2	52.24	3.052	12.4460	6.3891	8.9122	28.21	9.67	0.7933	41.12	83.65	5.98	73.73

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Table 2A - Physical Properties of Converted CWP Samples (cont'd)

Sample	Glue	Converting speed, mps	TMI Ply-bond g	Roll Diame-ter, cm	Roll Com-press Value, %	Break Modulus MD g/%	Break Modulus CD g/%	Color Mac-Beth a*-UV C, Unitless	Color Mac-Beth L*-UV C, Unitless	T.E.A. MD, mm-g/ mm^2	T.E.A. CD, mm-g/ mm^2	Basis Weight, Raw Wtg	Roll Comp, cm	Sofmess
a1	3% PVOH	5.1	6.35	11.4	27.24	35.91	55.29	-1.23	96.40	1.98	032	2.41	8.33	18.1
		7.6	5.65	11.5	29.13	35.53	55.43	-1.25	96.50	1.85	0.34	2.42	8.18	18.2
		10.2	3.58	11.5	27.20	33.31	51.01	-1.22	96.50	1.86	0.32	2.42	8.38	18.2
a2	3% PVOH + 5% NFC In	5.1	4.91	11.6	28.47	34.65	54.78	-1.24	96.50	2.01	0.34	2.44	8.31	18.1
		7.6	4.01	11 6	28.52	33.76	37.19	-1.25	96.50	1.91	0.36	2.44	8.31	18.2
		10.2	4.01	11.6	28.87	34.26	54.50	-1.23	96.49	1.88	0.33	2.42	8.26	18.2
a3	2.5% PVOH +5% NFC III	5.1	3.27	11.6	28.33	34.36	58.43	-1.24	96.55	2.03	0.34	2.45	8.28	18.6
		7.6	3.44	11.6	29.93	33.71	54.14	-1.25	96.50	1.85	0.35	2.42	8.13	18.7
		10.2	3.21	11.6	29.55	33.33	50.78	-1.21	96.56	1.88	0.36	2.43	8.20	18.7

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[0036] A series of towel products were prepared using the apparatus of **Figure 3** using a towel basesheet (100% softwood Kraft fiber) prepared by a TAD process. The basesheet had the properties indicated in **Table 3.** The finished product was provided with the pattern of raised embossments shown in **Figure 5** and plied with the glue formulations shown in **Table 4,** which also provides property data on the two-ply towel.

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Table 3. Physical Properties of TAD Towel Basesheet

Basis Weight lb/3000 ft^2	Caliper 8 Sheet mils/8 sht	Tensile MD g/3 in	Tensile CD g/3 in	Tensile GM g/3 in	Stretch MD %	Stretch CD %	Wet Tens Finch Cured.CD g/3 in	T.E.A. MD mm.g/mm^2	Break Modulus GM g/%	T.E.A. CD mm.g/mm^2	Break Modulus CD g/%	Break Modulus MD g/%
15.72	100.90	1242	1196	1218	13.6	7.1	342.32	1.133	123.23	0.569	167.71	90.57
15.40	101.75	1375	1240	1305	14.6	7.7	342.89	1.351	123.44	0.596	158.92	95.90

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Values are given SI units in Table 3A.

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Table 3A. Physical Properties of TAD Towel Basesheet

Basis Weight g/m^2	Caliper 8 Sheet mm/ 8 sht	Tensile MD g/mm	Tensile CD g/mm	Tensile GM g/mm	Stretch MD %	Stretch CD %	Wet Tens Finch Cured CD g/mm	T.E.A. MD mm.g/ mm^2	Break Modulus GM g/%	T.E.A. CD mm.g/ mm^2	Break Modulus CD g/%	Break Modulus MD g/%
25.58	2.563	16.30	15.70	15.98	13.6	7.1	4.49	1.133	123.23	0.569	167.71	90.57
25.06	2.584	18.04	16.27	17.13	14.6	7.7	4.50	1.351	123.44	0.596	158.92	95.90

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Table 4. Physical Properties of Converted TAD Paper Towels

Actual Glue Sample	Basis Weight lb/3000 ft^2	Caliper 8 Sheet mils/ 8 sht	Tensile MD g/3 in	Stretch MD %	Tensile CD g/3 in	Stretch CD %	Tensile GM g/3 in	Tensile Dry Ratio Unitless	Wet Tens Finch Cured CD g/3 in	Tensile Wet/Dry CD Unitles	SAT Capacity g/m^2	SAT Rate g/s^0.5	SAT Time s	Break Modulus MD g/%	Break Modulus CD g/%	Break Modulus GM g/%	T.E.A. MD mm-g/ mm^2	T.E.A. CD mm-g/ mm^2	Roll Diameter in	Roll Compress Value %	Roll Comp in	Softness
5% PVOH	31.2	214.2	2248	15.3	1951	8.0	2094	1.15	527	0.27	540	0.32	29.6	147	244	189	2.1	1.1	4.58	9.2	4.16	7.7
4.6% PVOH + 5% NFC	31.2	213.4	2336	15.4	1994	8.2	2157	1.17	512	0.26	549	0.32	27.2	152	240	191	2.2	1.1	4.58	9.3	4.15	8
4.4% PVOH + 5% NFC	31.1	213.9	2241	15.0	2027	8.1	2131	1.11	532	0.26	537	0.30	28.3	150	254	195	2.1	1.1	4.59	9.7	4.15	7.9
4% PVOH + 15% NFC	31.2	215.0	2290	15.3	1964	8.1	2120	1.17	514	0.26	547	0.32	26.2	150	244	191	2.2	1.1	4.60	9.8	4.15	7.6
3.6% PVOH + 15%	31.4	214.8	2262	15.0	1998	8.3	2126	1.13	525	0.26	535	0.32	28.6	153	241	192	2.1	1.1	4.60	10.1	4.14	7.8
4.2% PVOH	30.7	209.9	2392	14.7	2019	8.0	2197	1.18	535	0.27	538	0.28	28.6	163	253	203	2.2	1.1	4.57	11.4	4.05	7.8
4.2% PVOH + 10%	30.8	211.8	2186	14.6	1918	8.1	2047	1.14	517	0.27	546	0.32	26.8	150	236	188	2.0	1.0	4.57	10.3	4.10	7.8
3.8% PVOH	31.3	213.1	2233	14.6	1931	7.8	2076	1.16	521	0.27	536	0.31	25.7	154	249	196	2.0	1.0	4.60	10.7	4.11	7.6
3.8% PVOH + 15%	30.9	212.3	2206	15.1	1866	7.9	2029	1.18	511	0.27	558	0.31	24.8	146	236	186	2.0	1.0	4.58	10.3	4.11	7.7
3.8% PVOH + 10%	30.7	211.9	2169	14.9	1917	8.1	2039	1.13	502	0.26	554	0.31	25.1	147	238	187	2.0	1.1	4.59	10.2	4.12	7.6

Values are given SI units in Table 4A.

Table 4A. Physical Properties of Converted TAD Paper Towels

Actual Glue Sample	Basis Weight g/m^2	Caliper 8 Sheet mm/ 8 sht	Tensile MD g/mm	Stretch MD %	Tensile CD g/mm	Stretch CD %	Tensile GM g/mm	Tensile Dry Ratio Unitless	Wet Tens Finch Cured CD g/mm	Tensile Wet/Dry CD Unitless	SAT Capacity g/m^2	SAT Rate g/s$^{.5}$	SAT Time s	Break Modulus MD g/%	Break Modulus CD g/%	Break Modulus GM g/%	T.E.A. MD mm g/ mm^2	T.E.A. CD mm g/ mm^2	Roll Diameter cm	Roll Compress Value %	Roll Comp cm	Softness
5% PVOH	50.8	5,441	29.50	15.3	25.60	8.0	27.48	1.15	6.92	0.27	540	0.32	29.6	147	244	189	2.1	1.1	11.6	9.2	10.6	7.7
4.6% PVOH + 5% NFC	50.8	5,420	30.66	15.4	26.17	8.2	28.31	1.17	6.72	0.26	549	0.32	27.2	152	240	191	2.2	1.1	11.6	9.3	10.5	8
4.4% PVOH + 5% NFC	50.6	5,433	29.41	15.0	26.60	8.1	27.97	1.11	6.98	0.26	537	0.30	28.3	150	254	195	2.1	1.1	11.7	9.7	10.5	7.9
4% PVOH + 15% NFC	50.8	5,461	30.05	15.3	25.77	8.1	27.82	1.17	6.75	0.26	547	0.32	26.2	150	244	191	2.2	1.1	11.7	9.8	10.5	7.6
3.6% PVOH + 15%	51.1	5,456	29.68	15.0	26.22	8.3	27.90	1.13	6.89	0.26	535	0.32	28.6	153	241	192	2.1	1.1	11.7	10.1	10.5	7.8
4.2% PVOH	50.0	5,331	31.39	14.7	26.50	8.0	28.83	1.18	7.02	0.27	538	0.28	28.6	163	253	203	2.2	1.1	11.6	11.4	10.3	7.8
4.2% PVOH + 10%	50.1	5,380	28.69	14.6	25.17	8.1	26.86	1.14	6.78	0.27	546	0.32	26.8	150	236	188	2.0	1.0	11.6	10.3	10.4	7.8
3.9% PVOH	50.9	5,413	29.30	14.6	25.34	7.8	27.24	1.16	6.84	0.27	536	0.32	25.7	154	249	196	2.0	1.0	11.7	10.7	10.4	7.6
3.8% PVOH + 15%	50.3	5,392	28.95	15.1	24.49	7.9	26.63	1.18	6.71	0.27	558	0.31	24.8	146	236	186	2.0	1.0	11.6	10.3	10.4	7.7
3.8% PVOH + 10%	50.0	5,382	28.46	14.9	25.16	8.1	26.76	1.13	6.59	0.26	554	0.31	25.1	147	238	187	2.0	1.1	11.7	10.2	10.5	7.6

[0037] It is appreciated from **Figure 6** that the NFC containing glues of the invention provided unexpected results in Plybond values to PVOH glues, making it possible to use less glue for a given Plybond. This latter feature is believed to provide better softness as is seen in **Figures 7** and **8**. In **Figure 7**, it is seen that 4.6% and 4.4% POH glues with NFC

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provide better Plybond and better softness than the 5% PVOH control. In **Figure 8,** it is seen the invention products have low CD Tensile values and higher softness values than corresponding conventional products. In general, Wet CD Tensile is believed inversely related to softness which is consistent with results seen in **Figure 8.**

[0038] Apparatus **10** was also used to compare NFC containing PVOH adhesives with similar PVOH adhesives containing xanthan gums, described below.

Comparison with Xanthan Gum Glue Modifier

[0039] For purposes of discerning whether the properties imparted by the inventive adhesive to multi-ply sheet were due to viscosity modification of PVOH alone or whether the NFC imparted additional benefits, PVOH adhesives with NFC and with Xanthan gum instead of NFC, were prepared as described above. These adhesives had the composition and viscosity profiles shown in **Figure 9.**

[0040] These adhesives were used to produce two-ply, glue-bonded tissue as described generally in connection with the products described in **Table 2** with two-ply CWP embossed tissue. Plybond results appear in **Figure 10.**

[0041] The two-ply CWP bath tissue produced demonstrated that:

- NFC provides a plybond reinforcement effect for two-ply CWP
- The plybond improved by 77% and 25% at converting speed of 1500 fpm and 2000 fpm, respectively, (7.6 and 10 mps) with the addition of 2% NFC in 2.5% PVOH.
- The improvement of plybond by NFC reinforced glue was not only due to viscosity.

[0042] These adhesives were also used to produce two-ply, glue-bonded tissue as described generally in connection with the products described in **Table 5** with structured (fabric creped), embossed tissue. Plybond results appear in **Figure 11.**

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Table 5 - Structured Two-Ply Tissue Properties

two-ply structured Bath Tissue Description	Sample	Basis Weight lb/ 3000 ft^2	Caliper 8 Sheet mils/ 8 sht	Tensile MD g/3 in	Tensile CD g/3 in	Tensile GM g/3 in	Stretch MD %	Stretch CD %	Wet Tens Finch CD g/ 3 in	Break ModulusGM g/%	TMI Plybond g
Structured	43	26.7	124.1	963	630	779	17.5	7.8	79.1	66.9	2.5
Structured	44	26.9	125.5	931	622	760	17.2	7.9	76.6	65.5	2.1
Structured	45	26.7	125.5	938	599	749	17.0	7.7	79.1	65.5	1.8
Structured	46	27.0	125.7	940	597	748	16.4	7.9	77.1	66.3	1.0
Structured	47	26.7	125.3	886	577	714	15.9	7.6	74.9	65.7	10
Structured	48	27.1	126.0	891	605	734	15.3	7.4	77.4	69.5	0.8
Structured	49	26.8	125.3	922	603	745	15.3	7.4	77.6	70.3	0.7
Structured	52	27.5	124.3	967	657	796	17.1	7.5	81.7	70.8	1.6
Structured	53	27.4	124.7	954	645	784	17.9	7.5	79.1	68.1	1.8
Structured	55	27.1	124.7	931	615	756	17.5	7.5	77.5	65.9	1.3
Structured	56	27.1	125.0	947	612	761	17.2	7.5	76.6	67.5	1.1
Structured	57	27.2	123.9	934	585	739	17.6	7.3	74.5	66.1	0.9

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Values are given SI units in Table 5A.

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Table 5 - Structured Two-Ply Tissue Properties (cont'd)

two-ply structured Bath Tissue Description	Roll Diameter in	Roll Compress Value %	Break Modulus MD	Break Modulus CD g/ %	T.E.A. MD mm-g/ mm^2	T.E.A. CD mm-g/ mm^2	Roll Comp in	Softness	Total solids, %
Structured	4.3	18.3	55.0	81.4	1.2	0.3	3.5		
Structured	4.3	19.8	53.9	79.6	1.1	0.3	3.4	19.10	3.00
Structured	4.3	21.4	54.9	78.3	1.1	0.3	3.4		
Structured	4.3	21.3	57.1	77.1	1.1	0.3	3.4		
Structured	4.3	22.3	56.0	77.3	1.0	0.3	3.3	19.10	2.50
Structured	4.2	22.3	58.5	82.5	1.0	0.3	3.3		
Structured	4.3	23.1	60.5	81.8	1.0	0.3	3.3	19.30	2.00
Structured	4.2	20.6	57.4	87.4	1.2	0.3	3.3		
Structured	4.2	23.5	53.4	87.0	1.2	0.3	3.2	19.10	2.55
Structured	43	19.7	53.8	80.8	1.2	0.3	3.4		
Structured	4.3	22.7	56.1	81.2	1.2	0.3	3.3	19.30	2.51
Structured	4.3	22.3	54.0	80.9	1.2	0.3	3.3		

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Values are given SI units in Table 5A.

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Table 5A - Structured Two-Ply Tissue Properties

two-ply structured Bath Tissue Description	Sample	Basis Weight g/m^2	Caliper 8 Sheet mm/ 8 sht	Tensile MD g/mm	Tensile CD g/mm	Tensile GM g/mm	Stretch MD %	Stretch CD %	wet Tens Finch CD g/mm	Break Modulus GM g/%	TMI Plybond 8
Structured	43	43.5	3.152	12.6	8.27	10.22	17.5	7.8	1.04	66.9	2.5
Structured	44	43.8	3.188	12.2	8.16	9.97	17.2	7.9	1.01	65.5	2.1
Structured	45	43.5	3.188	12.3	7.86	9.83	17.0	7.7	1.04	65.5	1.8
Structured	46	43.9	3.193	12.3	7.83	9.82	16.4	7.9	1.01	66.3	1.0
Structured	47	43.5	3.183	11.6	7.57	9.37	15.9	7.6	0.98	65.7	0.8
Structured	48	44.1	3.200	11.7	7.94	9.63	15.3	7.4	1.02	69.5	0.7
Structured	49	43.6	3.183	12.1	7.91	9.78	15.3	7.4	1.02	70.3	1.6
Structured	52	44.8	3.157	12.7	8.62	10.45	17.1	7.5	1.07	70.8	1.8
Structured	53	44.6	3.167	12.5	8.46	10.29	17.9	7.5	1.04	68.1	1.5
Structured	55	44.1	3.167	12.2	8.07	9.92	17.5	7.5	1.02	65.9	1.3
Structured	56	44.1	3.175	12.4	8.03	9.99	17.2	7.5	1.01	67.5	1.1
Structured	57	44.3	3.147	12.3	7.68	9.70	17.6	7.3	0.98	66.1	0.9

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Table 5A - Structured Two-Ply Tissue Properties (cont'd)

two-ply structured Bath Tissue, Description	Roll Diameter, in	Roll Compress Value, %	Break Modulus MD, g/%	Break Modulus CD, g/%	T.E.A. MD, mm-g/mm^2	T.E.A. CD, mm-g/mm^2	Roll Comp, in	Softness	Total solids, %
Structured	11	18.3	55.0	81.4	1.2	0.3	8.9		
Structured	11	19.8	53.9	79.6	1.1	0.3	8.6	19.10	3.00
Structured	11	21.4	54.9	78.3	1.1	0.3	8.6		
Structured	11	21.3	57.1	77.1	1.1	0.3	8.6		
Structured	11	22.3	56.0	77.3	1.0	0.3	8.4	19.10	2.50
Structured	11	22.3	58.5	82.5	1.0	0.3	8.4		
Structured	11	23.1	60.5	81.8	1.0	0.3	8.4	19.30	2.00
Structured	11	20.6	57.4	87.4	1.2	0.3	8.6		
Structured	11	23.5	53.4	87.0	1.2	0.3	8.1	19.10	2.55
Structured	11	19.7	53.8	80.8	1.2	0.3	8.6		
Structured	11	22.7	56.1	81.2	1.2	0.3	8.4	19.30	2.51
Structured	11	22.3	54.0	80.9	1.2	0.3	8.4		

[0043] The structured bath tissue demonstrated that:

- two-ply structured bath tissue had significantly lower plybond by using the same glue and same converting conditions as two-ply CWP.
- NFC shows plybond reinforcement effect for two-ply structured bath tissue. The plybond improved by 80% and 88% at converting speed of 1000 fpm and 1500 fpm, respectively, (5 and 7.6 mps) with the addition of 2% NFC in 2.5% PVOH.
- The improvement of plybond by NFC reinforced glue was not only due to viscosity.

Three-Plv Products

[0044] In some preferred embodiments, the present invention relates to three-ply products such as three-ply tissue products as shown in **Figure 12A.** A three-ply product **35** includes a first outer ply **38,** a central ply **40** and a second outer ply **42.** The plies are adhered together by PVOH/NFC adhesive securing plies together at their interfaces indicated at **44, 46.** Three-ply products may be made by successive lamination of the plies or by way of simultaneous lamination as is known in the art. Towel products may likewise be produced as three-ply absorbent structures, if so desired.

[0045] One preferred method of preparing 3-ply absorbent sheet is illustrated in connection with **Figure 12B,** wherein there is shown a converting apparatus **110** for embossing and plying basesheet into a multi-ply product. Apparatus **110** includes a glue chamber **112** an anilox roll **114**, an applicator roll **116**, an embossing roll **118**, a marrying roll **120** and an upper rubber roll **122** which is softer than marrying roll **120** which is made of hard rubber. A micro-embossing nip **145** including a micro-embossing roll **147** and a rubber roll **149** is provided for embossing a bottom sheet, as is noted below.

[0046] In operation, a top ply basesheet **138** and a middle ply basesheet **140** are fed to the nip between upper roll **122** and embossing roll **118** where the top ply (and to a lesser extent, ply **140**) are provided with an emboss pattern. NFC/PVOH glue is provided as an aqueous composition to glue chamber **112,** is picked up by anilox roll **114** and transferred to applicator roll **116**. From applicator roll **116** the glue is applied to sheet **140.**

[0047] Concurrently with processing layers **140, 138,** a bottom ply basesheet **142** is fed to micro-embossing nip **145** where it is micro-embossed. Sheet **142** is advanced to the nip defined by marrying roll **120** and embossing roll **118** such that the layers are pressed-together to produce 3-ply product **135.**

[0048] Using the procedures and materials generally described above, 3-ply tissue products were prepared by micro embossing the bottom ply and applying the ply bonding adhesive on the middle layer followed by pressing the middle and bottom plies together, as shown and described in connection with Figure **12B.** The development of the target plybond between the top and middle layer was due to the adhesive wicking through to middle layer facilitated by marrying roll pressing. Although PVOH/NFC glue had less and slower penetration into the sheet, due to the highly efficient reinforcement property of NFC, even a little PVOH/NFC glue might achieve the target plybond (2.2 g) between the top and middle layer. For a top sheet emboss pattern bordered by compressed lines as is seen in **Figure 12C,** results appear in **Table 6.** The NFC glue resulted in a 0.2 sensory softness boost at the same GM tensiles and the same finished product ply bond of 2.2 g, when added to the PVOH glue when it was 4.1% solids. There was a 0.1 sensory softness boost when added to the PVOH glue when it was at 3.5% solids.

Table 6 - 3-Ply Softness, Plybond

	Control glue 5% PVOH	NFC glue 1 4.1% PVOH + 5% NFC (4.3% total solids)	NFC glue 2 3.5% PVOH + 5% NFC 3.7% total solids)
Softness	19.6	19.8	19.7
Geometric mean tensile, g/3"	594	598	629
TMI plybond, g	2.2	2.2	2.2

Values are given SI units in Table 6A.

Table 6A - 3-Ply Softness, Plybond

	Control glue 5% PVOH	NFC glue 1 4.1% PVOH + 5% NFC (4.3% total solids)	NFC glue 2 3.5% PVOH + 5% NFC 3.7% total solids)
Softness	19.6	19.8	19.7

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(continued)

	Control glue 5% PVOH	NFC glue 1 4.1% PVOH + 5% NFC (4.3% total solids)	NFC glue 2 3.5% PVOH + 5% NFC 3.7% total solids)
Geometric mean tensile, g/mm	7.80	7.85	8.25
TMI plybond, g	2.2	2.2	2.2

[0049] Using a slightly different top sheet emboss pattern, bordered by dotted lines as is seen in **Figure 12D,** the NFC boosted glue yielded the same sensory softness as ply bond glue. Results appear in **Table 7.** *Note* that the plybond was significantly higher for the NFC prototype. Due to the increased geometric mean tensile of the finished product listed in **Table 7,** and possibly the differences in the emboss patterns, the overall sensory softness for both of these prototypes was significantly lower than for the sensory softness for the prototypes made in **Table 6.**

Table 7- 3-Ply Softness, Plybond

	Control PVOH glue (5% total solids)	5% PVOH glue with 5% NFC (5.25% total solids)
Softness	19.2	19.2
Geometric mean tensile, g/3"	758	789
TMI plybond, g	1.6	6.4

Values are given SI units in **Table 7A.**

Table 7A- 3-Ply Softness, Plybond

	Control PVOH glue (5% total solids)	5% PVOH glue with 5% NFC (5.25% total solids)
Softness	19.2	19.2
Geometric mean tensile, g/mm	9.95	10.4
TMI plybond, g	1.6	6.4

[0050] Further details concerning materials, adhesive formulation and testing are described below.

Materials, Adhesive Formulation and Sample Testing

[0051] Dry tensile strengths, stretch, ratios thereof, modulus, break modulus, stress and strain are measured with a standard Instron test device or other suitable elongation tensile tester which may be configured in various ways, typically using 3 or 1 inch (8 or 3 cm) wide strips of material, suitably conditioned in an atmosphere of 23° ± 1°C (73.4° ± 1°F) at 50% relative humidity for 2 hours. This conditioning method is preferably employed for all specimens testing. The tensile test is typically run at a crosshead speed of 2 in/min (5 cm/min). Tensile strength is sometimes referred to simply as "tensile" and is reported herein for NFC as breaking length (km), which is the tensile in kg/m divided by the basis weight of the sample in g/m^2. See United States Patent No. 8,409,404 for additional measurements and details.

[0052] The term "Characteristic Breaking Length" when referring to NFC refers to the breaking length of a handsheet or film made from 100% of the NFC. The handsheet (50-70 g/m^2) is made by using vacuum filtration and a suitable membrane as is described in more detail hereinafter followed by restrained air drying

[0053] The modulus of a specimen (also referred to as stiffness modulus or tensile modulus) is determined by the procedure for measuring tensile strength described above, using a sample with a length of 1 inch (3 cm) and width of 15 mm (0.59 in), and the modulus recorded is the chord slope of the load/elongation curve measured over the range of 0-50 grams load. The specific modulus is the modulus divided by density.

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Polyvinyl Alcohol and Characteristic PVOH Viscosity

[0054] Characteristic PVOH Viscosity is measured at 4 wt% solution of the polyvinyl alcohol in water at a temperature of 20°C. Viscosity is expressed in centipoises unless otherwise indicated, abbreviated cps or cP.

[0055] Polyvinyl alcohols for use in connection with the present invention include those obtainable from Sekisui Specialty Chemicals, Houston, Texas as well as other suppliers and distributors. Commercial polyvinyl alcohol resins are produced by saponifying polyvinyl acetate and include significant levels of vinyl acetate repeat units. The degree of hydrolysis (mol %) indicates the mol % alcohol repeat units in the polyvinyl alcohol, with the remainder being in acetate form. A partially hydrolyzed polyvinyl alcohol may be used and dissolved in water that is from about 70 mole percent to about 90 mole percent hydrolyzed, such as from about 84 mole percent to about 89 mole percent hydrolyzed. Partially hydrolyzed polyvinyl alcohols more rapidly dissolve; however, polyvinyl alcohols that are hydrolyzed to a greater extent may be used. For instance, polyvinyl alcohols may also be used in the process that has a percent hydrolysis (mole %) of greater than 90%. In some cases, the polyvinyl alcohol may be from about 91% to about 99.31% hydrolyzed. The molecular weight of the polyvinyl alcohol used can also vary. A relatively low molecular weight polyvinyl alcohol may be used. For instance, the polyvinyl alcohol may have a viscosity at 4% solids and at 20° C of less than about 10 cps. For instance, the viscosity of the polyvinyl alcohol at 4% solids and 20° C can be from about 3.5 cps to about 4.5 cps. In other embodiments, however, higher molecular weight polyvinyl alcohols can be used that have a viscosity at 4% solids and at 20° C of greater than about 5 cps, such as up to about 75 cps. Generally, polyvinyl alcohol or PVOH resins consist mostly of hydrolyzed polyvinyl acetate repeat units (more than 50 mole %), but may include monomers other than polyvinyl acetate in amounts up to about 10 mole % or so in typical commercial resins. Suitable co-monomers include vinyl co-monomers in general and especially those with carboxylate or sulfonate functionality as is seen in United States Patent No. 7,642,226. Typical commercial polyvinyl alcohols are listed in **Table 8** below.

Table 8 - Commercial Polyvinyl Alcohol for Adhesive

Grade	% Hydrolysis,	Viscosity, cps	pH	Volatiles, % Max.	Ash, % Max.[3]
Super Hydrolyzed					
Selvol 125	99.3+	28-32	5.5-7.5	5	1.2
Selvol 165	99.3+	62-72	5.5-7.5	5	1.2
Fully Hydrolyzed					
Selvol 103	98.0-98.8	3.5-4.5	5.0-7.0	5	1.2
Selvol 107	98.0-98.8	5.5-6.6	5.0-7.0	5	1.2
Selvol 310	98.0-98.8	9.0-11.0	5.0-7.0	5	1.2
Selvol 325	98.0-98.8	28.0-32.0	5.0-7.0	5	1.2
Selvol 350	98.0-98.8	62-72	5.0-7.0	5	1.2
Intermediate Hydrolyzed					
Selvol 418	91.0-93.0	14.5-19.5	4.5-7.0	5	0.9
Selvol 425	95.5-96.5	27-31	4.5-6.5	5	0.9
Partially Hydrolyzed					
Selvol 502	87.0-89.0	3.0-3.7	4.5-6.5	5	0.9
Selvol 203	87.0-89.0	3.5-4.5	4.5-6.5	5	0.9
Selvol 205	87.0-89.0	5.2-6.2	4.5-6.5	5	0.7
Selvol 513	86.0-89.0	13-15	4.5-6.5	5	0.7
Selvol 523	87.0-89.0	23-27	4.0-6.0	5	0.5
Selvol 540	87.0-89.0	45-55	4.0-6.0	5	0.5
4% aqueous solution, 20°C					

[0056] Commercial adhesive formulations containing PVOH are available from a variety of sources including H. B. fuller of Minnesota. Such compositions may contain optional additives if so desired. *See* United States Patent No.

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7,201,815.

Nanofibrillated Cellulose

[0057] NFC is commonly produced by mechanically disintegrating wood pulp, such as hardwood or softwood Kraft pulp which can include chemical pre- or post-treatments. The pulp used may be pre-processed enzymatically or chemically, for example, to reduce the quantity of hemicellulose. Furthermore, the cellulose fibers may be chemically modified, wherein the cellulose molecules contain functional groups other than in the original cellulose. Such groups include, among others, carboxymethyl (CMC), aldehyde and/or carboxyl groups (cellulose obtained by N-oxyl mediated oxidation, for example "TEMPO"), or quaternary ammonium (cationic cellulose).

[0058] Generally, a high shear zone is formed during disintegration to delaminate multilayer cell walls of wood fibers and separate fibrils while minimizing cutting and entangling. This process is used to isolate high aspect ratio, semi-crystalline cellulose fibrils with robust mechanical properties from the wood furnish. Nanofibrils are typically on the order of 4-20 nm wide and 500-2000 nm long. They possess good axial tensile strength due to inter- and intra-molecular hydrogen bonding among highly oriented cellulose molecules. Various processes suitable for making NFC are described in the following references: United States Patent Application Publication No. US 2011/0277947, entitled "Cellulose Nanofilaments and Method to Produce Same", of Hua et al.; United States Patent Application Publication No. US 2014/0083634, entitled "Method and an Apparatus for Producing Nanocellulose", of Bjoerkqvist et al.; and United States Patent Application Publication No. US 2014/0284407, entitled "A Method for Producing Nanofibrillar Cellulose", of Tamper et al.

[0059] The fiber morphology influences the amount of energy required to disintegrate it into NFC. Delamination can be facilitated by weakening fiber cell walls or decreasing the strength of fiber-to-fiber bonds through enzymatic or oxidative pretreatments as noted above. Pretreatments can be targeted to certain regions of the fiber or cause a general weakening effect. For example, cellulase enzymes degrade the amorphous portion of the fiber, whereas the TEMPO oxidation weakens the entire surface of the fiber by decreasing the degree of polymerization of cellulose. The TEMPO pretreatment weakens the fiber indiscriminately by converting primary hydroxyl groups of polysaccharides to carboxyl groups. The same techniques can also be used after mechanical fibrillation to achieve a desired quality of NFC. The choice and extent of pretreatment, as well as the morphology of the starting material, will influence the morphology of the nanofibrillated cellulose produced. For example, pulps that undergo extensive enzymatic hydrolysis before disintegration tend to be more uniform in size with a higher degree of crystallinity. With a lower fraction of amorphous cellulose, these fibers look more like cellulose nanocrystals and have a lower specific surface area. Mechanical disintegration with a microgrinder will increase the surface area of the fibrils and cause more branching. For glue reinforcement applications, this is a desired outcome as greater surface area will increase the amount of interfacial bonding with the matrix glue, PVOH.

[0060] Further details concerning making NFC or MFC with peroxide or ozone are seen in United States Patent No. 7,700,764 to Heijnesson-Hultén, entitled *Method of Preparing Microfibrillar Polysaccharide* (Akzo Nobel N.V.);United States Patent Application Publication No. US 2015/0167243 of Bilodeau et al., entitled *Energy Efficient Process for Preparing Nanocellulose Fibers* (University of Main System Board of Trustees); and United States Patent No. 8,747,612 to Heiskanen et al., entitled *Process for the Production of Microfibrillated Cellulose in an Extruder and Microfibrillated Cellulose Produced According to the Process* (Stora Enso OYJ). Discussion relating to making NFC or MFC with N-oxyl compounds is seen in United States Patent No. 8,992,728 to Isogai et al., entitled *Cellulose Nanofiber, Production Method of Same and Cellulose Nanofiber Dispersion* (University of Tokyo); United States Patent No. 8,377,563 to Miyawaki et al., entitled *Papermaking Additive and Paper Containing the Same* (Nippon Paper Industries Co., Ltd.); and United States Patent No. 8,287,692 to Miyawaki et al., entitled *Processes for Producing Cellulose Nanofibers* (Nippon Paper Industries Co., Ltd.) which discloses a process for making nanofibers using N-oxyl compounds (TEMPO). References for making NFC or MFC with enzymes include United States Patent No. 8,778,134 to Vehvilainen et al., entitled *Process for Producing Microfibrillated Cellulose* (Stora Enso OYJ); United States Patent No. 8,728,273 to Heiskanen et al., entitled *Process for the Production of a Composition Comprising Fibrillated Cellulose and a Composition* (Stora Enso OYJ); United States Patent No. 8,647,468 to Heiskanen et al., entitled *Process for Producing Microfibrillated Cellulose* (Stora Enso OYJ) which proposes two enzymatic treatments of the pulp used to make microfibers; and United States Patent No. 8,546,558 to Ankerfors et al., entitled *Method for the Manufacture of Microfibrillated Cellulose* (STFI-Packforsk AB) which also relates to the use of an enzyme treatment.

[0061] NFC may be obtained through the University of Maine; *see* "The University of Maine-The Process Development Center- Nanofiber R & D," [Online]. Available: http://umaine.edu/pdc/nanofiber-r-d/. [Accessed 24 November 2014]. This source is referred to as NFC I in the text and figures. NFC may also be obtained from Centre Technique du Papier in Grenoble, France. This source will be referred to as NFC II in the text and **Figures.** NFC may also be obtained from Paperlogic, operator of the first US commercial nanocellulose plant at the former Southworth Paper and now Paperlogic mill in Turners Falls, MA. This source is referred to as NFC PL.

[0062] **Table 9,** below, shows energy input data and fiber length data for a typical disintegration process for making

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NFC, wherein the pulp employed was southern hardwood Kraft fines and the pulp was ground in a disk grinder at essentially zero gap. It is seen in **Table 9** that the fiber length decreases substantially and the fines increase sharply as the pulp is ground. The NFC formed by this process is shown in the electron microscope image of **Figure 13.** This source of NFC will be referred to as NFC III in the text and figures. While hardwood fines are generally regarded as an undesirable pulp fraction, they may be suitable for making NFC suitable for use in adhesives with the advantage that NFC produced from this material requires less energy input than NFC produced from Kraft pulp generally, which usually has a fines content of less than 50% by MorFi® fiber analysis, discussed below. Thus, the adhesives of the invention advantageously employ NFC made from pulp having greater than 50% fines (% files (Lw) as discussed below.

Table 9. Calculated energy input and fiber length for nanofibrillated cellulose made from Southern Hardwood Fines

Time (min)	Power (watts) 264	Net KW	Gross KW	Net energy Cumulative (KW-hr/mt)	Gross Energy / time increment	Gross energy cumulative (KW-hr/mt)	L_w (mm)	Fines (% length)
0	52	0.26		0.0		0.0	0.72	76.
15	8	4	0.43	140.	361.	361.8	5	5
30	43	0.16	2	7	8	725.4	0.65	77.
45	2	8	0.43	282.	363.	1090.	7	7
60	43	0.16	2	1	6	9	0.58	80.
90	2	8	0.43	424.	365.	1437.	9	1
10	43	0.16	2	2	5	9	0.52	83.

[0063] The fiber length data in **Table 9** was measured with a MorFi® fiber analyzer (MFA) which calculates fiber length as:

$$L_w = \frac{\sum n_i L_i^2}{\sum n_i L_i}$$

i= 1,2...N categories (bins)
n_i = fiber count in the ith category/bin
L_i = contour length- histogram class center length in the ith category/bin

[0064] The smallest "fine" particle the MFA records include is about 5 μm and it measures fibers up to about 10 mm in length in the Lw calculation. While the analyzer excludes nanofibrils, the data nevertheless provides a characterization of the fibrillation process in terms of length reduction and fines increase as the cellulose pulp is nanofibrillated.

[0065] The MFA calculates the length weighted fines content by summing up the length of all the fines, *Lfines,* (i.e. 10 μm < fiber length < 200 μm) divided by the length of all fibers, *LT*:

$$\%F(L_w) = \frac{\sum L_{fines}}{L_T}$$

[0066] For present purposes, NFC is characterized by viscosity profiles and breaking length as is discussed below.

Characteristic Nanofiber Viscosity and Adhesive Viscosity

[0067] Characteristic Nanofiber Viscosity is measured on a 1 wt% suspension of the subject NFC in water.

[0068] Viscosity of the glues and NFC suspensions is measured at room temperature, using a TA instruments Discovery Hybrid Rheometer (DHR) 2. A cone and plate geometry was used for analysis. A few drops of sample were placed on a flat metal peltier plate and the cone spindle, which has a 60 mm diameter and 2° angle, was brought down to make contact with the sample to initiate the spreading action. The sample that flowed out of the circumference of the cone spindle was trimmed. The experimental conditions were as follows: flow logarithmic sweep, shear rate 0.5-2000Hz at room temperature. Trim and geometric gap was 54 microns. Room temperature means ambient temperature between 23°C and 29°C, typically. If a specific value is required, 25°C is used.

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Viscosity Analysis of NFC

[0069] NFC suspensions were prepared to obtain 1% consistency. The suspensions were then characterized for their viscosity profiles using the test method and apparatus described above. Results appear in **Table 10.**

Table 10 - NFC Viscosity Profiles

	NFC I	NFC II	NFC III	NFC P1
shear rate, 1/s	Viscosity,cP	Viscosity, cP	Viscosity, cP	Viscosity, cP
0.5	523000	989	9190	47567.1
0.8	366000	650	5940	30257
1.3	237000	387	4360	20858.7
2.0	144000	229	2910	18659.4
3.2	108000	144	2000	20986.7
5.0	80400	107	1320	33391.9
7.9	93300	80.9	843	50741.6
12.6	54100	61.2	548	51552.9
19.9	72000	50.3	579	53049.5
31.5	53200	53.8	1400	46991.5
50.0	21900	42	1300	17077.7
79.2	14100	23	1160	9200.18
126.0	5670	15.1	983	9716.41
199.0	2640	11.4	683	5740.54
315.0	1190	9.08	473	3052.84
500.0	553	7.61	303	1381.11
792.0	234	6.65	198	673.671
1260.0	100	6.15	132	307.663
1990.0	45.8	6.13	75.4	123.97
2000	30.8	6.03	79.5	111.168

[0070] The data from **Table 10** is shown graphically in Figure **14.** It is appreciated from **Figure 14** that NFC properties vary depending upon the degree of fibrillation, especially at low shear. At higher shear rates, viscosity values converge.

NFC Breaking Length, Stretch and Modulus

[0071] 100% NFC films or handsheets were formed by vacuum filtration using nylon membrane with 0.45 μm pore size utilizing the NFC I, NFC II, NFC III and NFC PI materials. Fully restrained drying of NFC films was conducted by attachment of one side of the film to a metal plate and the other side was pressed by a customized perforated ring with a piece of heavy metal on top. The diameter of dried NFC films was 1.5 in. (3.8 cm). Each film was cut into a 15 mm × 1 in (3 cm) strip for tensile testing which provided the information to calculate the breaking length, maximum stretch at break, and Specific Young's modulus. Results appear in **Table 11,** as well as in **Figures 15,** 16 and 17 for NFC I, II, III and PL.

Table 11 NFC Properties and Sheet Basis Weight

Sample	Breaking length, km	Max stretch, %	Specific Young's modulus, Mpa/g.cm^3	Basis Weight, g/m^2
NFC I	6.9	7.5	2194	56
NFC II	5.9	4.6	2095	59

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(continued)

Sample	Breaking length, km	Max stretch, %	Specific Young's modulus, Mpa/g.cm^3	Basis Weight, g/m^2
NFC III	5.0	7.0	1156	69
NFC PI	6.3	11.4	1416	62

Glue Formulation

[0072] Glue was formulated from commercial polyvinyl alcohol (PVOH) adhesive and NFC by diluting a commercially available 8% solids by weight aqueous PVOH adhesive and thoroughly mixing with NFC as detailed in **Table 12,** wherein it is seen Conventional PVOH glue was diluted to 4-6% solid content from commercial PVOH plybond water-based adhesive (WB2746, H.B. Fuller, 8% solids). Two types of NFC were employed in the formulations of **Table 12** : NFC I, a relatively fine grade in an aqueous dispersion, 3.28% by weight solids; NFC II, a somewhat coarser grade in an aqueous dispersion, 1.92% solids were mixed with the commercial PVOH to prepare NFC reinforced PVOH glues having the composition shown in **Table 12.**

Table 12 - Preparation of Glue

Glue #	Sample	PVOH Solids, % (w/w)	8% PVOH, g	3.28% NFC I, g	1.92% NFC II, g	Water, g	Total, g
1	PVOH	4	150			150.00	300.00
2		4.5	170			132.22	302.22
3		5	190			114.00	304.00
4		5.5	210			95.45	305.45
5		6	225			75.00	300.00
6	PVOH+5%NFC I	4	150	18.29		131.71	300.00
7		4.5	170	20.73		111.49	302.22
8		5	190	23.17		90.83	304.00
9		5.5	210	25.61		69.84	305.45
10		6	225	27.44		47.56	300.00
11	PVOH+5%NFC II	4	150		31.25	118.75	300.00
12		4.5	170		35.42	96.81	302.22
13		5	190		39.58	74.42	304.00
14		5.5	210		43.75	51.70	305.45
15		6	225		46.88	28.13	300.00

[0073] The above and additional glues with different levels of PVOH and NFC were tested for their viscosity with respect to shear rate using the procedure noted above. The viscosity of each glue represented as centiPoise vs. shear rate ($\dot{\gamma}$, which is proportional to rotor speed and inversely related to gap) is shown in **Figures 18** and **19.** All the PVOH glues without NFC were typical newtonian fluids in which viscosity stays the same regardless of shear rate in the range of 0.5-2000 s^{-1}. Viscosity of 4.5% PVOH was over three times the viscosity of 3% PVOH. All the glues that contain 5% NFC based on the dry weight of PVOH displayed a shear thinning property. For the NFC reinforced glues, 3% PVOH+5% NFC and 4.5% PVOH+5% NFC, the incorporation of NFC significantly increased the viscosity of the glue and the degree of increase depends on the shear rate. Two glue samples, 3% PVOH and 2.5% PVOH+5% NFC, had very similar viscosity curves. Therefore, it is likely that a similar volume of glue will be applied on base web when using these two types of glue. However, 2.5% PVOH+5% NFC provides a benefit in terms of softness since less total PVOH is used as is seen in **Figure 1.**

[0074] **Figures 18, 19** likewise show that standard PVOH glue is converted from a Newtonian fluid to a pseudoplastic (shear-thinning) fluid by addition of a small quantity of NFC. Low-shear viscosity is also significantly increased. Glue containing 2.5% PVOH with NFC has a viscosity in a similar range as 3% PVOH. If the fluid dynamics of each glue results in the transfer of a similar liquid volume, it is reasonable to assume that the NFC glue supplied about 20% less PVOH (2.5/3). Softness is improved due to the smaller amount of glue being less detectable to touch. The glue/tissue interface between the applicator roll and emboss roll may involve the most important transfer of glue, and the shear rate becomes an important consideration for non-Newtonian fluids. If the shear rate is low, the alternative glues will have

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higher viscosity than 3% PVOH. If the shear rate is above about 10 sec^{-1}, the alternative glues will be thinner. Given that the roll speeds are matched and the nip pressure is low, the shear rate is expected to be low. Thus, the alternative glues are hypothesized to act as higher viscosity glues in terms of wet tack while delivering a smaller quantity of dry residual.

Peel Test Plybond

[0075] In order to characterize the adhesive strength of each glue, a strip of TAD basesheet was adhered to a metal plate followed by measurement of the force required to peel the sheet off. Ten drops of glue approximately 0.5 g was evenly spread on a 2" × 8" (5 x 20 cm) stainless steel test panel plate using a number 40 wire rod to apply a film of approximately 50 microns, followed by attaching a 2" × 12" (5 x 30 cm) TAD towel basesheet, *see* Table 3 for specifics to the glued plate surface and pressing it from one end to another for 3 times using a metal roller. After drying the glued towel basesheet, the plybond between basesheet and steel plate was measured by a peeling test using an Instron tensile test machine 5966. The free end of the basesheet strip was separated by hand for 2" (5 cm). The specimen was placed in the testing machine by clamping the steel plate in the bottom grip and turning up the free end of the basesheet and clamping it in the upper grip. The peeling test was performed by stripping the basesheet from the steel plate approximately at an angle of 180° and a ramp rate of 10"/min (25 cm/min) for 10" (25 cm) displacement. At least 6 specimens were tested for each glue sample. After each test, the steel plate was washed with DI water and acetone to remove the residual glue before the next use. These tests are generally in accordance with test method ASTM D 903-98 except for the differences noted.

Plybond

[0076] Generally the force needed to separate a ply of a multi-ply sheet or Plybond is measured with a Lab Master Slip and Friction tester available from Testing Machines, Inc. (Islandia, N.Y.) fitted with a sample clamp platform available from Research Dimensions (Neenah, WI). A top ply of the sample is separated and clamped in a clamp attached to a load cell and the average force required to separate the ply from another ply is recorded as the plies are separated. Details appear below for 2-ply testing; while 3-ply testing is substantially the same.

[0077] Plybond strengths reported herein are determined from the average load required to separate the plies of two-ply tissue, towel, napkin, and facial finished products using TMI Plybond Lab Master Slip & Friction tester Model 32-90, with high-sensitivity load measuring option and custom planar top without elevator available from: Testing Machines Inc. 2910 Expressway Drive South Islandia, NY 11722; (800)-678-3221; www.testingmachines.com. Plybond clamps are available from: Research Dimensions, 1720 Oakridge Road, Neenah, WI 54956, Contact: 920-722-2289 and Fax: 920-725-6874.

[0078] Samples are preconditioned according to TAPPI standards and handled only by the edges and corners care being exercised to minimize touching the area of the sample to be tested.

[0079] At least ten sheets following the tail seal are discarded. Four samples are cut from the roll thereafter, each having a length equivalent to 2 sheets but the cuts are made ¼" (0.64 cm) away from the perf lines by making a first CD cut ¼" (0.64 cm) before a first perforation and a second CD cut ¼" (0.64 cm) before the third perforation so that the second perforation remains roughly centered in the sheet. The plies of the each specimen are initially separated in the leading edge area before the first perforation continuing to approximately ½" (1.3 cm) past this perforation.

[0080] The sample is positioned so that the interior ply faces upwardly, the separated portion of the ply is folded back to a location ½" (1.3 cm) from the initial cut and ¼" (0.64 cm) from the first perforation, and creased there. The folded back portion of the top ply is secured in one clamp so that the line contact of the top grip is on the perforation; and the clamp is placed back onto the load cell. The exterior ply of the samples is secured to the platform, aligning the perforation with the line contact of the grip and centering it with the clamp edges.

[0081] After ensuring that the sample is aligned with the clamps and perforations, the load-measuring arm is slowly moved to the left at a speed of 25.4cm/min, the average load on the arm (in g.) is measured and recorded. The average of 3 samples is recorded with the fourth sample being reserved for use in case of damage to one of the first three. See United States Patent No. 8,287,986.

[0082] Plybond and Peel Test Plybond values for various glues are shown in **Figures 2, 6, 7, 10, 11, 20, 21** and **22.** It is seen in **Figure 2,** in particular, that NFC greatly increases Peel Test Plybond tested on TAD towel basesheet up to 300% and more; as compared to the same glue composition without any NFC. In **Figures 6, 10, 11** it is seen that Plybond values are significantly increased by addition of NFC in relatively small amounts.

[0083] A comparison of the adhesion between conventional PVOH glues and NFC reinforced PVOH glues are shown in **Figure 20** for Peel Test Plybond tested on TAD towel. At each PVOH content from 4% to 6%, NFC I reinforced PVOH glues showed stronger adhesion than conventional PVOH. The differences in adhesion values were significant. Selected results also appear in **Figures 21** and **22.**

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Glue Absorbency Rate

[0084] Without intending to be bound by any particular theory, the unexpected and advantageous properties in terms of softness and increased plybond realized in accordance with the invention are believed due, in part, to the longer absorption times (Glue Absorbency Rates) exhibited by the inventive adhesives on absorbent sheet in the absence of shear stress. The Glue Absorbency Rate is the time, in seconds, taken for the TAD towel basesheet, **Table 3** to completely absorb a 0.05 ml droplet of tested glue. The longer time it takes, the more likely it is for glue to contribute to plybond rather than being wicked into the towel. The droplet is disposed on its surface by way of an automated syringe. The test specimens are preferably conditioned at 23° C± 1° C (73.4 ± 1.8°F) at 50 % relative humidity. For each sample, 4 3x3 inch (8x8 cm) test specimens are prepared. Each specimen is placed in a sample holder such that a high intensity lamp is directed toward the specimen. 0.05 ml of glue is deposited on the specimen surface and a stop watch is started. When the droplet is absorbed, as indicated by lack of further reflection of light from the drop, the stopwatch is stopped and the time recorded to the nearest 0.1 seconds. The procedure is repeated for each specimen and the results averaged for the sample. Glue Absorbency Rate is otherwise measured in accordance with TAPPI method T-432 cm-99.

[0085] **Figure 23** is a plot of Glue Absorbency Rate versus PVOH solids on a TAD towel basesheet for various glues. It is seen that the absorption rate of regular PVOH glue increased with increasing PVOH concentration from 4% to 5%, and then leveled off from 5% to 6% PVOH. This trend was coincident with the changes of plybond. The absorption time dramatically increased with the addition of NFC at addition level from 5% to 20%; as more NFC was added, the longer the absorption time. This result is consistent with the notion that the reinforcement function of NFC glue as the presence of NFC not only contributes to the hydrogen bonding with the paper, it also largely restricts the penetration of liquid glue into the basesheet, allowing the majority of glue to stay as a glue film for developing plybond rather than being wicked by the basesheet. In this way, it is possible to avoid excessive application of plybond glue which stiffens the basesheet and reduces the softness of the product.

Embodiments of the Invention

[0086] There is thus provided in accordance with the invention in one aspect,

embodiment No. 1 which is directed to a multi-ply absorbent sheet comprising:

(a) a first absorbent ply of cellulosic sheet;

(b) a second absorbent ply of cellulosic sheet; and

(c) a ply bonding adhesive interposed between said first absorbent ply and said second absorbent ply, said ply-bonding adhesive adhering said absorbent plies together,

wherein said ply-bonding adhesive comprises polyvinyl alcohol and nanofibrillated cellulose.

Embodiment No. 2 is the multi-ply absorbent sheet according to Embodiment No. 1, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of at least 3 km.

Embodiment No. 3 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 3 km to 10 km.

Embodiment No. 4 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 4.5 km to 9 km.

Embodiment No. 5 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 6.5 km to 7.5 km.

Embodiment No. 6 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 200,000 cP at a shear rate of 1 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 50,000 cP at a shear rate of 50 sec^{-1}.

Embodiment No. 7 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 350 cP at a shear rate of 1 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 50 cP at a shear rate of 50 sec^{-1}.

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Embodiment No. 8 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 4,000 cP at a shear rate of 1 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 1,500 cP at a shear rate of 50 sec^{-1}.

Embodiment No. 9 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 50% as the shear rate is increased from 1 sec^{-1} to 50 sec^{-1}.

Embodiment No. 10 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 60% as the shear rate is increased from 1 sec^{-1} to 50 sec^{-1}.

Embodiment No. 11 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 70% as the shear rate is increased from 1 sec^{-1} to 50 sec^{-1}.

Embodiment No. 12 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 15,000 cP at a shear rate of 5 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 2,000 cP at a shear rate of 500 sec^{-1}.

Embodiment No. 13 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 60% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 14 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 70% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 15 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 80% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 16 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 90% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 17 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the polyvinyl alcohol in the adhesives comprises partially hydrolyzed polyvinyl alcohol having a degree of hydrolysis between 70 and 98 mol%.

Embodiment No. 18 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the polyvinyl alcohol in the adhesive has a Characteristic PVOH Viscosity of from 3 to 75 cP.

Embodiment No. 19 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the polyvinyl alcohol in the adhesive has a Characteristic PVOH Viscosity of from 25cP to 55 cP.

Embodiment No. 20 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the adhesive contains from 0.5% by weight to 20% or 30% or 40% or up to 50% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 21 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the adhesive contains from 1% by weight to 10% or 20% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 22 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the adhesive contains from 1.5 % by weight to 5% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

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Embodiment No. 23 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the adhesive contains from 1.75% by weight to 2.5% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 24 is the multi-ply tissue sheet according to any of the foregoing embodiments, wherein the adhesive is applied between the plies as an aqueous composition containing from 1.5% to 10% by weight of the composition polyvinyl alcohol.

Embodiment No. 25 is the multi-ply tissue sheet according to any of the foregoing embodiments, wherein the adhesive is applied between the plies as an aqueous composition containing from 1.5% to 6% by weight of the composition polyvinyl alcohol.

Embodiment No. 26 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the adhesive is applied between the plies as an aqueous composition containing from 1.5% to 3% by weight of the composition polyvinyl alcohol.

Embodiment No. 27 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the adhesive is applied between the plies in a discontinuous pattern.

Embodiment No. 28 is the multi-ply absorbent sheet according to Embodiment No. 27, wherein the discontinuous pattern corresponds to a pattern of raised embossments on one of the absorbent plies of cellulosic sheet.

Embodiment No. 29 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the multi-ply absorbent sheet is a multi-ply tissue sheet composed predominantly of hardwood papermaking fiber.

Embodiment No. 30 is the multi-ply tissue sheet according to Embodiment No. 29, wherein the adhesive is applied between the plies as an aqueous composition containing from 1.5% to 7.5% by weight of the composition polyvinyl alcohol and the adhesive comprises from 1.5% to 10% by weight nanofibrillated fiber based on the weight of polyvinyl alcohol.

Embodiment No. 31 is the multi-ply tissue sheet according to Embodiment No. 29, wherein the adhesive is applied between the plies as an aqueous composition containing from 1.5% to 3% by weight of the composition polyvinyl alcohol and the adhesive comprises from 1.5% to 10% by weight nanofibrillated fiber based on the weight of polyvinyl alcohol.

Embodiment No. 32 is the multi-ply tissue sheet according to Embodiment No. 29, having a basis weight of 20 to 40 lbs/3000 ft^2 (33 to 65 g/m^2).

Embodiment No. 33 is the multi-ply absorbent sheet according to any one of Embodiment Nos. 1 through 28, wherein the multi-ply absorbent sheet is a multi-ply towel sheet composed predominantly of softwood fiber.

Embodiment No. 34 is the multi-ply towel sheet according to Embodiment No. 33, having a basis weight of from 20 to 40 lbs/3000 ft^2 (33 to 65 g/m^2).

Embodiment No. 35 is the multi-ply absorbent sheet according to any of the foregoing embodiments, wherein the multi-ply sheet comprises a third absorbent ply of cellulosic sheet plied together with the first and second ply.

Embodiment No. 36 is the multiply absorbent sheet according to any of the foregoing embodiments, consisting of three plies laminated together, wherein the ply bonding adhesive is applied only between two plies prior to lamination.

Embodiment No. 37 is the multi-ply absorbent sheet according to any of the foregoing embodiments, which exhibits a Relative Plybond value of at least 110 % as compared with a like product made without nanofibrillated cellulose in the adhesive.

Embodiment No. 38 is the multi-ply absorbent sheet according to any of the foregoing embodiments, which exhibits a Relative Plybond value of at least 125% as compared with a like product made without nanofibrillated cellulose in the adhesive.

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Embodiment No. 39 is the multi-ply absorbent sheet according to any of the foregoing embodiments, which exhibits a Relative Plybond value of at least 140% as compared with a like product made without nanofibrillated cellulose in the adhesive.

Embodiment No. 40 is a method of making absorbent sheet comprising:

(a) feeding a first absorbent cellulosic basesheet to an embossing nip;

(b) embossing a pattern of raised embossments in said first basesheet;

(c) applying an aqueous adhesive containing polyvinyl alcohol and nanofibrillated cellulose to the raised embossments of said first sheet; and

(d) plying a second absorbent cellulosic basesheet with said first sheet by pressing said second cellulosic sheet to the adhesive disposed on the raised embossments of said first cellulosic sheet.

Embodiment No. 41 is the method of making a multi-ply absorbent sheet according to Embodiment No. 40, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of at least 3 km.

Embodiment No. 42 is the method of making a multi-ply absorbent sheet according to Embodiment Nos. 40 or 41, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 3 km to 10 km.

Embodiment No. 43 is the method of making a multi-ply absorbent sheet according to any one of Embodiment Nos. 40 through 42, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 4.5 km to 9 km.

Embodiment No. 44 is the method of making a multi-ply absorbent sheet according to any one of Embodiment Nos. 40 through 43, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 6.5 km to 7.5km.

Embodiment No. 45 is the method of making a multi-ply absorbent sheet according to any one of Embodiment Nos. 40 through 44 wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 200,000 cP at a shear rate of 1 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 50,000 cP at a shear rate of 50 sec^{-1}.

Embodiment No. 46 is the method of making a multi-ply absorbent sheet according to any one of Embodiment Nos. 40 through 45, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 350 cP at a shear rate of 1 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 50 cP at a shear rate of 50 sec^{-1}.

Embodiment No. 47 is the method of making a multi-ply absorbent sheet according to any one of Embodiment Nos. 40 through 46, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 4,000 cP at a shear rate of 1 sec^{-1} and a Characteristic Viscosity of less than 1,500 cP at a shear rate of 50 sec^{-1}.

Embodiment No. 48 is the method of making a multi-ply absorbed sheet according to any one of Embodiment Nos. 40 through 47, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 50% as the shear rate is increased from 1 sec^{-1} to 50 sec^{-1}.

Embodiment No. 49 is the method of making a multi-ply absorbent sheet according to any one of Embodiment Nos. 40 through 48, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 60% as the shear rate is increased from 1 sec^{-1} to 50 sec^{-1}.

Embodiment No. 50 is the method of making a multi-ply absorbent sheet according to any one of Embodiment Nos. 40 through 49, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 70% as the shear rate is increased from 1 sec^{-1} to 50 sec^{-1}.

Embodiment No. 51 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 50, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 15,000 cP at a shear rate of 5 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 2,000 cP at a shear rate of 500 sec^{-1}.

Embodiment No. 52 is the method of making a multi-ply absorbent sheet according to any one of Embodiments

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Nos. 40 through 51, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 60% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 53 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 52, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 70% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 54 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 53, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 80% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 55 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 54, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 90% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 56 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 55, wherein the polyvinyl alcohol in the adhesives comprises partially hydrolyzed polyvinyl alcohol having a degree of hydrolysis between 70 and 98 mol%.

Embodiment No. 57 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 56, wherein the polyvinyl alcohol in the adhesive has a Characteristic PVOH Viscosity of from 3 to 75 cP.

Embodiment No. 58 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 57, wherein the polyvinyl alcohol in the adhesive has a Characteristic PVOH Viscosity of from 25 cP to 55 cP.

Embodiment No. 59 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 58, wherein the adhesive contains from 0.5% by weight to 20% or 30% or 40% or up to 50% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 60 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 59, wherein the adhesive contains from 1% by weight to 10% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 61 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 60, wherein the adhesive contains from 1.5 % by weight to 5% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 62 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 61, wherein the adhesive contains from 1.75% by weight to 2.5% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 63 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 62, wherein the adhesive is applied between the plies as an aqueous solution containing from 1.5% to 10% by weight of the composition polyvinyl alcohol.

Embodiment No. 64 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 63, wherein the adhesive is applied between the plies as an aqueous solution containing from 1.5% to 6% by weight of the composition polyvinyl alcohol.

Embodiment No. 65 is the method of making a multi-ply absorbent sheet according to any one of Embodiments Nos. 40 through 64, wherein the adhesive is applied between the plies as an aqueous solution containing from 1.5% to 3% by weight of the composition polyvinyl alcohol.

Embodiment No. 66 is the method of making a multi-ply absorbent sheet according to any of Embodiment Nos. 40 through 65, further comprising plying a third cellulosic basesheet with said first and second cellulosic basesheets without additional adhesive.

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Embodiment No. 67 is a ply bonding adhesive for the manufacture of multi-ply paper tissue and multi-ply paper towel comprising:

(a) water;

(b) polyvinyl alcohol in an amount of from 1.5% to 10% by weight based on the weight of the adhesive composition; and

(c) from 1% to 50% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

Embodiment No. 68 is the ply bonding adhesive according to Embodiment No. 67, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of at least 3 km.

Embodiment No. 69 is the ply bonding adhesive according to Embodiment Nos. 67 or 68, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 3 km to 10 km.

Embodiment No. 70 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 69, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 4.5 km to 9 km.

Embodiment No. 71 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 70, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 6.5 km to 7.5 km.

Embodiment No. 72 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 71, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 200,000 cP at a shear rate of 1 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 50,000 cP at a shear rate of 50 sec^{-1}.

Embodiment No. 73 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 72, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 350 cP at a shear rate of 1 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 50 cP at a shear rate of 50 sec^{-1}.

Embodiment No. 74 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 73, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 4,000 cP at a shear rate of 1 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 1,500 cP at a shear rate of 50 sec^{-1}.

Embodiment No. 75 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 74, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 50% as the shear rate is increased from 1 sec^{-1} to 50 sec^{-1}.

Embodiment No. 76 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 75, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 60% as the shear rate is increased from 1 sec^{-1} to 50 sec^{-1}.

Embodiment No. 77 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 76, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 70% as the shear rate is increased from 1 sec^{-1} to 50 sec^{-1}.

Embodiment No. 78 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 77, wherein said nanofibrillated cellulose has a Characteristic Nanofiber Viscosity of greater than 15,000 cP at a shear rate of 5 sec^{-1} and a Characteristic Nanofiber Viscosity of less than 2,000 cP at a shear rate of 500 sec^{-1}.

Embodiment No. 79 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 78, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 60% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 80 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 79, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 70% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

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Embodiment No. 81 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 80, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 80% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 82 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 81, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 90% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

Embodiment No. 83 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 82, wherein the polyvinyl alcohol in the adhesives comprises partially hydrolyzed polyvinyl alcohol having a degree of hydrolysis between 70 and 98 mol%.

Embodiment No. 84 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 83, wherein the polyvinyl alcohol in the adhesive has a Characteristic PVOH Viscosity of from 3 to 75 cP.

Embodiment No. 85 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 84, wherein the polyvinyl alcohol in the adhesive has a Characteristic PVOH Viscosity of from 25 cP to 55 cP.

Embodiment No. 86 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 85, wherein the adhesive contains from 0.5% by weight to 20% or 30% or 40% or up to 50% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 87 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 86, wherein the adhesive contains from 1% by weight to 10% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 88 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 87, wherein the adhesive contains from 1.5% by weight to 5% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 89 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 88, wherein the adhesive contains from 1.75% by weight to 2.5% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

Embodiment No. 90 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 89, wherein the adhesive is applied between plies of a multi-ply absorbent sheet as an aqueous composition containing from 1.5% to 10% by weight of the composition polyvinyl alcohol.

Embodiment No. 91 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 90, wherein the adhesive is applied between plies of a multi-ply absorbent sheet as an aqueous composition containing from 1.5% to 6% by weight of the composition polyvinyl alcohol.

Embodiment No. 92 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 91, wherein the adhesive is applied between plies of a multi-ply absorbent sheet as an aqueous composition containing from 1.5% to 3% by weight of the composition polyvinyl alcohol.

Embodiment No. 93 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 92, wherein the adhesive comprises from 90-98.5% by weight of the composition water, from to 1.5% to 6% by weight of the composition polyvinyl alcohol and from 1% to 20% or 30% or 40% or up to 50% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

Embodiment No. 94 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 93, wherein the adhesive comprises from 94-98.5% by weight of the composition water, from to 1.5% to 6% by weight of the composition polyvinyl alcohol and from 1% to 20% or 30% or 40% or up to 50% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

Embodiment No. 95 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 94, wherein the adhesive comprises from 97-98.5% by weight of the composition water, from to 1.5% to 2.5 % by weight of the

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composition polyvinyl alcohol and from 1% to 5% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

Embodiment No. 96 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 94, wherein the adhesive comprises from 94-98.5% by weight of the composition water, from to 1.5% to 6% by weight of the composition polyvinyl alcohol and from 1% to 20% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

Embodiment No. 97 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 96, wherein the adhesive consists essentially of water, polyvinyl alcohol and nanofibrillated cellulose.

Embodiment No. 98 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 97, wherein the adhesive exhibits an Adhesive Viscosity reduction of at least 15% as shear rate is increased from 1 sec^{-1} to 100 sec^{-1}.

Embodiment No. 99 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 98, wherein the adhesive exhibits an Adhesive Viscosity reduction of at least 25% as shear rate is increased from 1 sec^{-1} to 100 sec^{-1}.

Embodiment No. 100 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 99, wherein the adhesive exhibits an Adhesive Viscosity reduction of at least 50% as shear rate is increased from 1 sec^{-1} to 100 sec^{-1}.

Embodiment No. 101 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 100, wherein the adhesive exhibits a Relative Peel Test Plybond value of at least 115% as compared to an adhesive of the same composition without nanofibrillated cellulose.

Embodiment No. 102 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 101, wherein the adhesive exhibits a Relative Peel Test Plybond value of at least 125% as compared to an adhesive of the same composition without nanofibrillated cellulose.

Embodiment No. 103 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 102, wherein the adhesive exhibits a Relative Peel Test Plybond value of at least 150% as compared to an adhesive of the same composition without nanofibrillated cellulose.

Embodiment No. 104 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 103, wherein the adhesive exhibits a Relative Peel Test Plybond value of at least 200% as compared to an adhesive of the same composition without nanofibrillated cellulose.

Embodiment No. 105 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 104, wherein the adhesive exhibits a Relative Peel Test Plybond value of at least 250% as compared to an adhesive of the same composition without nanofibrillated cellulose.

Embodiment No. 106 is the ply bonding adhesive according to any one of Embodiment Nos. 67 through 105, wherein the adhesive exhibits a Relative Peel Test Plybond value of at least 300% as compared to an adhesive of the same composition without nanofibrillated cellulose.

Embodiment No. 107 is the ply bonding adhesive according to any one of Embodiment Nos.. 67 through 106, wherein the adhesive exhibits a Relative Peel Test Plybond value of at least 400% as compared to an adhesive of the same composition without nanofibrillated cellulose.

Embodiment No. 108 is a ply bonding adhesive composition for the manufacture of multi-ply paper tissue and multi-ply paper towel comprising: (a) water; (b) polyvinyl alcohol; and (c) nanofibrillated cellulose.

Embodiment no. 109 is the ply bonding adhesive composition according to Embodiment No. 108, wherein the adhesive comprises from 90-98.5% by weight of the composition water, from to 0.5% to 10% by weight of the composition polyvinyl alcohol and from 0.05% to 2.5% by weight of the composition nanofibrillated cellulose.

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Embodiment No. 110 is the ply bonding adhesive composition according to Embodiment Nos. 108 or 109, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.025 and up to 2.

Embodiment No. 111 is the ply bonding adhesive composition according to Embodiment Nos. 108 to 110, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.25 and up to 2.

Embodiment No. 112 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 110, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.2.

Embodiment No. 113 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 112, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.3

Embodiment No. 114 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 113, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.4.

Embodiment No. 115 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 114, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.5.

Embodiment No. 116 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 115, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.6.

Embodiment No. 117 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 110, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.2 and up to 2.

Embodiment No. 118 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 117, wherein nanofibrillated cellulose is present in an amount of greater than 0.4 percent by weight based on the weight of the aqueous composition.

Embodiment No. 119 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 118, wherein nanofibrillated cellulose is present in an amount of greater than 0.4 percent by weight based on the weight of the aqueous composition and up to 1.5 percent by weight based on the weight of the aqueous composition.

Embodiment No. 120 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 119, wherein the ply bonding adhesive contains from 0.25 percent by weight to 3 percent by weight of nanofibrillated cellulose based on the weight of the aqueous composition.

Embodiment No. 121 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 120, wherein the ply bonding adhesive contains from 0.25 percent by weight to 2.5 percent by weight of nanofibrillated cellulose based on the weight of the aqueous composition.

Embodiment No. 122 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 121, wherein the ply bonding adhesive contains from 0.35 percent by weight to 1.5 percent by weight of nanofibrillated cellulose based on the weight of the aqueous composition.

Embodiment No. 123 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 122, wherein the ply bonding adhesive contains from 0.35 percent by weight to 1 percent by weight of nanofibrillated cellulose based on the weight of the aqueous composition.

Embodiment No. 124 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 123, wherein the ply bonding adhesive contains from 0.35 percent by weight to 0.75 percent by weight of nanofibrillated cellulose based on the weight of the aqueous composition.

Embodiment No. 125 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 124, wherein the ply bonding adhesive contains from 0.4 percent by weight to 0.6 percent by weight of nanofibrillated cellulose based on the weight of the aqueous composition.

Embodiment no. 126 is the ply bonding adhesive composition according to any of Embodiment Nos. 108 to 125, wherein the adhesive comprises from 90-98.5% by weight of the composition water, from to 0.5% to 10% by weight

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of the composition polyvinyl alcohol and from 0.25% to 2.5% by weight of the composition nanofibrillated cellulose.

[0087] While the invention has been described in detail, modifications within the spirit and scope of the invention will be readily apparent to those of skill in the art. Such modifications are also to be considered as part of the present invention. In view of the foregoing discussion, relevant knowledge in the art and references discussed above in connection with the Background of the Invention, the disclosures of which are all incorporated herein by reference, further description is deemed unnecessary. In addition, it should be understood from the foregoing discussion that aspects of the invention and portions of various embodiments may be combined or interchanged either in whole or in part. Furthermore, those of ordinary skill in the art will appreciate that the foregoing description is by way of example only, and is not intended to limit the invention.

[0088] The invention is also defined by the following embodiments:

1. A ply bonding adhesive composition for the manufacture of multi-ply paper tissue and multi-ply paper towel comprising:

(a) water;

(b) polyvinyl alcohol; and

(c) nanofibrillated cellulose.

2. The ply bonding adhesive composition according to embodiment 1, wherein the adhesive comprises from 90-98.5% by weight of the composition water, from to 0.5% to 1 0% by weight of the composition polyvinyl alcohol and from 0.05% to 2.5% by weight of the composition nanofibrillated cellulose.

3. The ply bonding adhesive composition according to embodiment 1, wherein the adhesive comprises from 90-98.5% by weight of the composition water, from to 0.5% to 10% by weight of the composition polyvinyl alcohol and from 0.25% to 2.5% by weight of the composition nanofibrillated cellulose.

4. The ply bonding adhesive composition according to any of embodiments 1 to 3 , wherein said nanofibrillated cellulose has a Characteristic Breaking Length of at least 3 km.

5. The ply bonding adhesive composition according to any of embodiments 1 to 4 , wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 4.5 km to 9 km.

6. The ply bonding adhesive composition according to any of embodiments 1 to 5 , wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 80% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

7. The ply bonding adhesive composition according to any of embodiments 1 to 6, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.025 and up to 2.

8. The ply bonding adhesive composition according to any of embodiments 1 to 7, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.25 and up to 2.

9. The ply bonding adhesive composition according to any of 1 to 8 , wherein nanofibrillated cellulose is present in an amount of greater than 0.4 percent by weight based on the weight of the aqueous composition and up to 1.5 percent by weight based on the weight of the aqueous composition.

10. The ply bonding adhesive composition according to any of embodiments 1 to 9, wherein the adhesive contains from 0.5% by weight to 50% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

11. The ply bonding adhesive composition according to any of 1 to 10 , wherein the adhesive contains from 1 % by weight to 30% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

12. The ply bonding adhesive composition according to any of embodiments 1 to 11, wherein the adhesive contains from 1.5 % by weight to 20% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

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13. The ply bonding adhesive composition according to any of embodiments 1 to 10, comprising polyvinyl alcohol in an amount of from 1.5% to 10% by weight based on the weight of the adhesive composition; and from 1% to 50% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

14. The ply bonding adhesive composition according to embodiment 13, wherein the adhesive comprises from 90-98.5% by weight of the composition water, from to 1.5% to 6% by weight of the composition polyvinyl alcohol and from 1% to 30% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

15. The ply bonding adhesive composition according to embodiment 14, wherein the adhesive comprises from 94-98.5% by weight of the composition water, from to 1.5% to 6% by weight of the composition polyvinyl alcohol and from 1% to 30% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

16. A multi-ply absorbent sheet comprising:

(a) a first absorbent ply of cellulosic sheet;

(b) a second absorbent ply of cellulosic sheet; and

(c) a ply bonding adhesive interposed between said first absorbent ply and said second absorbent ply, said ply-bonding adhesive adhering said absorbent plies together,

wherein said first absorbent ply of cellulosic sheet and said second absorbent ply of absorbent sheet are adhered together utilizing the ply-bonding adhesive composition of any of embodiments 1 through 15. embodiment

17. The multi-ply absorbent sheet according to 16, wherein the multi-ply sheet comprises a third absorbent ply of cellulosic sheet plied together with the first and second ply.

18. The multiply absorbent sheet according to embodiment 17, consisting of three plies laminated together, wherein the ply bonding adhesive is applied only between two plies prior to lamination.

19. A method of making absorbent sheet comprising:

(a) providing a first absorbent cellulosic basesheet;

(b) applying an aqueous adhesive containing polyvinyl alcohol and nanofibrillated cellulose according to any of embodiments 1 to 15 to said first sheet; and

(c) plying a second absorbent cellulosic basesheet with said first sheet by pressing said second cellulosic sheet to the adhesive disposed on said first cellulosic sheet.

20. The method of making absorbent sheet according to embodiment 19, comprising:

(a) feeding a first absorbent cellulosic basesheet to an embossing nip;

(b) embossing a pattern of raised embossments in said first basesheet;

(c) applying the aqueous adhesive containing polyvinyl alcohol and nanofibrillated cellulose according to any of embodiments 1 to 15 to the raised embossments of said first sheet; and

(d) plying a second absorbent cellulosic basesheet with said first sheet by pressing said second cellulosic sheet to the adhesive disposed on the raised embossments of said first cellulosic sheet.

Claims

1. A ply bonding adhesive composition for the manufacture of multi-ply paper tissue and multiply paper towel comprising:

(a) water;

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(b) polyvinyl alcohol; and
(c) nanofibrillated cellulose,

wherein the adhesive comprises from 90-98.5% by weight of the composition water, from to 0.5% to 10% by weight of the composition polyvinyl alcohol and from 0.05% to 2.5% by weight of the composition nanofibrillated cellulose.

2. The ply bonding adhesive composition according to Claim 1, wherein the adhesive comprises from 90-98.5% by weight of the composition water, from to 0.5% to 10% by weight of the composition polyvinyl alcohol and from 0.25% to 2.5% by weight of the composition nanofibrillated cellulose.

3. The ply bonding adhesive composition according to any of Claims 1 or 2, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of at least 3 km.

4. The ply bonding adhesive composition according to any of Claims 1 to 3, wherein said nanofibrillated cellulose has a Characteristic Breaking Length of from 4.5 km to 9 km.

5. The ply bonding adhesive composition according to any of Claims 1 to 4, wherein said nanofibrillated cellulose exhibits a Characteristic Nanofiber Viscosity reduction of at least 80% as the shear rate is increased from 5 sec^{-1} to 500 sec^{-1}.

6. The ply bonding adhesive composition according to any of Claims 1 to 5, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.025 and up to 2.

7. The ply bonding adhesive composition according to any of Claims 1 to 6, wherein the weight ratio of nanofibrillated cellulose:PVOH is greater than 0.25 and up to 2.

8. The ply bonding adhesive composition according to any of Claims 1 to 7, wherein nanofibrillated cellulose is present in an amount of greater than 0.4 percent by weight based on the weight of the aqueous composition and up to 1.5 percent by weight based on the weight of the aqueous composition.

9. The ply bonding adhesive composition according to any of Claims 1 to 8, wherein the adhesive contains from 0.5% by weight to 50% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

10. The ply bonding adhesive composition according to any of Claims 1 to 9, wherein the adhesive contains from 1% by weight to 30% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

11. The ply bonding adhesive composition according to any of Claims 1 to 10, wherein the adhesive contains from 1.5 % by weight to 20% by weight of nanofibrillated cellulose, based on the weight of polyvinyl alcohol.

12. The ply bonding adhesive composition according to any of Claims 1 to 9, comprising polyvinyl alcohol in an amount of from 1.5% to 10% by weight based on the weight of the adhesive composition; and from 1% to 50% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

13. The ply bonding adhesive composition according to Claim 12, wherein the adhesive comprises from 90-98.5% by weight of the composition water, from to 1.5% to 6% by weight of the composition polyvinyl alcohol and from 1% to 30% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

14. The ply bonding adhesive composition according to Claim 13, wherein the adhesive comprises from 94-98.5% by weight of the composition water, from to 1.5% to 6% by weight of the composition polyvinyl alcohol and from 1% to 30% by weight of nanofibrillated cellulose based on the weight of polyvinyl alcohol in the adhesive.

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FIG. 1

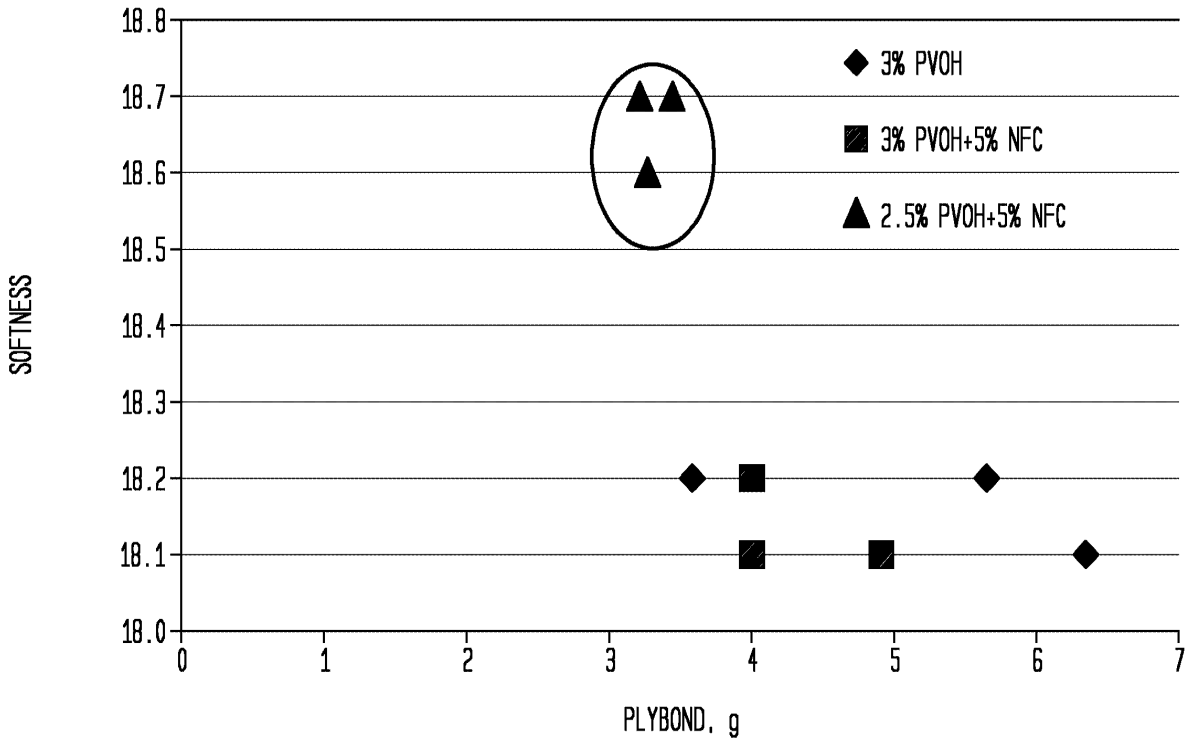

18.8
18.7
18.6
18.5
18.4
18.3
18.2
18.1
18.0
SOFTNESS
0
1
2
3
4
5
6
7
PLYBOND, g
3% PVOH
3% PVOH+5% NFC
2.5% PVOH+5% NFC

FIG. 2

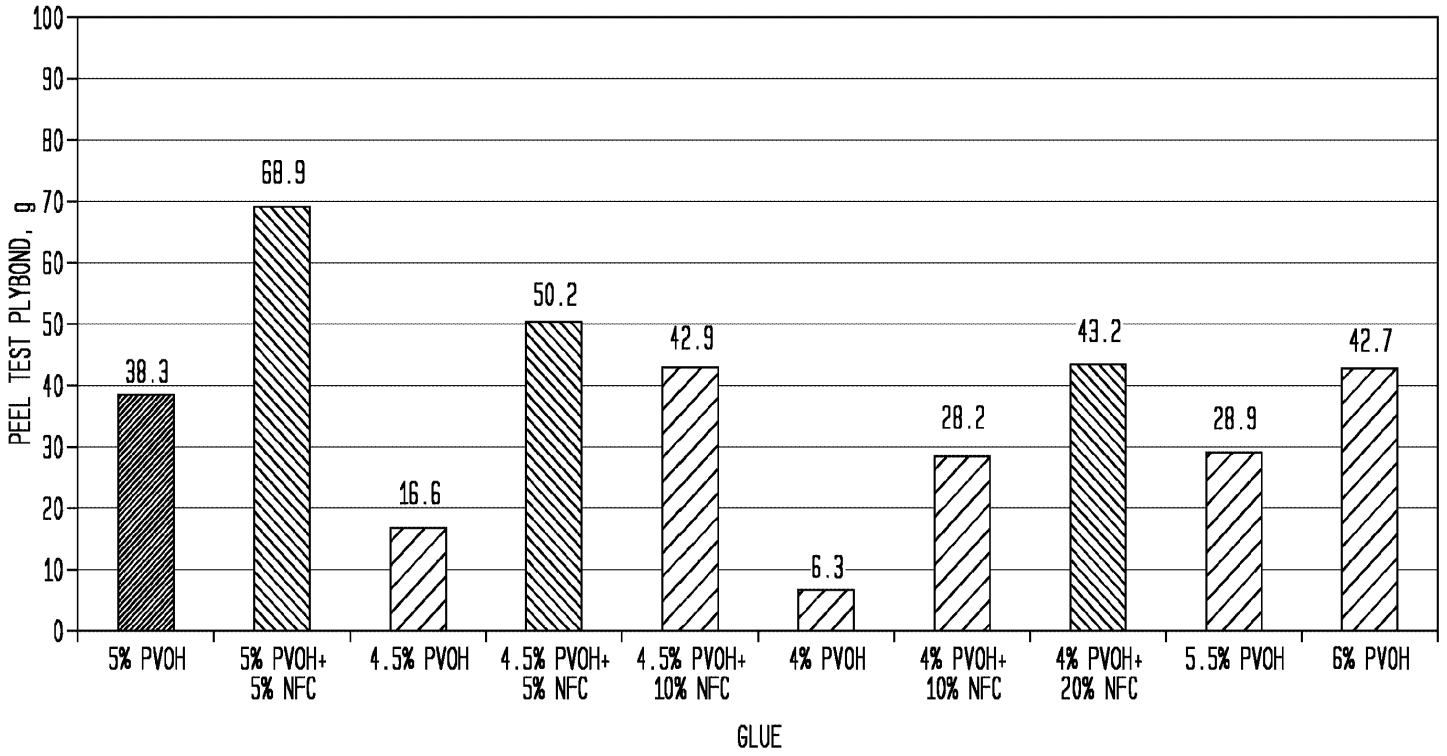
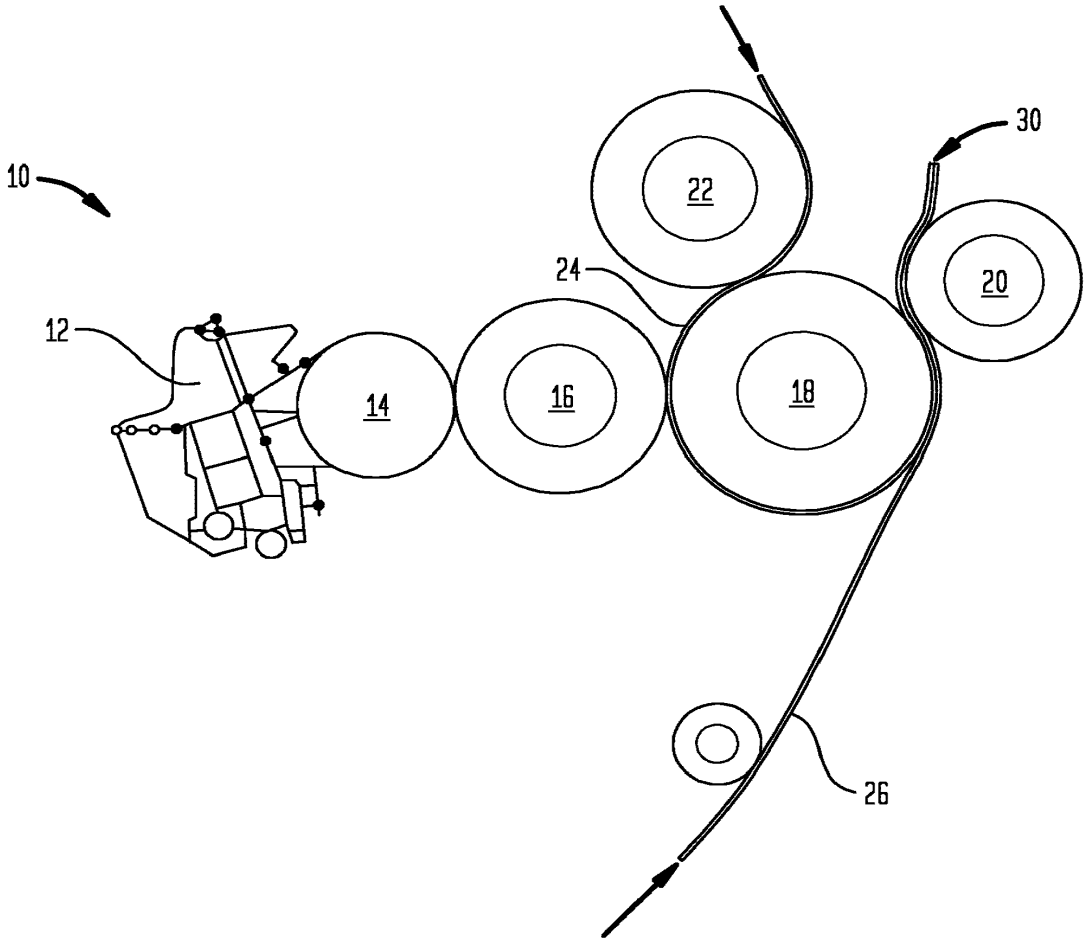
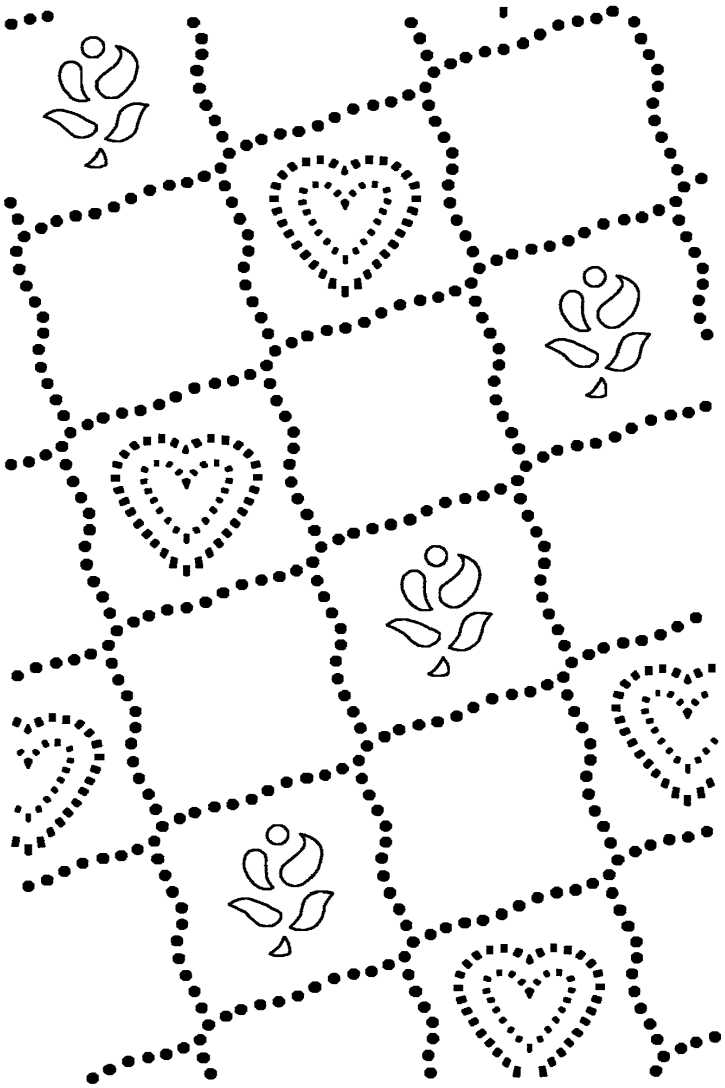

PEEL TEST PLYBOND, g
100
90
80
70
60
50
40
30
20
10
0
38.3
68.9
16.6
50.2
42.9
6.3
28.2
43.2
28.9
42.7
5% PVOH
5% PVOH+ 5% NFC
4.5% PVOH
4.5% PVOH+ 5% NFC
4.5% PVOH+ 10% NFC
4% PVOH
4% PVOH+ 10% NFC
4% PVOH+ 20% NFC
5.5% PVOH
6% PVOH
GLUE

FIG. 3



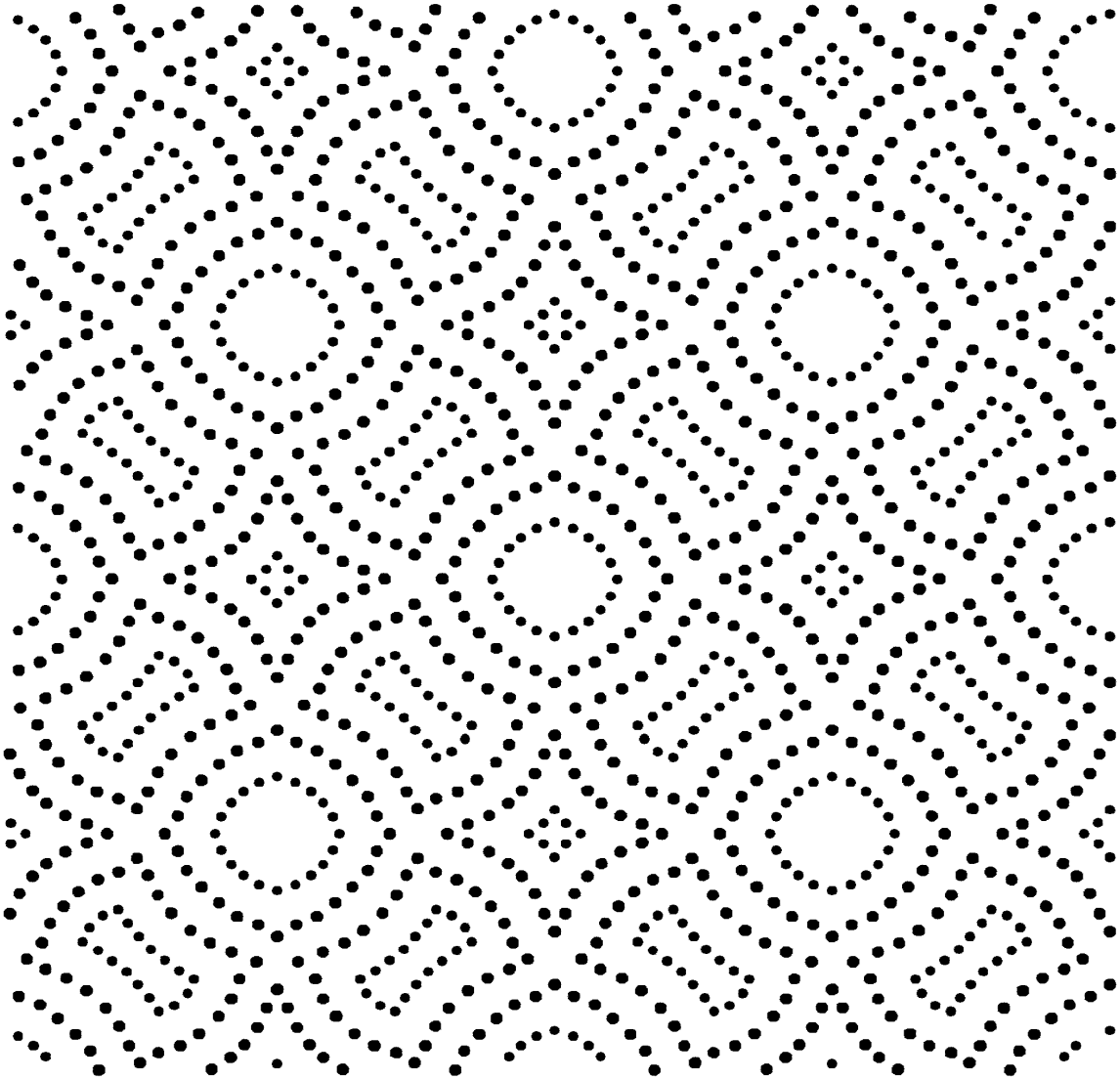
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FIG. 4



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FIG. 5



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FIG. 6

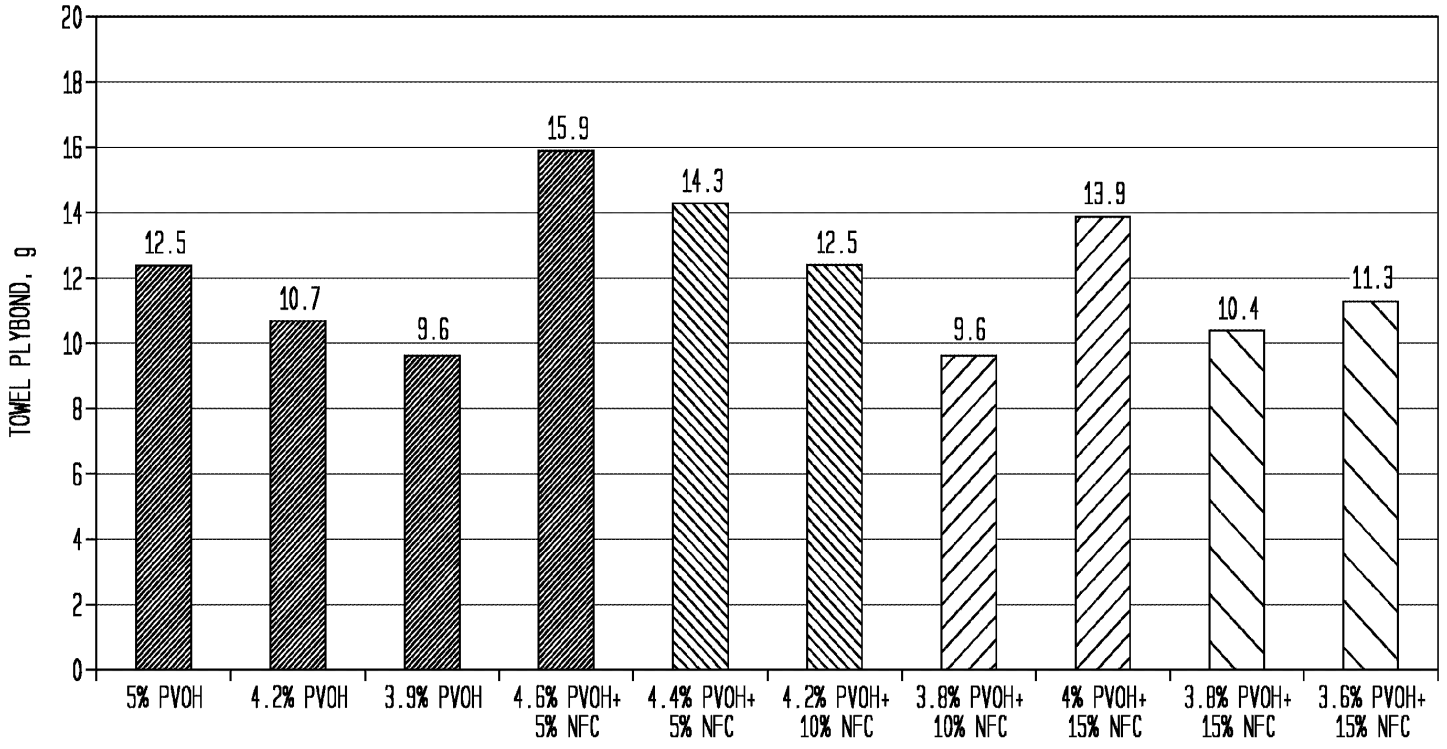
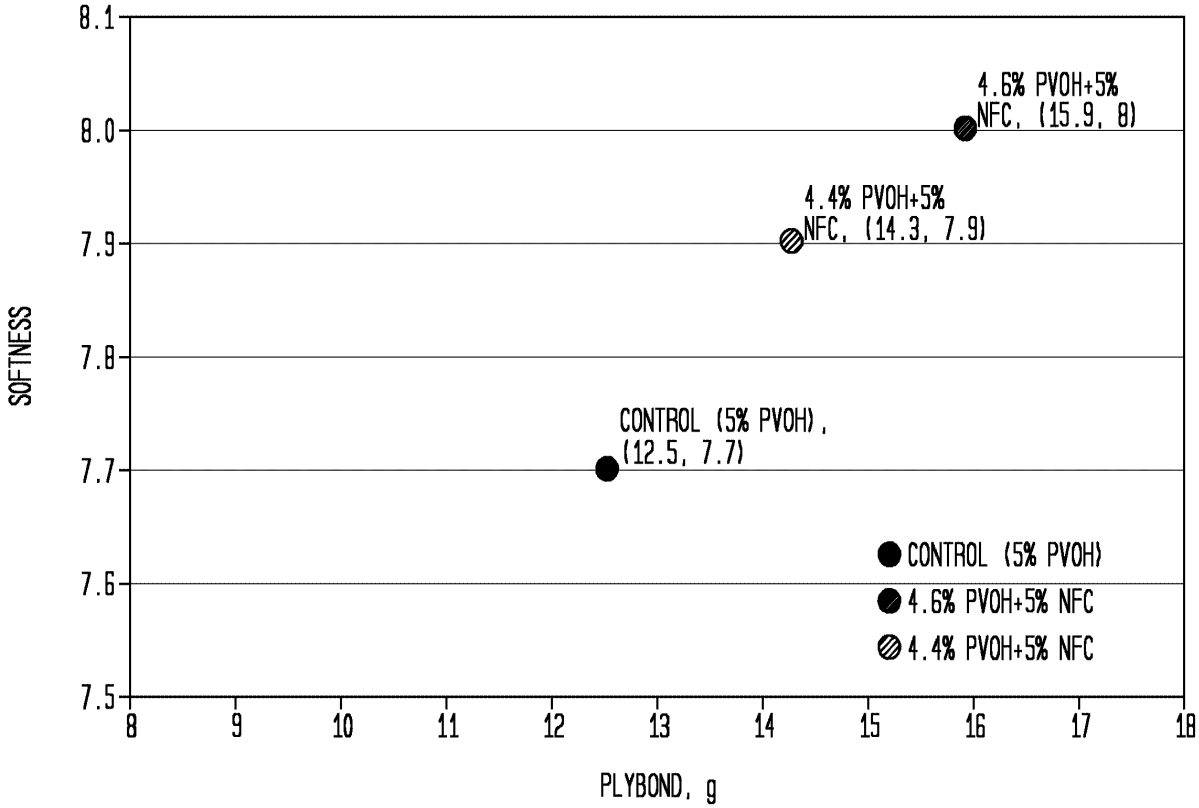

TOWEL PLYBOND, g
0
2
4
6
8
10
12
14
16
18
20
12.5
10.7
9.6
15.9
14.3
12.5
9.6
13.9
10.4
11.3
5% PVOH
4.2% PVOH
3.9% PVOH
4.6% PVOH+ 5% NFC
4.4% PVOH+ 5% NFC
4.2% PVOH+ 10% NFC
3.8% PVOH+ 10% NFC
4% PVOH+ 15% NFC
3.8% PVOH+ 15% NFC
3.6% PVOH+ 15% NFC

FIG. 7



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FIG. 8

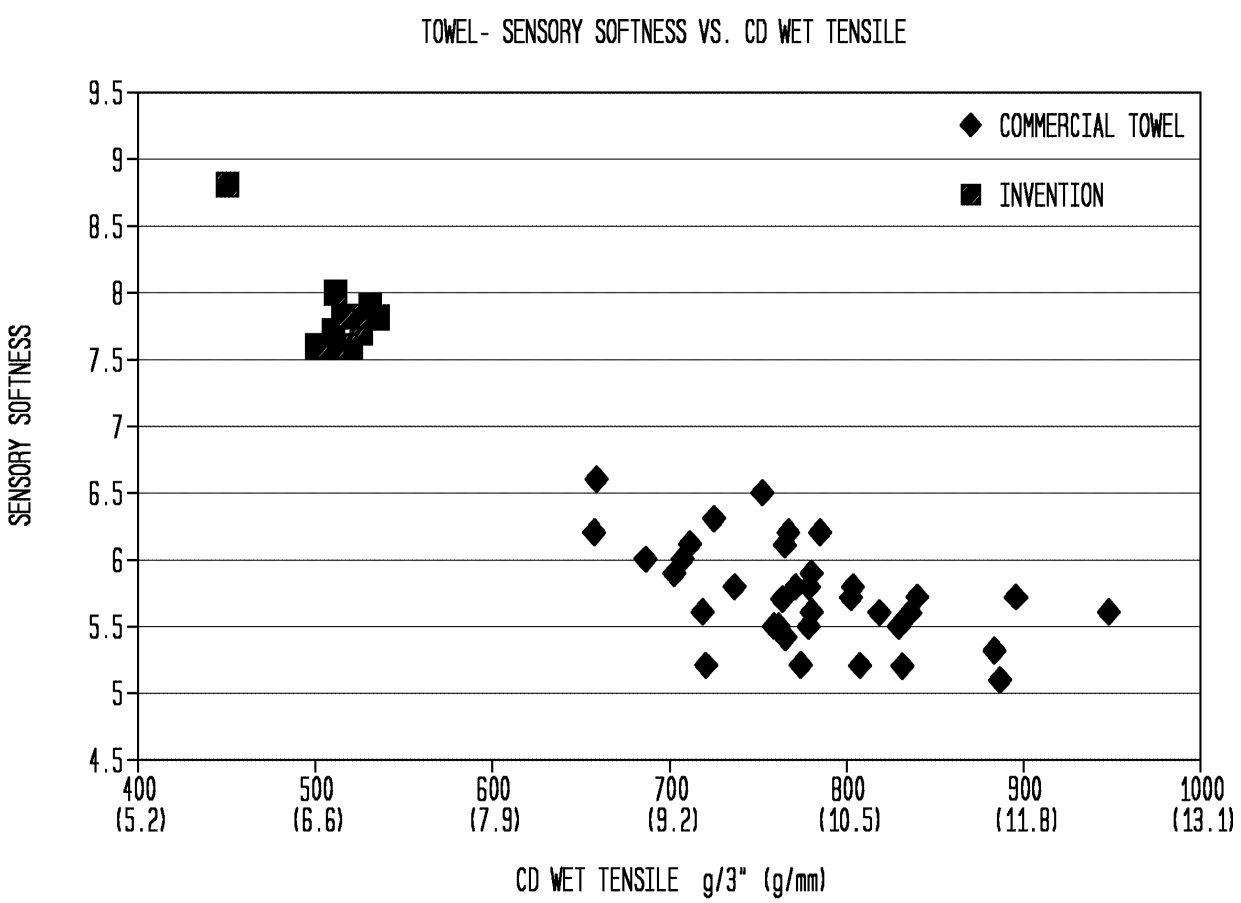

TOWEL- SENSORY SOFTNESS VS. CD WET TENSILE
SENSORY SOFTNESS
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
COMMERCIAL TOWEL
INVENTION
400 (5.2)
500 (6.6)
600 (7.9)
700 (9.2)
800 (10.5)
900 (11.8)
1000 (13.1)
CD WET TENSILE g/3" (g/mm)

FIG. 9

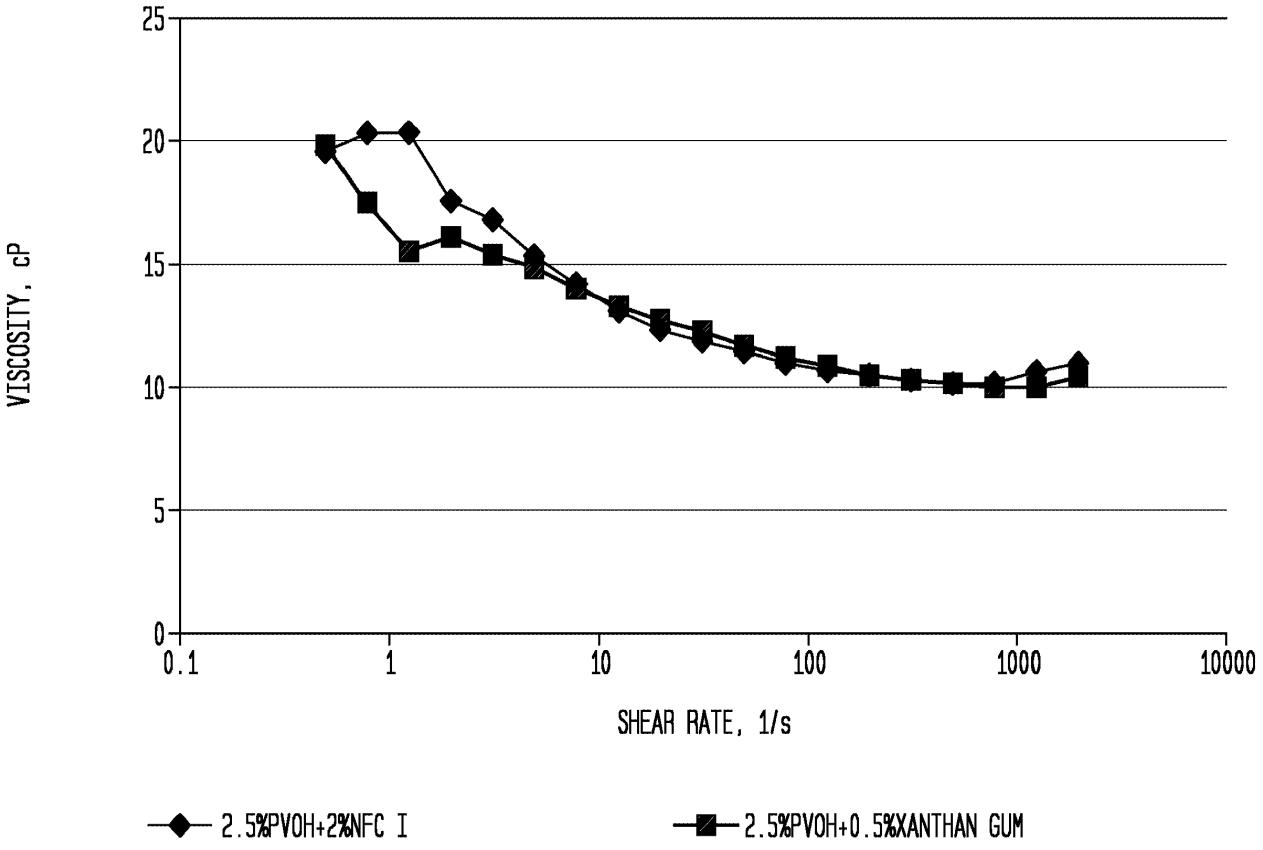
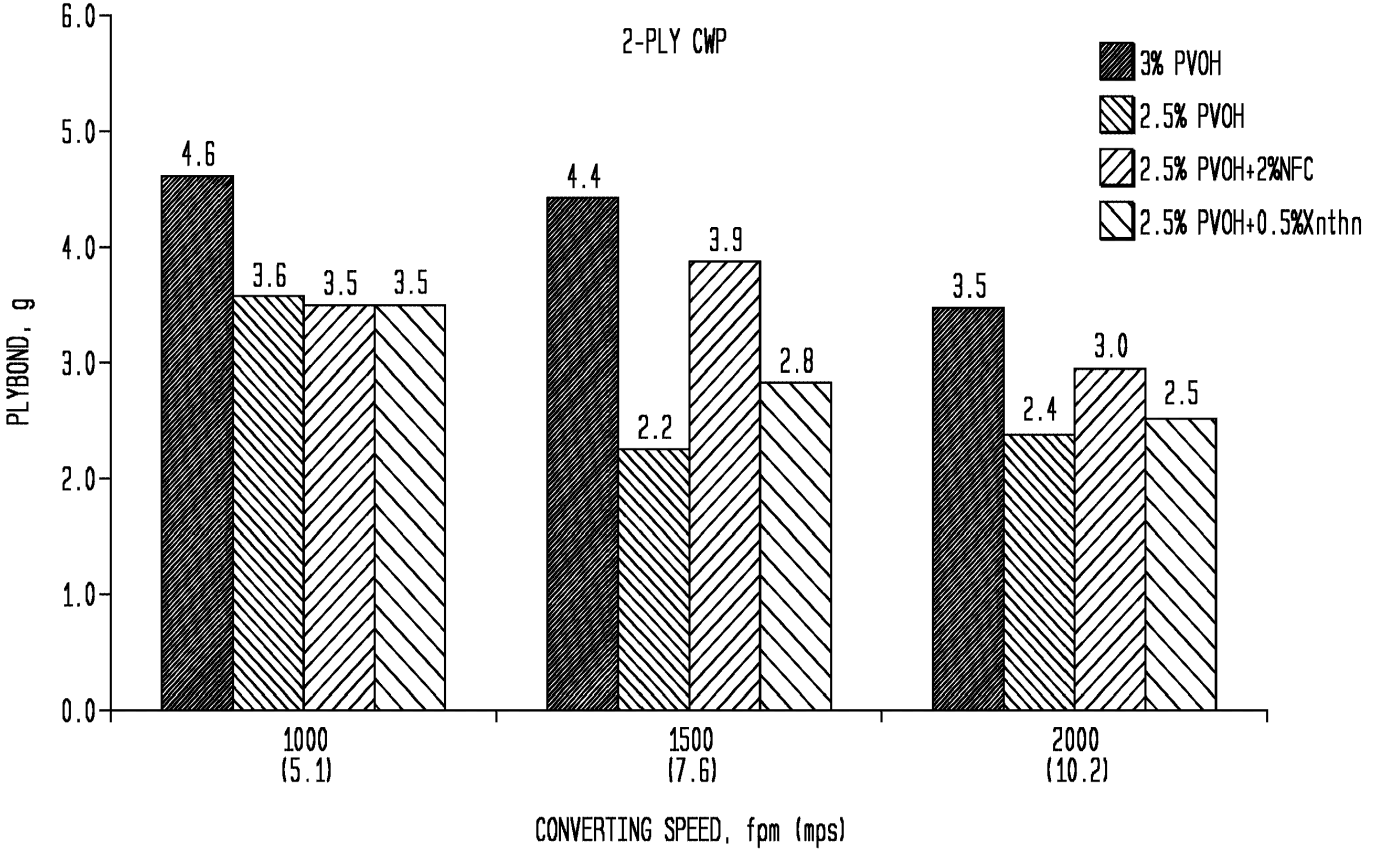
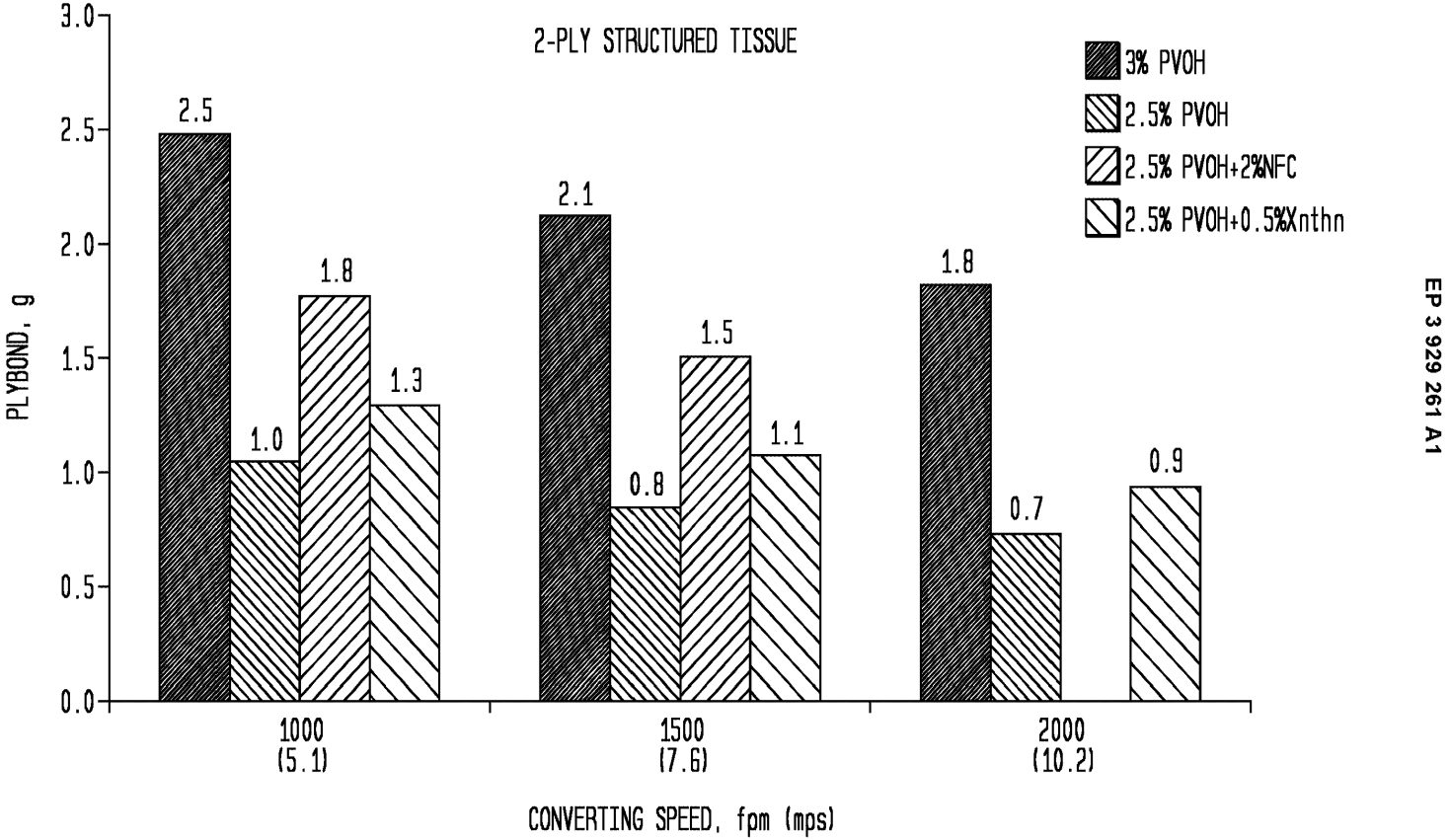

25
20
15
10
5
0
VISCOSITY, cP
0.1
1
10
100
1000
10000
SHEAR RATE, 1/s
2.5%PVOH+2%NFC I
2.5%PVOH+0.5%XANTHAN GUM

FIG. 10



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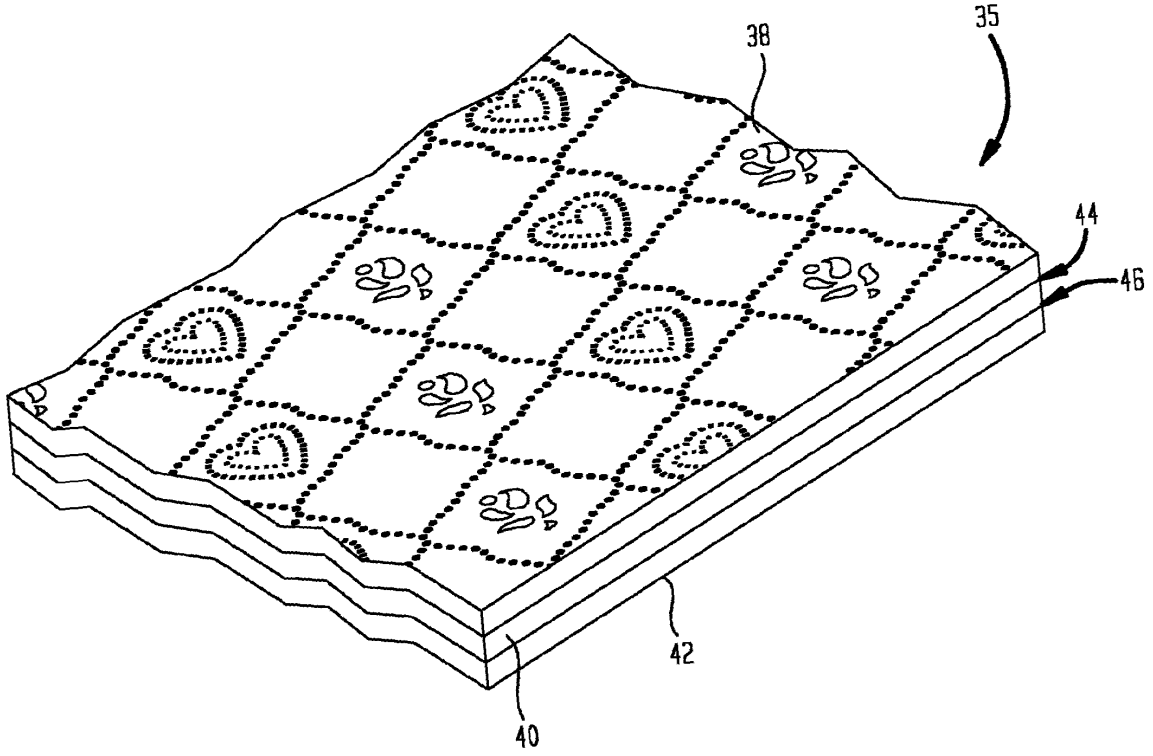
FIG. 11



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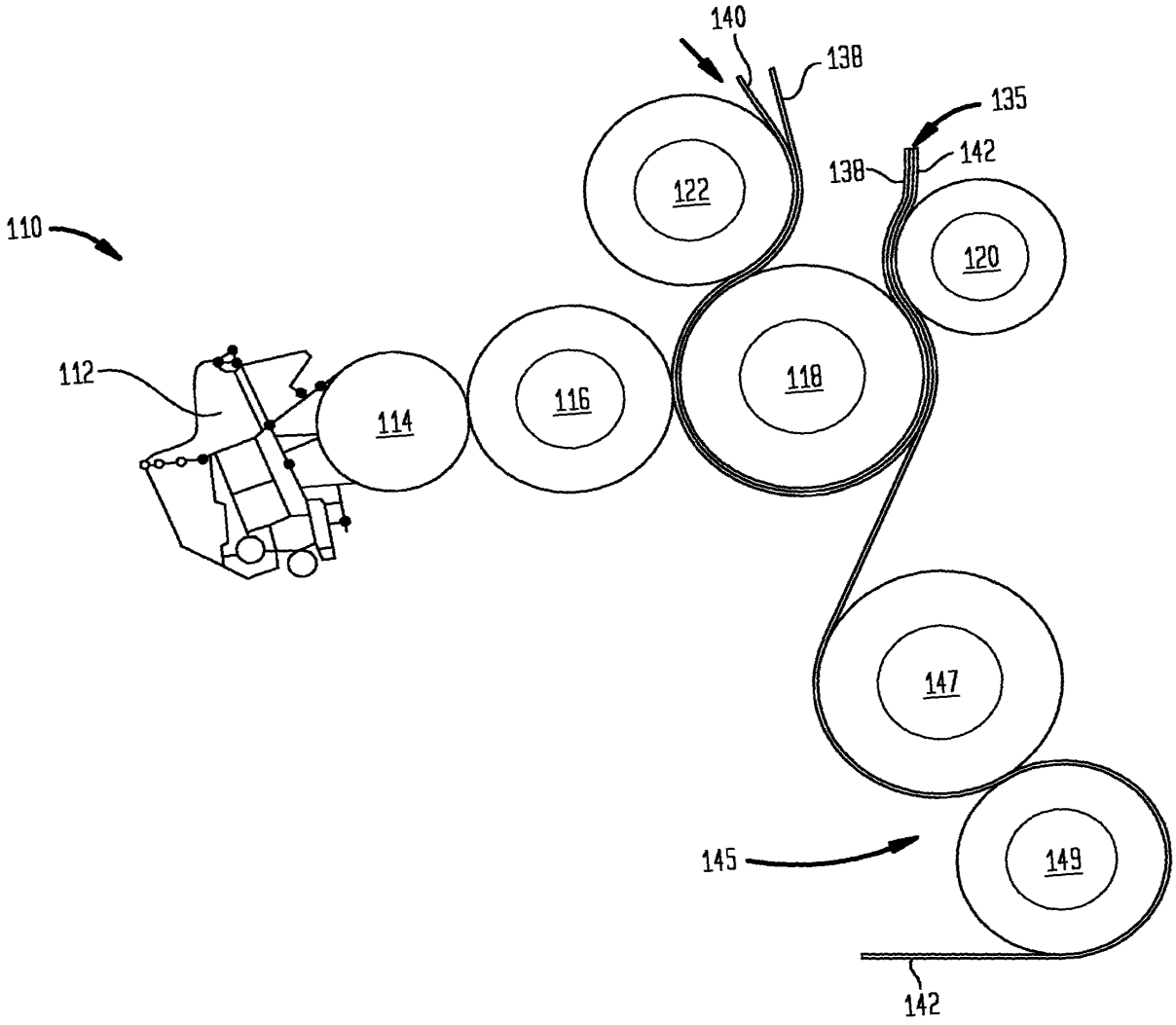
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FIG. 12A



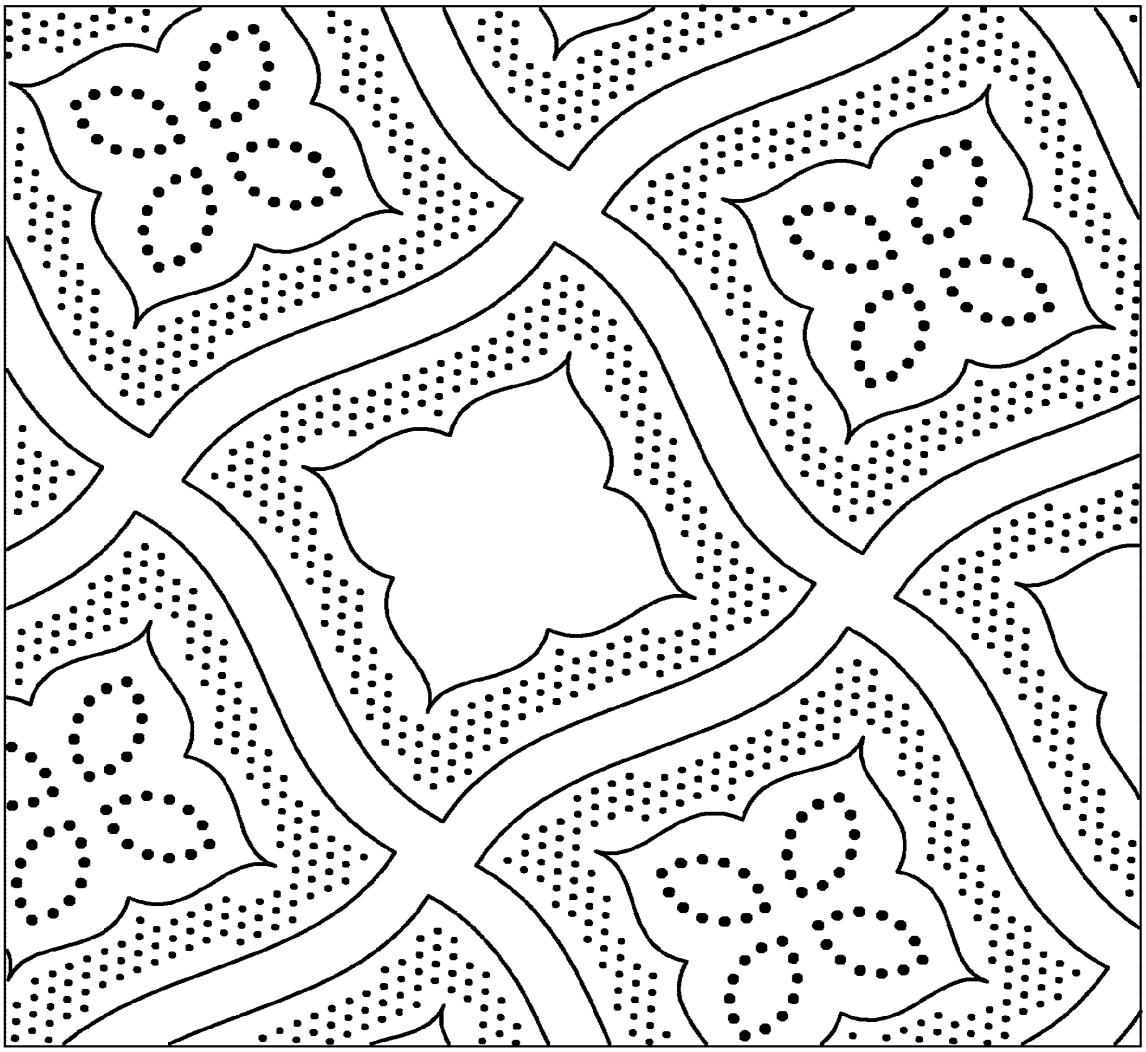
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FIG. 12B



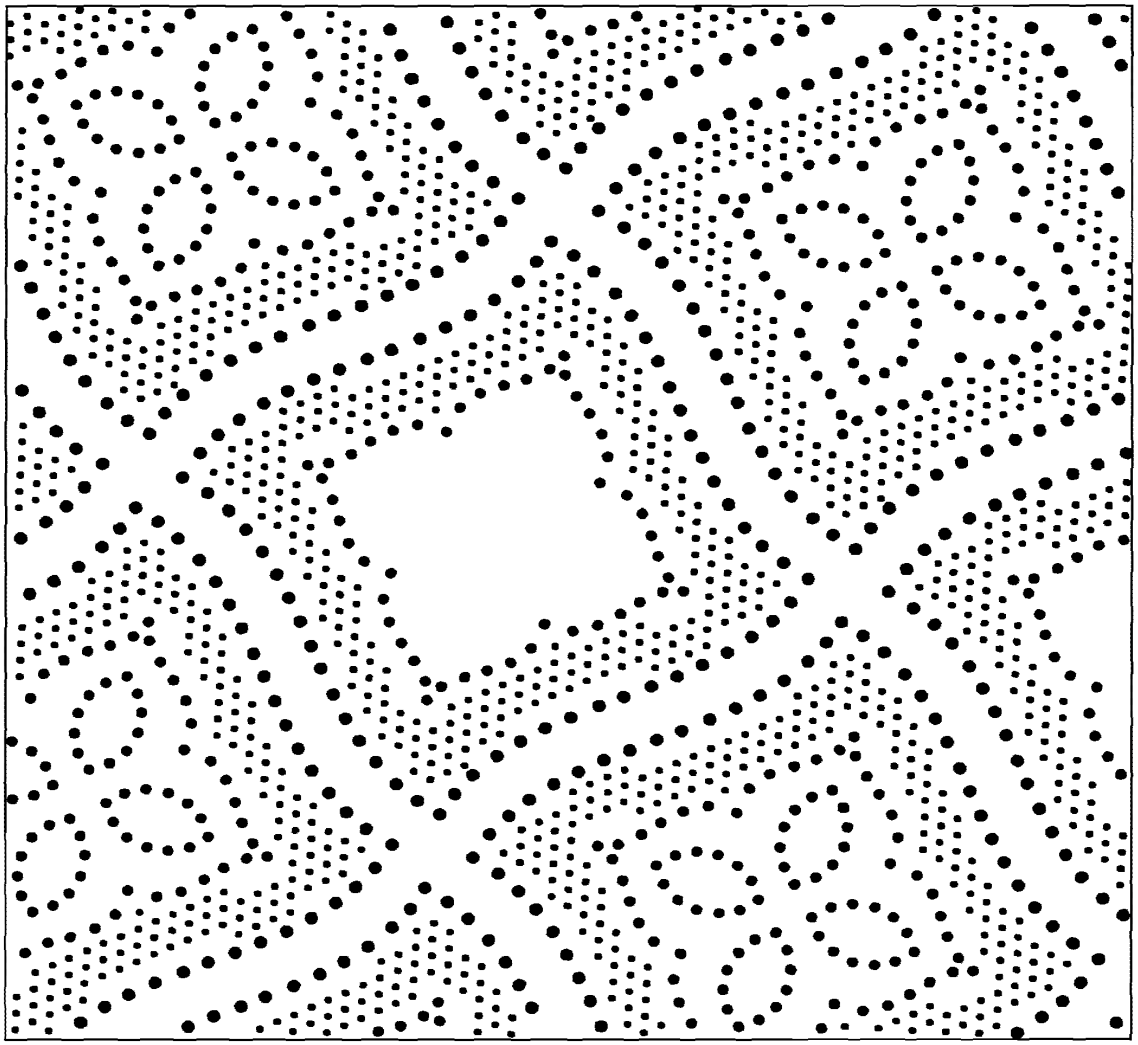
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FIG. 12C



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FIG. 12D



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FIG. 13

SCANNING ELECTRON MICROSCOPE IMAGE OF CELLULOSE NANOFIBRILS MADE FROM SOUTHERN HARDWOOD FINES. MAGNIFICATION 10,000x.

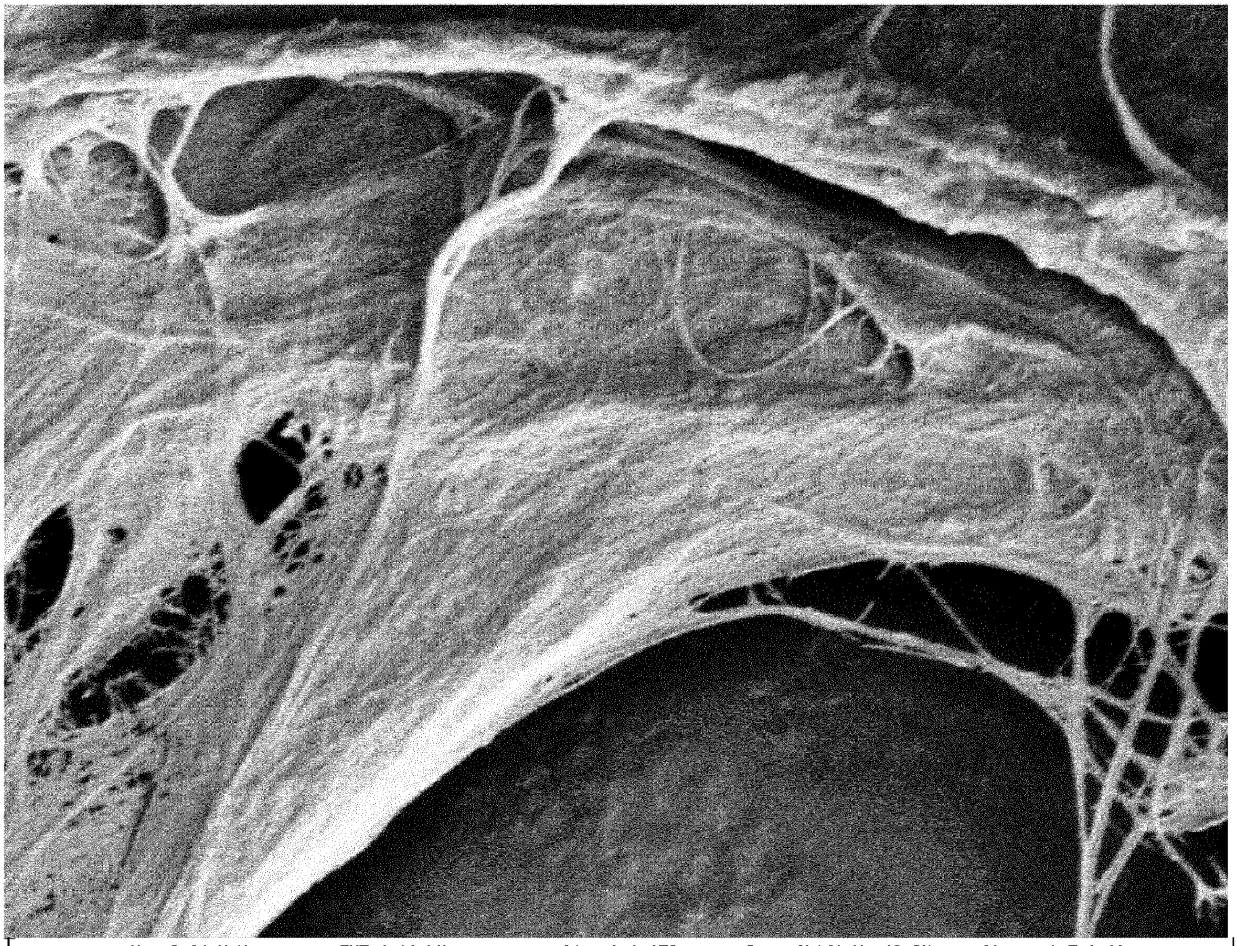


FIG. 14

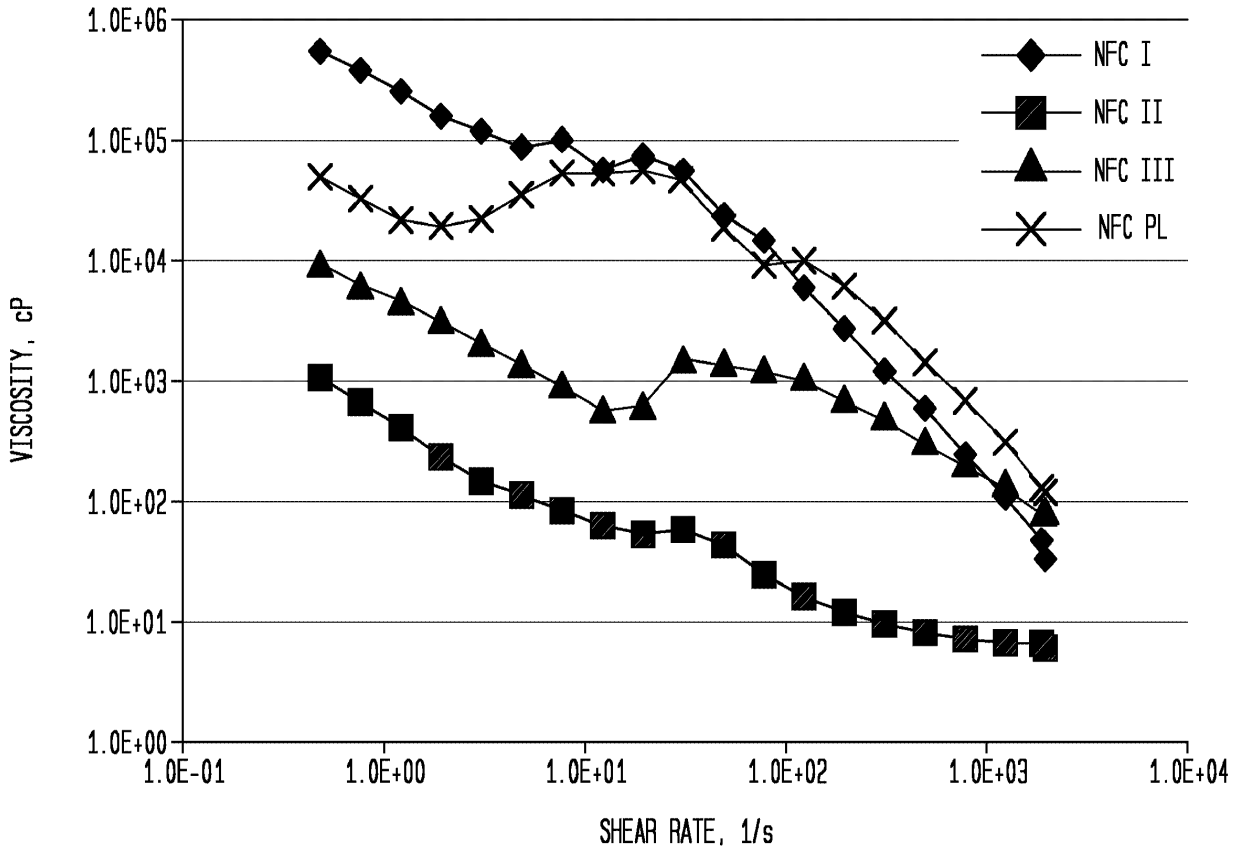

1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
1.0E+00
VISCOSITY, cP
1.0E-01
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
SHEAR RATE, 1/s
NFC I
NFC II
NFC III
NFC PL

FIG. 15

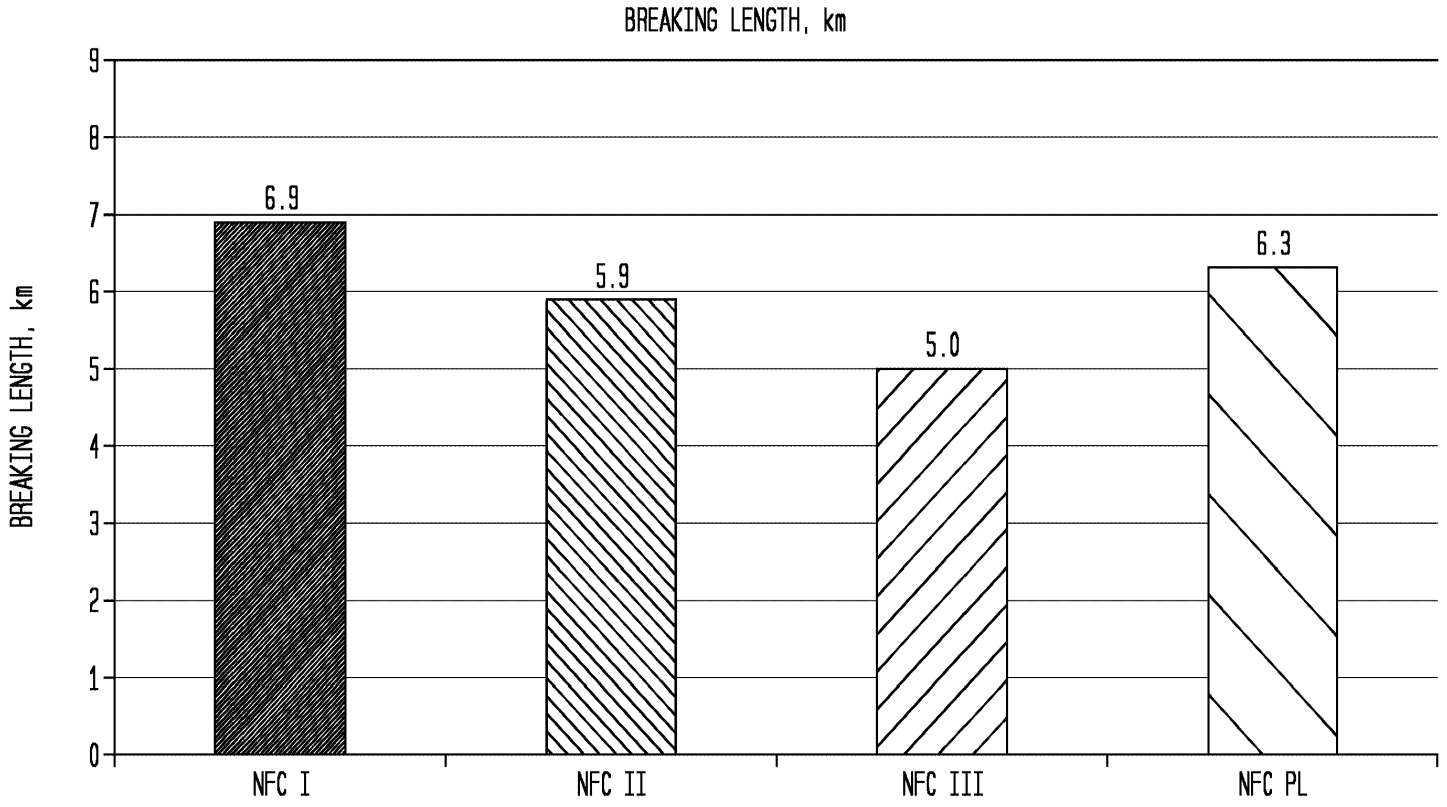

BREAKING LENGTH, km
BREAKING LENGTH, km
0
1
2
3
4
5
6
7
8
9
6.9
5.9
5.0
6.3
NFC I
NFC II
NFC III
NFC PL

FIG. 16

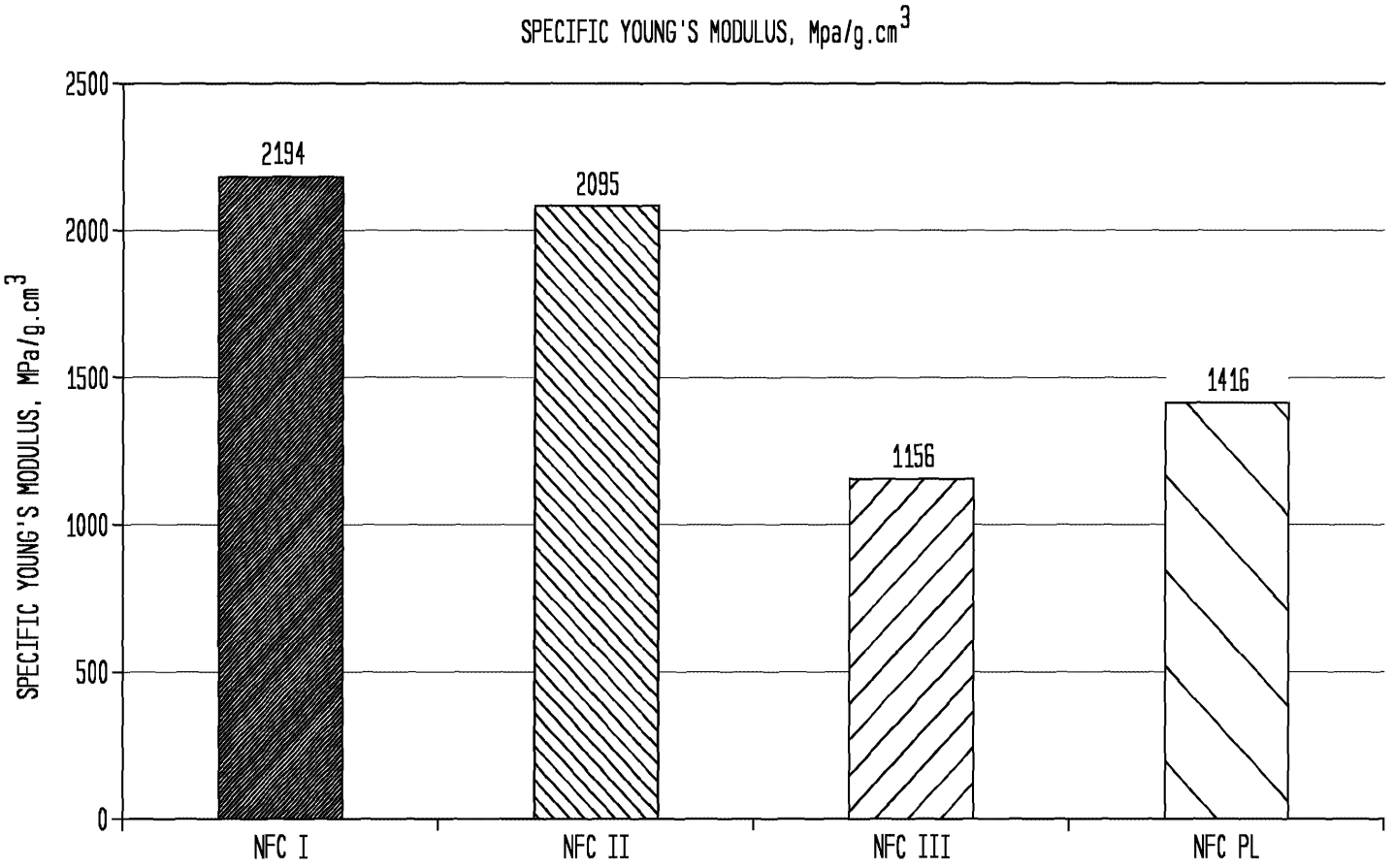

SPECIFIC YOUNG'S MODULUS, Mpa/g.cm3
SPECIFIC YOUNG'S MODULUS, MPa/g.cm3
2500
2000
1500
1000
500
0
2194
2095
1156
1416
NFC I
NFC II
NFC III
NFC PL

FIG. 17

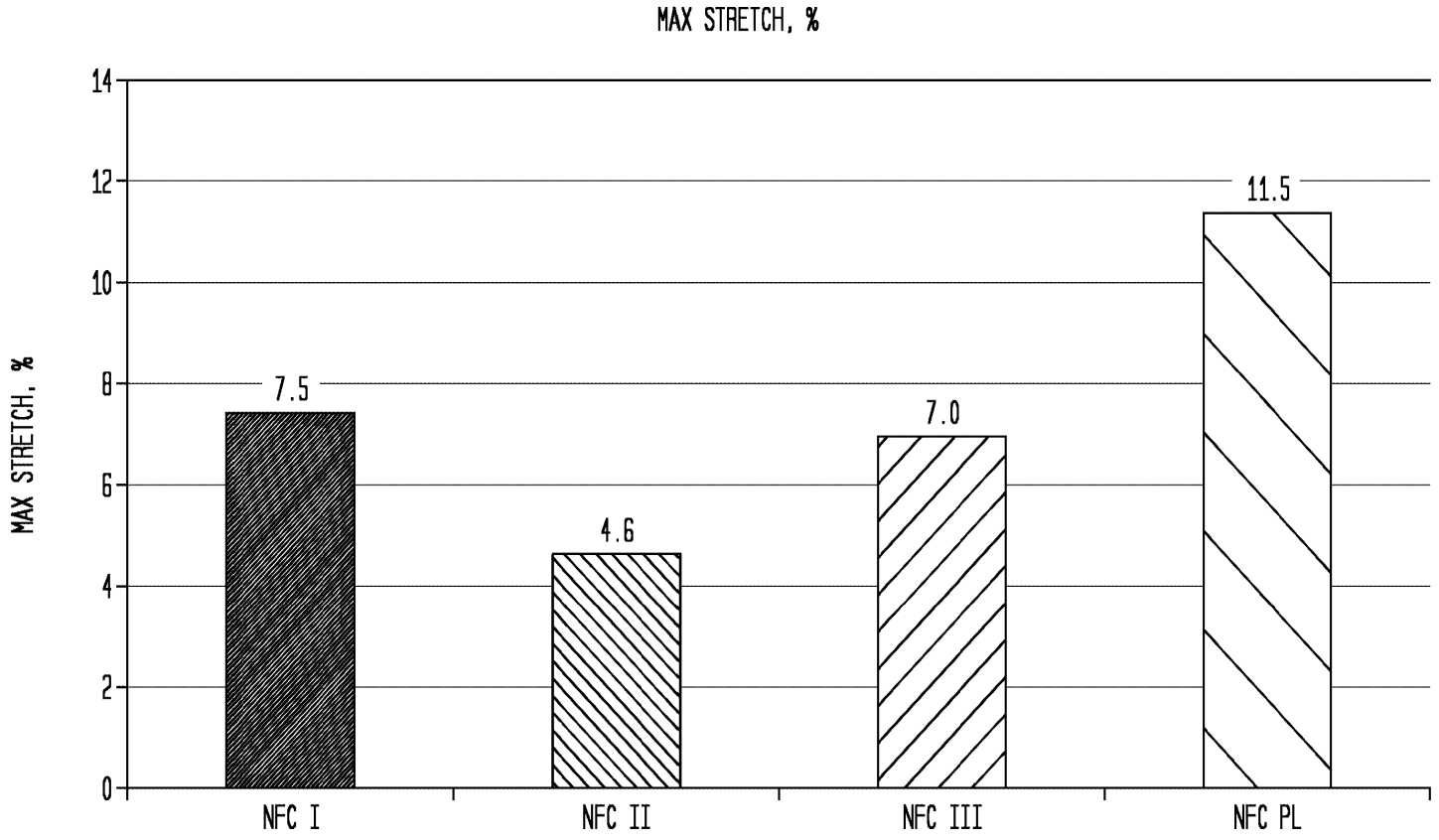

MAX STRETCH, %
MAX STRETCH, %
14
12
10
8
6
4
2
0
7.5
4.6
7.0
11.5
NFC I
NFC II
NFC III
NFC PL

FIG. 18

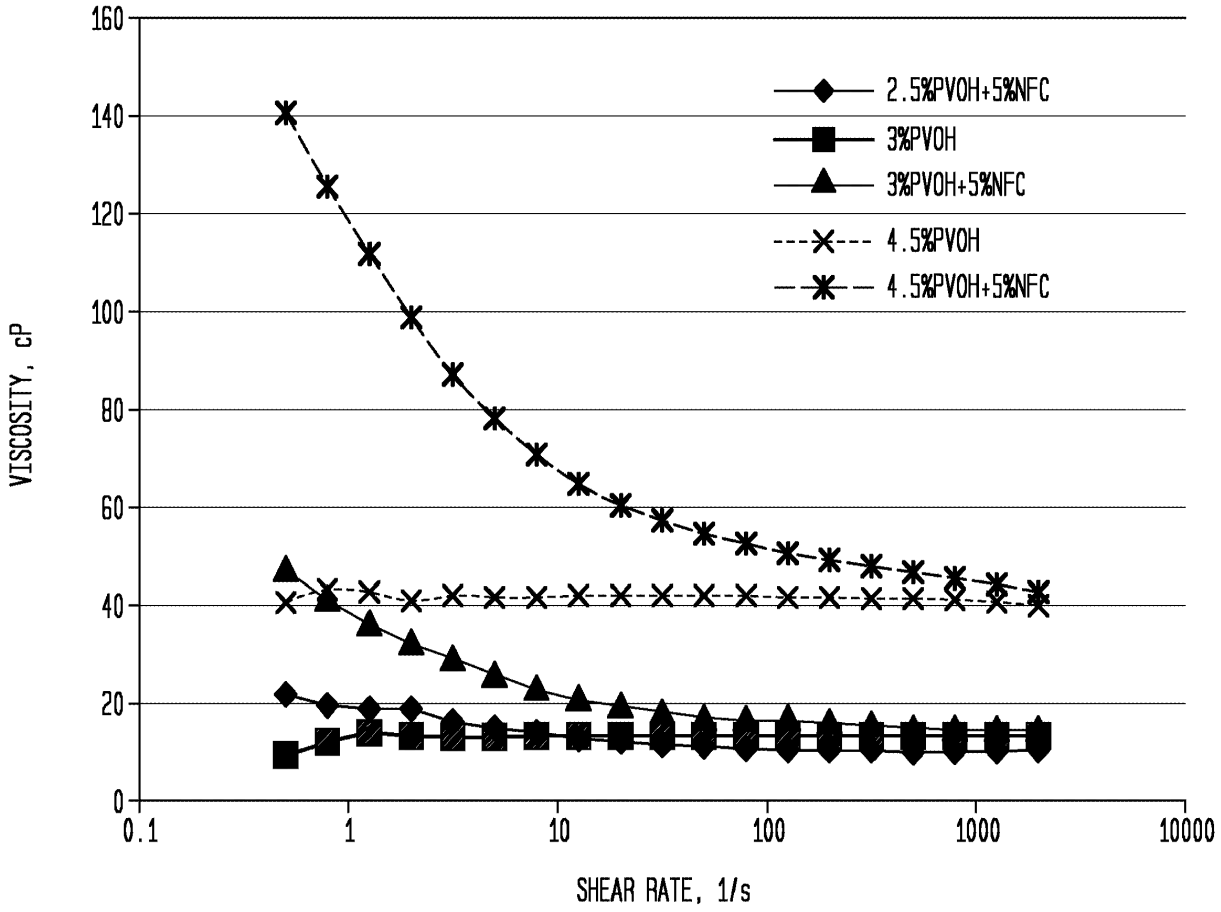

160
140
120
100
80
60
40
20
0
VISCOSITY, cP
0.1
1
10
100
1000
10000
SHEAR RATE, 1/s
2.5%PVOH+5%NFC
3%PVOH
3%PVOH+5%NFC
4.5%PVOH
4.5%PVOH+5%NFC

FIG. 19

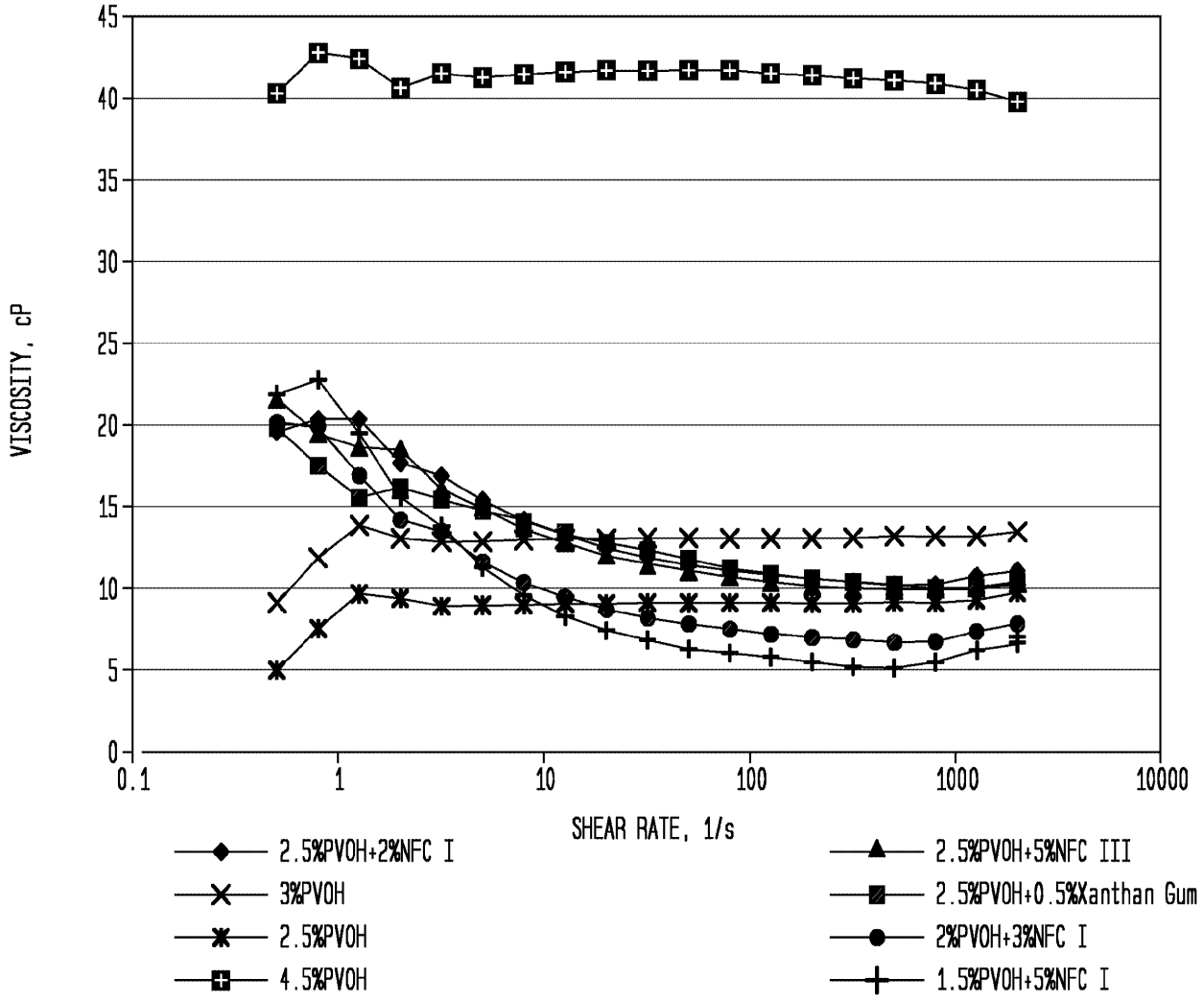

VISCOSITY, cP
45
40
35
30
25
20
15
10
5
0
0.1
1
10
100
1000
10000
SHEAR RATE, 1/s
2.5%PVOH+2%NFC I
3%PVOH
2.5%PVOH
4.5%PVOH
2.5%PVOH+5%NFC III
2.5%PVOH+0.5%Xanthan Gum
2%PVOH+3%NFC I
1.5%PVOH+5%NFC I

FIG. 20

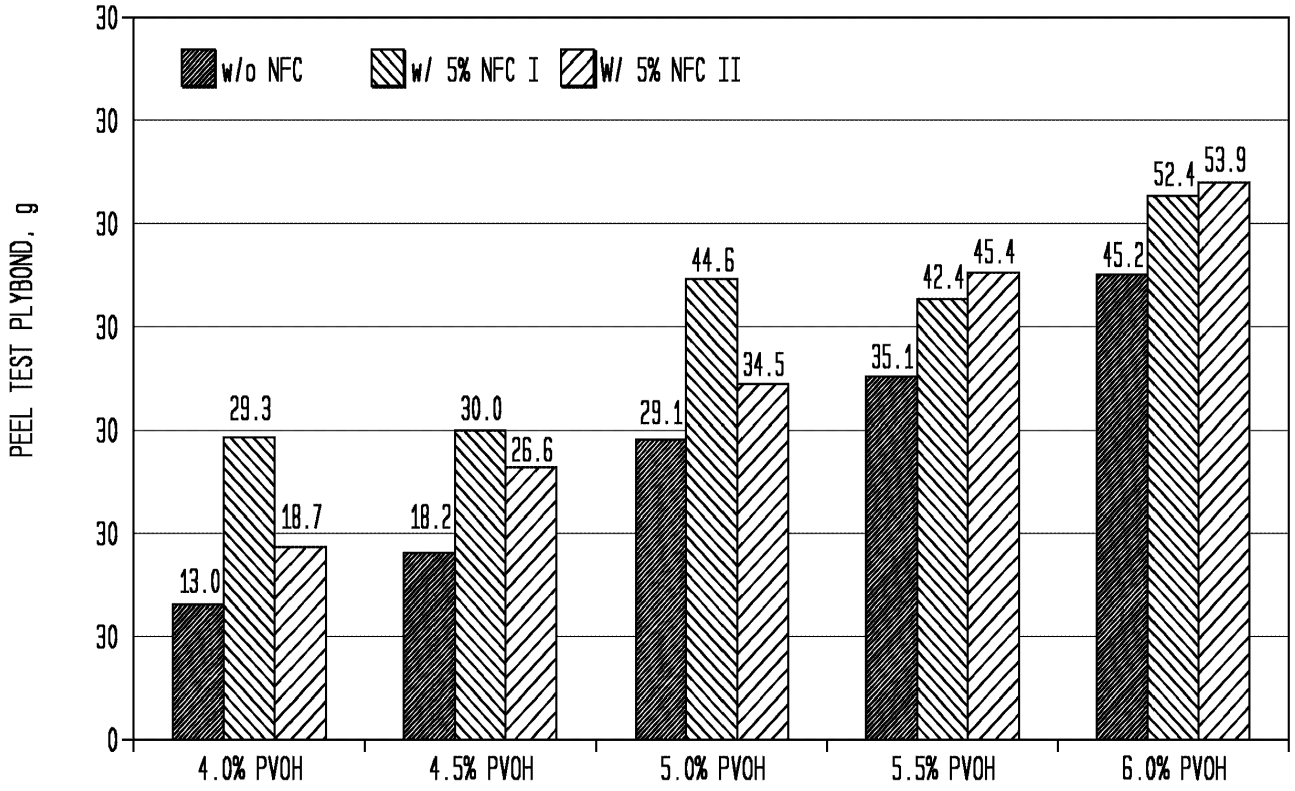
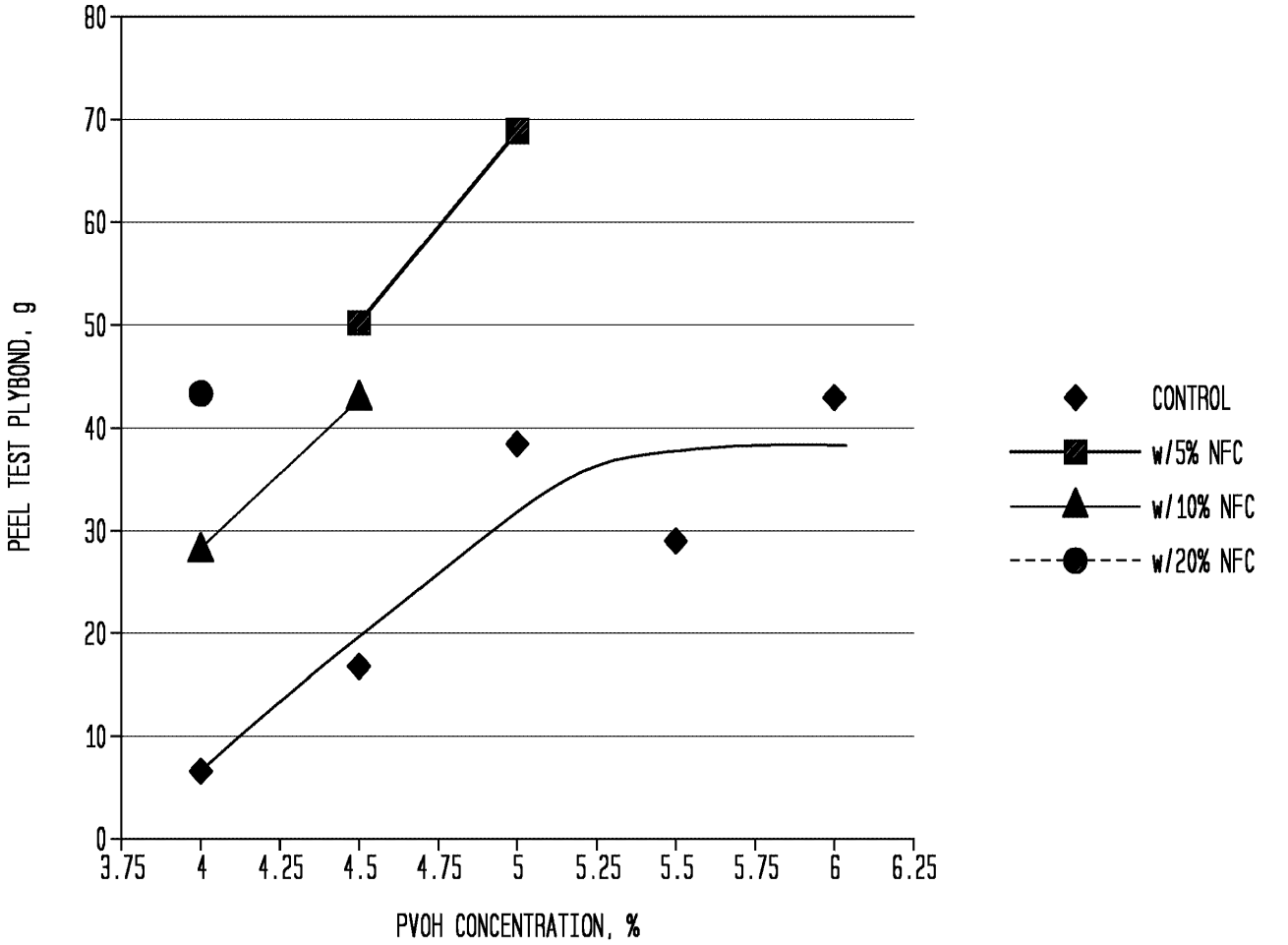

w/o NFC
w/ 5% NFC I
W/ 5% NFC II
PEEL TEST PLYBOND, g
30
30
30
30
30
30
0
13.0
29.3
18.7
18.2
30.0
26.6
29.1
44.6
34.5
35.1
42.4
45.4
45.2
52.4
53.9
4.0% PVOH
4.5% PVOH
5.0% PVOH
5.5% PVOH
6.0% PVOH

FIG. 21



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FIG. 22

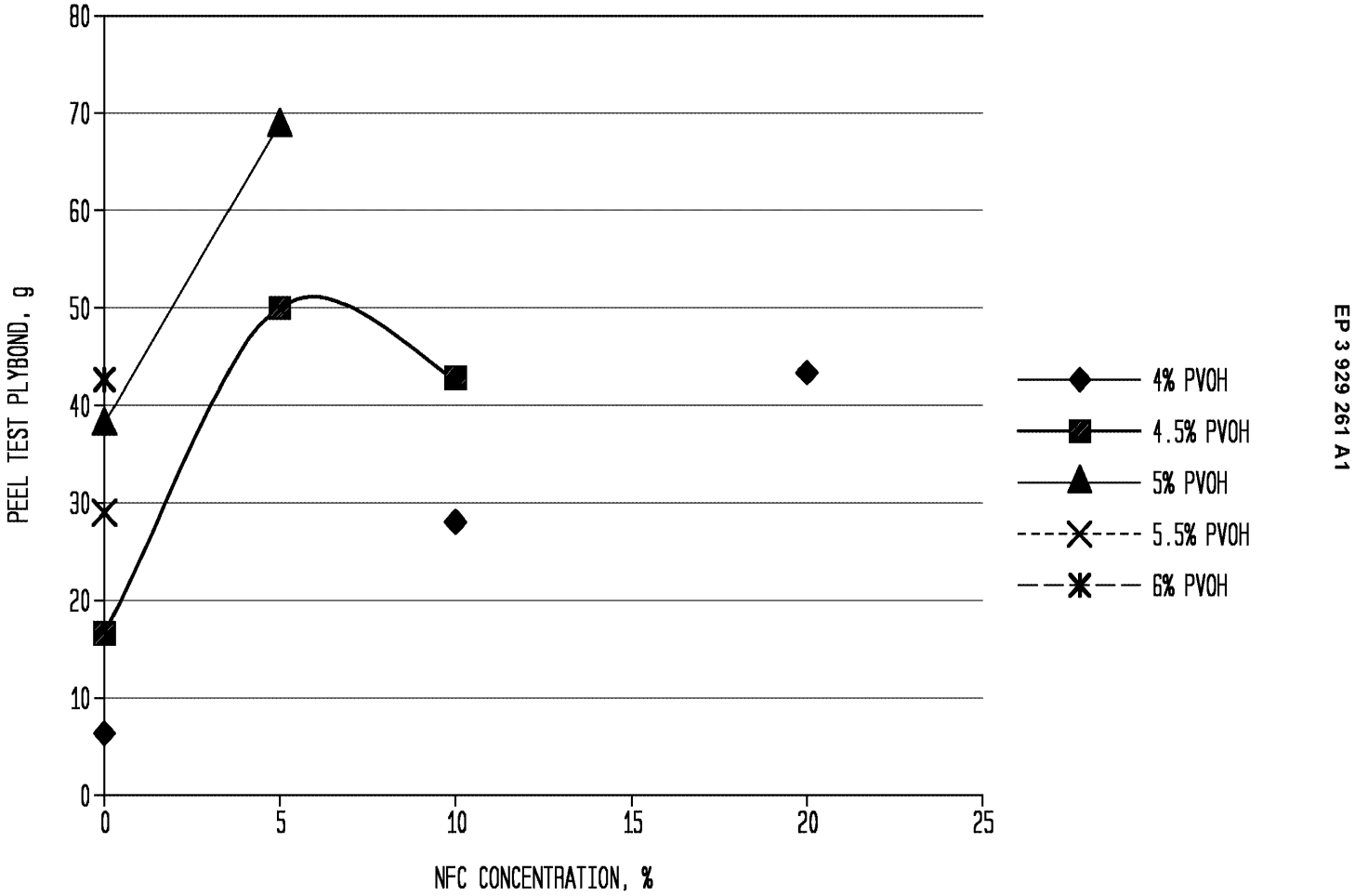
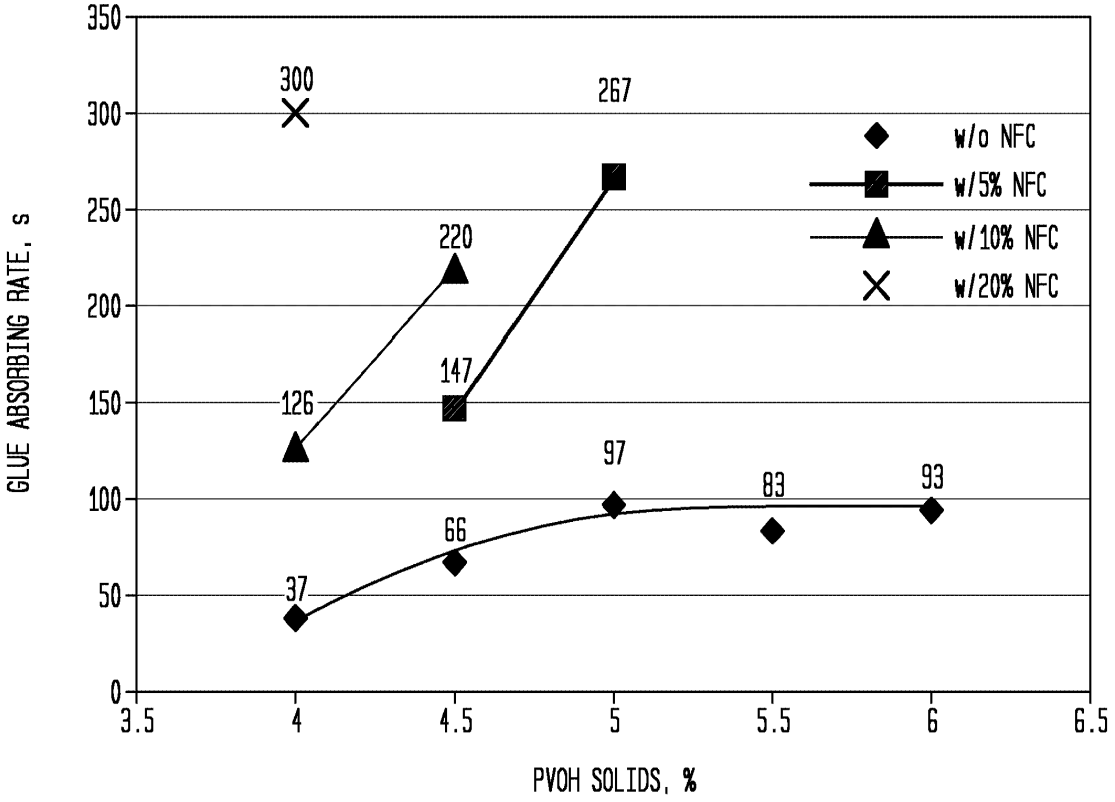

80
70
60
50
40
30
20
10
0
PEEL TEST PLYBOND, g
0
5
10
15
20
25
NFC CONCENTRATION, %
4% PVOH
4.5% PVOH
5% PVOH
5.5% PVOH
6% PVOH

FIG. 23


GLUE ABSORBING RATE, s
PVOH SOLIDS, %
w/o NFC
w/5% NFC
w/10% NFC
w/20% NFC
300
267
220
147
126
97
83
93
66
37
350
300
250
200
150
100
50
0
3.5
4
4.5
5
5.5
6
6.5

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 19 1818

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 97/08387 A1 (PROCTER & GAMBLE [US]) 6 March 1997 (1997-03-06) * page 2, paragraph 1-4 * -----	1-14	INV. C09J129/04 C09J11/08 B32B29/00
A	WO 97/11226 A1 (PROCTER & GAMBLE [US]) 27 March 1997 (1997-03-27) * page 2, line 24 - page 3, column 8 * -----	1-14	B31F5/04 D21H27/32
X	JONJANKIAT SUNAN ET AL: "Improvement of poly (vinyl alcohol) adhesives with cellulose microfibre from sugarcane bagasse", IRANIAN POLYMER JOURNAL, IRAN POLYMER AND PETROCHEMICAL INSTITUTE, IR, vol. 20, no. 4, 1 January 2011 (2011-01-01), pages 305-317, XP009506501, ISSN: 1026-1265 * the whole document * -----	1-5,9-11	
X	DATABASE CA [Online] CHEMICAL ABSTRACTS SERVICE, COLUMBUS, OHIO, US; BERTOLLA, L. ET AL: "Preparation and characterization of Bioglass-based scaffolds reinforced by poly-vinyl alcohol/microfibrillated cellulose composite coating", XP002782684, retrieved from STN Database accession no. 2014:723664 * abstract * -/--	1-5,9-11	TECHNICAL FIELDS SEARCHED (IPC) D21H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	23 November 2021	Parry, Julian

CATEGORY OF CITED DOCUMENTS

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Y : particularly relevant if combined with another document of the same category
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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EUROPEAN SEARCH REPORT

Application Number
EP 21 19 1818

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
	-& BERTOLLA, L. ET AL: "Preparation and characterization of Bioglass-based scaffolds reinforced by poly-vinyl alcohol/microfibrillated cellulose composite coating", JOURNAL OF THE EUROPEAN CERAMIC SOCIETY , 34(14), 3379-3387 CODEN: JECSER; ISSN: 0955-2219, 2014, XP009506511, DOI: 10.1016/J.JEURCERAMSOC.2014.04.003 -----		

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	23 November 2021	Parry, Julian

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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EPO FORM 1503 03.82 (P04C01)

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 19 1818

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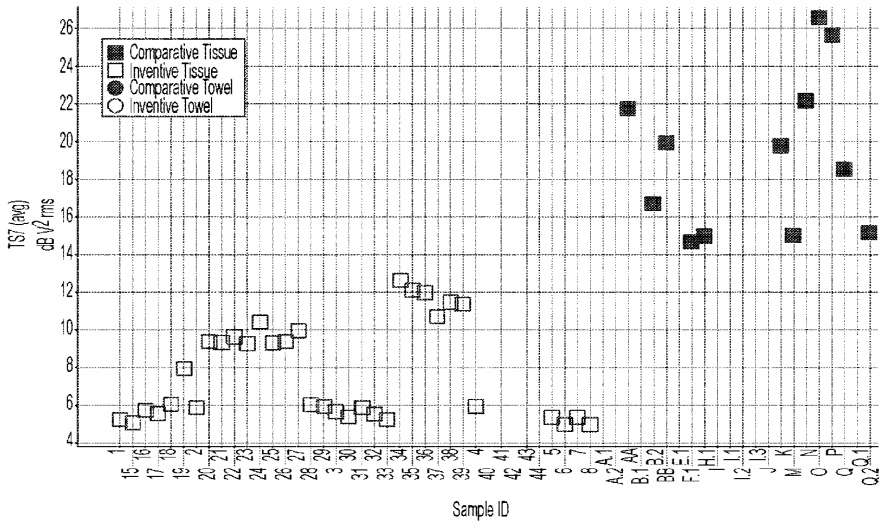


FIG. 1A

(57) Abstract: Sanitary tissue products of the present disclosure may comprise non-wood fibers selected from the group consisting of bamboo, abaca, and mixtures thereof, and may have a TS7 of less than about 14 dB V^2 rms. Sanitary tissue products of the present disclosure may comprise bamboo fibers and may have a TS750 less than about 20 dB V^2 rms. Sanitary tissue products of the present disclosure may be structured and may comprise non-wood fibers selected from the group consisting of bamboo, abaca, and mixtures thereof, and may have a TS750 less than about 45 dB V^2 rms. Sanitary tissue products of the present disclosure may comprise non-wood fibers selected from the group consisting of bamboo, abaca, and mixtures thereof, and may have a slip stick less than about 435. Sanitary tissue products of the present disclosure may comprise non-wood fibers selected from the group consisting of bamboo, abaca, and mixtures thereof, and may have a slip stick less than about 605.

[Continued on next page]

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SOFT SANITARY TISSUE PRODUCTS COMPRISING NON-WOOD FIBERS

FIELD

The present disclosure generally relates to fibrous structures and, more particularly, to fibrous structures comprising non-wood fibers, including sanitary tissue products comprising non-wood fibers.

BACKGROUND

Of particular interest is the softness of sanitary tissue products. But, this is where so many sustainable sanitary tissue products comprising non-woods fail. The art does not disclose how to achieve soft fibrous structures comprising bamboo, abaca, or other sustainable non-wood fibers; incorporation of non-woods into sanitary tissue products is a real challenge, even for experienced papermakers. This becomes truer as non-wood fiber inclusion increases. The inventors of the present disclosure have, however, found that adding coarse bamboo fibers (bamboo is especially coarse versus eucalyptus) into the fibrous structure, even at high inclusion levels, and/or even disposed at a consumer-facing side of a sheet, can result in sanitary tissue products with good softness, even with premium softness. There are a number of ways the inventors have accomplished this, including creation of differential densities, utilizing unique layering, and/or fiber mixes, as well as other ways disclosed herein.

The inventors of the present disclosure have found that they are able to deliver soft sustainable fibrous structures that also have low lint values. Typically, higher lint values accompany greater softness values (e.g., TS7, TS750). Beyond the difficulties of processing fibrous structures that are linty, lint can cause unwanted debris at the point of use, which can be messy and can be aesthetically undesirable. Thus, it is a real benefit to achieve greater softness while maintaining lower lint values. The inventors of the present disclosure have not only improved sustainable fibrous structures, but have improved the general offering of fibrous structures beyond what is otherwise available today, even versus what is available on the shelf today as high-tier offerings consisting only of wood fibers.

Related to softness, another consumer-desired characteristic is surface smoothness/glide. Slip-stick is a good metric for quantifying how much "glide" a substrate has. Low slip-stick values in a fibrous structure are consumer preferred. Typical design levers for improving the slip stick of a substrate include calendaring and/or to replace coarser softwood fibers with shorter, thinner, and lower coarseness hardwood fibers, such as eucalyptus. Conventionally, eucalyptus is used to balance softwood incorporation, such as NSK, which provides strength characteristics. However,

upon experimentation, the inventors of the present disclosure have shown that the introduction of coarse, non-wood fibers such as bamboo (even at high inclusion amounts) can still create low slip stick substrates while still maintaining acceptable strength characteristics.

So, despite the shortcomings of so many manufacturers and the poorly performing non-wood products that they market, which are not soft and/or have higher lint values, the inventive sustainable offerings as disclosed herein may be used to offer the public the soft and/or low lint sanitary tissue products they desire. And, the inventive sanitary tissue products disclosed herein may, in many instances, be considered high-tier due to the properties (including improved TS7, TS750, slip stick, etc.) the inventors of the present disclosure have achieved.

SUMMARY

In a first aspect of the present disclosure, a sanitary tissue product may comprise non-wood fibers selected from the group consisting of bamboo, abaca, and mixtures thereof, and may have a TS7 of less than about 14 dB V^2 rms.

In a second aspect of the present disclosure, a sanitary tissue product may comprise bamboo fibers and may have a TS750 less than about 20 dB V^2 rms.

In a third aspect of the present disclosure, a sanitary tissue product may be structured and may comprise non-wood fibers selected from the group consisting of bamboo, abaca, and mixtures thereof, and may have a TS750 less than about 45 dB V^2 rms.

In a fourth aspect of the present disclosure, a sanitary tissue product may comprise non-wood fibers selected from the group consisting of bamboo, abaca, and mixtures thereof, and may have a slip stick less than about 435.

In a fifth aspect of the present disclosure, a sanitary tissue product may comprise non-wood fibers selected from the group consisting of bamboo, abaca, and mixtures thereof, and may have a slip stick less than about 605.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of this disclosure, and the manner of attaining them, will become more apparent and the disclosure itself will be better understood by reference to the following description of non-limiting examples of the disclosure taken in conjunction with the accompanying drawings, wherein:

FIG. 1A is a TS7 (y-axis) graph illustrating inventive and comparative non-wood tissue (bath) samples of Table 3.

FIG. 1B is a graph illustrating slip stick (y-axis) and dry caliper (x-axis) values of inventive and comparative non-wood tissue (bath) samples of Table 3.

FIG. 1C is a graph illustrating TS7 (y-axis) and lint (x-axis) values of inventive and comparative non-wood tissue (bath) samples of Table 3.

FIG. 1D is a graph illustrating TS7 (y-axis) and total dry tensile (x-axis) values of inventive and comparative non-wood tissue (bath) samples of Table 3.

FIG. 1E is a graph illustrating TS7 (y-axis) and TS750 (x-axis) values of inventive and comparative non-wood tissue (bath) samples of Table 3.

FIG. 2A is a TS7 (y-axis) graph illustrating inventive and comparative non-wood (paper) towel samples of Table 3a.

FIG. 2B is a graph illustrating TS7 (y-axis) and total dry tensile (x-axis) values of inventive and comparative non-wood (paper) towel samples of Table 3a.

FIG. 2C is a graph illustrating CD modulus (y-axis) and total dry tensile (x-axis) values of inventive and comparative non-wood (paper) towel and tissue (bath) samples of Tables 3 and 3a.

FIG. 2D is a graph illustrating MD modulus (y-axis) and total dry tensile (x-axis) values of inventive and comparative non-wood (paper) towel and tissue (bath) samples of Tables 3 and 3a.

FIG. 2E is a graph illustrating geometric mean (GM) dry modulus (y-axis) and total dry tensile (x-axis) values of inventive and comparative non-wood (paper) towel and tissue (bath) samples of Tables 3 and 3a.

FIG. 2F is a graph illustrating TS7 (y-axis) and wet burst strength (x-axis) values of inventive and comparative non-wood (paper) towel and tissue (bath) samples of Table 3 and 3a.

FIG. 2G is a graph illustrating TS7 (y-axis) and total wet tensile (x-axis) values of inventive and comparative non-wood (paper) towel samples of Table 3a.

FIG. 2H is a graph illustrating TS7 (y-axis) and Wet Bust Strength/Total Dry Tensile (x-axis) values of inventive and comparative non-wood (paper) towel and tissue (bath) samples of Tables 3 and 3a.

FIG. 3A is a photograph of a portion of a fibrous structure, particularly a paper towel, comprising non-wood fiber(s) and comprising knuckles and pillows.

FIG. 3B is a photograph of a portion of a fibrous structure, particularly a WSO bath tissue, comprising non-wood fiber(s) and comprising knuckles and pillows.

FIG. 3C is a photograph of a portion of a fibrous structure, particularly a FSO bath tissue, comprising non-wood fiber(s) and comprising knuckles and pillows.

FIG. 4A is a representative cross-section view of a sanitary tissue product comprising knuckles and pillows and made according to a typical TAD process such as the one illustrated in FIG. 6A. In FIG. 4A, each ply 53 is fabric side out (FSO).

FIG. 4B is a representative cross-section view of a sanitary tissue product made according to an UCTAD process such as the one illustrated in FIGS. 6B and 6C – this sanitary tissue product does not have distinct knuckle and pillow regions or zones.

FIG. 4C is a representative cross-section view of a sanitary tissue product comprising knuckles and pillows and made according to a typical TAD process such as the one illustrated in FIG. 6A. In FIG. 4C, ply 53 is wire side out (WSO) and ply 53' is FSO.

FIG. 4D is a representative cross-section view of a sanitary tissue product made according to an UCTAD process such as the one illustrated in FIGS. 6B and 6C– this sanitary tissue product does not have distinct knuckle and pillow regions or zones.

FIG. 4E is a representative cross-section view of a sanitary tissue product made according to an UCTAD process such as the one illustrated in FIGS. 6B and 6C– this sanitary tissue product does not have distinct knuckle and pillow regions or zones.

FIG. 4F is a representative cross-section view of a sanitary tissue product comprising knuckles and pillows and made according to a typical TAD process such as the one illustrated in FIG. 6A.

FIG. 4G is a cross-section view of a sanitary tissue product made according to an UCTAD process such as the one illustrated in FIGS. 6B and 6C – this sanitary tissue product does not have distinct knuckle and pillow regions or zones.

FIG. 4H is a representative cross-section view of a sanitary tissue product made according to a conventional wet press process – this sanitary tissue product does not have distinct knuckle and pillow regions or zones.

FIG. 4I is a representative cross-section view of a sanitary tissue product made according to a conventional wet press process – this sanitary tissue product does not have distinct knuckle and pillow regions or zones.

FIG. 5 is a plan view of a portion of a mask pattern used to make the papermaking belt that produced the fibrous structure of FIG. 3A.

FIG. 6A is a schematic representation of one method for making the new fibrous structures detailed herein. Specific details of the process and equipment represented by FIG. 6A can be found in U.S. Patent Nos. 5,714,041; 9,217,226; 9,435,081; 9,631,323; 9,752,281;10,240,296; and U.S. Publication Nos. 2013-0048239; 2022-0010497.

FIG. 6B is a schematic representation of one method for making the new fibrous structures detailed herein. Specific details of the process and equipment represented by FIG. 6B can be found in U.S. Patent No. 7,972,474.

FIG. 6C is a schematic representation of one method for making the new fibrous structures detailed herein.

FIG. 7 is a perspective view of a test stand for measuring roll compressibility properties as detailed herein.

FIG. 8 is perspective view of the testing device used in the roll firmness measurement detailed herein.

FIG. 9 is a diagram of an SST Test Method set up as detailed herein.

FIG. 10 is a schematic illustrating the Position of Gocator camera to a testing surface relating to the Moist Towel Surface Structure Method.

FIG. 11 is an enlarged view of a cell group overlapped by a quadrilateral related to the Continuous Region Density Difference Measurement.

FIG. 12 is a density image for use in the Micro-CT Intensive Property Measurement Method.

FIG. 13 is a binary image for use in the Micro-CT Intensive Property Measurement Method.

FIG. 14 is an example of a sample support rack used in the HFS and VFS Test Methods.

FIG. 14A is a cross-sectional view of the sample support rack of FIG. 14.

FIG. 15 is an example of a sample support rack cover used in the HFS and VFS Test Methods.

FIG. 15A is a cross-sectional view of the sample support rack cover of Fig. 15.

FIG. 16A is a portion of a fibrous structure of the present disclosure comprising an emboss pattern.

FIG. 16B is a portion of a fibrous structure of the present disclosure comprising an emboss pattern.

FIG. 17 is a representative papermaking belt of the kind useful to make fibrous structures comprising non-wood fibers of the present disclosure.

Beyond the figures of the present application and their descriptions disclosed above, the figures and their descriptions, including FIGS. 1A – 2JJ, disclosed in U.S. Provisional Patent Application Serial No. 63/456,020, titled "Fibrous Structures Comprising Non-wood Fibers," filed on March 31, 2023, Young as the first-named inventor, are within the scope of the present disclosure.

DETAILED DESCRIPTION

Various non-limiting examples of the present disclosure will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the fibrous structures comprising non-woods disclosed herein. One or more non-limiting examples are illustrated in the accompanying drawings. Those of ordinary skill in the art will understand that the fibrous structures described herein and illustrated in the accompanying drawings are non-limiting examples. The features illustrated and/or described in connection with one non-limiting example can be combined with the features of other non-limiting examples. Such modifications and variations are intended to be included within the scope of the present disclosure.

MAKING FIBROUS STRUCTURES OF THE PRESENT DISCLOSURE

"Machine Direction" or "MD" as used herein means the direction parallel to the flow of the fibrous structure through the papermaking machine and/or product manufacturing equipment.

"Cross Machine Direction" or "CD" as used herein means the direction perpendicular to the machine direction in the same plane of the fibrous structure.

Generally, fibrous structures of the present disclosure are typically made in "wet-laid" papermaking processes. In such papermaking processes, a fiber slurry, usually wood pulp fibers, is deposited onto a forming wire and/or one or more papermaking belts such that an embryonic fibrous structure is formed. After drying and/or bonding the fibers of the embryonic fibrous structure together, a fibrous structure is formed. Further processing of the fibrous structure can then be carried out after the papermaking process. For example, the fibrous structure can be wound on the reel and/or ply-bonded and/or embossed. As further discussed herein, visually distinct features may be imparted to the fibrous structures in different ways. In a first method, the fibrous structures can have visually distinct features added during the papermaking process. In a second method, the fibrous structures can have visually distinct features added during the converting process (*i.e.*, after the papermaking process). Some fibrous structure examples disclosed herein may have visually distinct features added only during the papermaking process, and some fibrous structure examples may have visually distinct features added both during the papermaking process and the converting process.

Regarding the first method, a wet-laid papermaking process can be designed such that the fibrous structure has visually distinct features "wet-formed" during the papermaking process. Any of the various forming wires and papermaking belts utilized can be designed to leave physical, three-dimensional features within the fibrous structure. Such three-dimensional features are well known in the art, particularly in the art of "through air drying" (TAD) papermaking processes, with

such features often being referred to in terms of "knuckles" and "pillows." "Knuckles" or "knuckle regions" or "knuckle zones" are typically relatively high-density regions that are wet-formed within the fibrous structure (extending from a pillow surface of the fibrous structure) and correspond to the knuckles of a papermaking belt, *i.e.*, the filaments or resinous structures that are raised at a higher elevation than other portions of the belt. "Relatively high density" as used herein means a portion of a fibrous structure having a density that is higher than a relatively low-density portion of the fibrous structure. Relatively high density zones or regions can be about 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60, or about 65% higher than relatively low density regions or zones. For instance, discrete knuckles, measured according to Micro-CT Intensive Property Measurement Method, may have a density greater than about ("greater than about" used interchangeably with "at least about" herein) 30%, about 35%, about 40%, about 45%, about 50%, about 55%, about 60, or about 65% higher than pillows. Whether one is substituting short or long wood fibers with non-wood fibers, there are not direct non-wood substitutions available for several reasons, such as morphology differences between wood and non-wood fibers. For instance, even when fiber length is matched by the non-wood replacing the wood fiber, said non-wood fiber likely has important differences such as fiber width, stiffness, etc. For some of these reasons, generally speaking, knuckles and pillows comprising non-wood fibers will be different (e.g., less dense) than knuckles and pillows consisting of non-wood fibers. These are some of the reasons that incorporation of non-wood fibers into established sanitary tissue products is not straightforward and creates unexpected outcomes. This is especially true as one tries to achieve parity (when using non-wood fibers) for multiple key parameters of sanitary tissue products.

Likewise, "pillows" or "pillow regions" or "pillow zones" are typically relatively low-density regions that are wet-formed within the fibrous structure and correspond to the relatively open regions between or around the knuckles of the papermaking belt. The pillow regions form a pillow surface of the fibrous structure from which the knuckle regions extend. "Relatively low density" as used herein means a portion of a fibrous structure having a density that is lower than a relatively high-density portion of the fibrous structure. Further, the knuckles and pillows wet-formed within a fibrous structure can exhibit a range of basis weights and/or densities relative to one another, as varying the size of the knuckles or pillows on a papermaking belt can alter such basis weights and/or densities. A fibrous structure (*e.g.*, sanitary tissue products) made through a TAD papermaking process as detailed herein is known in the art as "TAD paper."

Thus, in the description herein, the terms "knuckles" or "knuckle regions" or "knuckle zones" or the like can be used to reference either the raised portions of a papermaking belt or the densified, raised portions wet-formed within the fibrous structure made on the papermaking belt

(*i.e.*, the raised portions that extend from a surface of the fibrous structure), and the meaning should be clear from the context of the description herein. Likewise "pillows" or "pillow regions" or "pillow zones" or the like can be used to reference either the portion of the papermaking belt between or around knuckles (also referred to in the art as "deflection conduits" or "pockets"), or the relatively uncompressed regions wet-formed between or around the knuckles within the fibrous structure made on the papermaking belt, and the meaning should be clear from the context of the description herein. Knuckles or pillows can each be either continuous or discrete, as described herein. As shown in FIGS. 5, such illustrated masks may be used in producing papermaking belts that would create fibrous structures that have discrete knuckles and continuous/substantially continuous pillows. Like masks may be used in producing papermaking belts that would create fibrous structures that have discrete pillows and continuous/substantially continuous knuckles. The term "discrete" as used herein with respect to knuckles and/or pillows means a portion of a papermaking belt or fibrous structure that is defined or surrounded by, or at least mostly defined or surrounded by, a continuous/substantially continuous knuckle or pillow. The term "continuous/substantially continuous" as used herein with respect to knuckles and/or pillows means a portion of a papermaking belt or fibrous structure network that fully, or at least mostly, defines or surrounds a discrete knuckle or pillow. Further, the substantially continuous member can be interrupted by macro patterns formed in the papermaking belt, as disclosed in US Pat. No. 5,820,730 issued to Phan et al. on October 13, 1998.

Knuckles and pillows in paper towels (also referred to as "towel") and bath tissue (also referred to as "toilet tissue," "bath," or "toilet paper") can be visible to the retail consumer of such products. The knuckles and pillows can be imparted to a fibrous structure from a papermaking belt at various stages of the papermaking process (*i.e.*, at various consistencies and at various unit operations during the drying process) and the visual pattern generated by the pattern of knuckles and pillows can be designed for functional performance enhancement as well as to be visually appealing. Such patterns of knuckles and pillows can be made according to the methods and processes described in US. Pat. No. 6,610,173, issued to Lindsay et al. on August 26, 2003, or US Pat. No. 4,514,345 issued to Trokhan on April 30, 1985, or US Pat. No. 6,398,910 issued to Burazin et al. on June 4, 2002, or US Pub. No. 2013/0199741; published in the name of Stage et al. on August 8, 2013. The Lindsay, Trokhan, Burazin and Stage disclosures describe belts that are representative of papermaking belts made with cured resin on a woven reinforcing member, of which aspects of the present disclosure are an improvement. But in addition, the improvements detailed herein can be utilized as a fabric crepe belt as disclosed in US Pat. No. 7,494,563, issued to Edwards et al. on Feb. 24, 2009 or US 8,152,958, issued to Super et al. on April 10, 2012, as

well as belt crepe belts, as described in US Pat. No. 8,293,072, issued to Super et al on October 23, 2012. When utilized as a fabric crepe belt, a papermaking belt of the present disclosure can provide the relatively large, recessed pockets and sufficient knuckle dimensions to redistribute the fiber upon high impact creping in a creping nip between a backing roll and the fabric to form additional bulk in conventional wet-laid press processes. Likewise, when utilized as a belt in a belt crepe method, a papermaking belt of the present disclosure can provide the fiber enriched dome regions arranged in a repeating pattern corresponding to the pattern of the papermaking belt, as well as the interconnected plurality of surrounding areas to form additional bulk and local basis weight distribution in a conventional wet-laid process. In addition, the improvements detailed herein, can be utilized as an uncreped through air dried (UCTAD) belt. UCTAD (un-creped through air drying) is a variation of the TAD process in which the sheet is not creped, but rather dried up to 99% solids using thermal drying, removed from the structured fabric, and then optionally calendered and reeled. U.S. Pat. No. 6,808,599 describes an uncreped through air dried process. U.S. Pat. No. 10,610,063 describes an uncreped through air dried product made using a belt. In addition, the improvements herein can be utilized as an ATMOS belt. The ATMOS process has been developed by the Voith company and marketed under the name ATMOS. The process/method and paper machine system has several variations, but all involve the use of a structured fabric in conjunction with a belt press. This process is described in numerous patent publications including U.S. Pat. Nos. 7,510,631, 7,686,923, 7,931,781, 8,075,739, and 8,092,652. In addition, the improvements herein can be utilized as an NTT belt. The NTT process has been developed by the Metso company and marketed under the name NTT. The NTT process includes an extended press nip where the sheet is transferred from a press felt onto a texturing belt. Examples of texturing belts used in the NTT process can be viewed in International Publication Number WO 2009/067079 A1 and US Patent Application Publication No. 2010/0065234 A1. An example of a papermaking belt structure of the general type useful in the present disclosure and made according to the disclosure of US Pat. No. 4,514,345 is shown in FIG. 17. As shown, the papermaking belt 17 can include cured resin elements 4 forming knuckles 20 on a woven reinforcing member 6. The reinforcing member 6 can be made of woven filaments 8 as is known in the art of papermaking belts, for example resin coated papermaking belts. The papermaking belt structure shown in FIG. 17 includes discrete knuckles 20 and a continuous deflection conduit, or pillow region (pillow zone). The discrete knuckles 20 can wet-form densified knuckles within the fibrous structure made thereon; and, likewise, the continuous deflection conduit, *i.e.*, pillow region, can wet-form a continuous pillow region within the fibrous structure made thereon. The knuckles can be arranged in a pattern described with reference to an X-Y coordinate plane, and the

distance between knuckles 20 in at least one of the X or Y directions can vary according to the examples disclosed herein. For clarity, a fibrous structure's visually distinct knuckle(s) and pillow(s) that are wet-formed in a wet-laid papermaking process are different from, and independent of, any further structure added to the fibrous structure during later, optional, converting processes (e.g., one or more embossing process). For certain embodiments of the present disclosure, it may be desirable to use the belts disclosed in U.S. Patent Nos. 9,435,081; 9,631,323; 9,752,281; 10,240,296; and U.S. Publication Nos. 2022-0010497; and 2021-0140114 as some of these belts create sinusoidal and/or serpentine pillow and/or knuckle regions or zones; in some embodiments, these pillow and/or knuckle zones or regions may be continuous and/or semi-continuous. These patterns referenced in the patents and publication of the previous sentence can be particularly useful for achieving the most desirable properties from webs comprising non-woods, even including high non-wood (e.g., bamboo) inclusion.

After completion of the papermaking process, a second way to provide visually distinct features to a fibrous structure is through embossing. Embossing is a well-known converting process in which at least one embossing roll having a plurality of discrete embossing elements extending radially outwardly from a surface thereof can be mated with a backing, or anvil, roll to form a nip in which the fibrous structure can pass such that the discrete embossing elements compress the fibrous structure to form relatively high density discrete elements ("embossed regions") in the fibrous structure while leaving an uncompressed, or substantially uncompressed, relatively low density continuous, or substantially continuous, network ("non-embossed regions") at least partially defining or surrounding the relatively high density discrete elements.

As illustrated in FIGS. 6B and 6C, beyond creating knuckles and pillows with resinous belts described above, and beyond the various types of creping, paper may be transformed in other ways, such that beneficial properties are created, especially as the speed of a belt or a wire transfers the web to a belt or a wire of a different speed, such as, for example, the upstream belt or wire moving faster than the downstream belt or wire. It may be desirable to have multiple such transfers in the same papermaking process. Further, it may be desirable to have different speed differentials at different transfers in such a process. As a more specific example, referring to FIG. 6B, in a first rush transfer 175, the speed of the forming fabric 154 can be travelling at a first rate, while the transfer fabric 174 travels at a second rate (slower than the first rate, but faster than 2,000 feet per minute (fpm), 2,050 fpm, 2,100 fpm, 2,150 fpm, 2.200 fpm, 2,250 fpm, 2,300 fpm, 2,350 fpm, 2,400 fpm, 2,450 fpm, 2,500 fpm, 2,600 fpm, 2,700 fpm, 2,800 fpm, 2,900 fpm, or greater than 3,000 fpm); further, a second rush transfer 175' may occur where the transfer fabric is travelling at the second rate, while the TAD fabric 164 travels at a third rate, which may be the faster or

slower (e.g., about 10%, about 15%, about 20%, about 25%, about 30%, about 40, about 50% faster or slower) than the second rate. While the UCTAD process does not form traditional density differentials (e.g., such as knuckles and pillows), said rush transfers can, depending on the speed differentials of the transfers, create fiber orientations within the web such that performance of the fibrous structure is improved, such as, for example, stretch, tensile ratio, tensile, modulus, caliper, bulk.

Embossed features in paper towels and bath tissues can be visible to the retail consumer of such products. Emboss designs as disclosed in U.S. Design. Pat. App. Nos. 29/673,106; 29/673,105; and 29/673,107 may be used to make fibrous structures of the present disclosure. Emboss patterns can be made according to the methods and processes described in US Pub. No. US 2010-0028621 A1 in the name of Byrne et al. or US 2010-0297395 A1 in the name of Mellin, or US Pat. No. 8,753,737 issued to McNeil et al. on June 17, 2014. For clarity, such embossed features originate during the converting process, and are different from, and independent of, the pillow and knuckle features that are wet-formed on a papermaking belt during a wet-laid papermaking process.

More particular papermaking processes are disclosed below and illustrated in FIGS. 6A and 6B, versus the more general description above. FIGS. 6A and 6B are simplified, schematic representations of continuous fibrous structure making processes and machines useful in the practice of the present disclosure. The following description of the process and machine include non-limiting examples of process parameters useful for making a fibrous structure of the present invention.

As shown in FIG. 6A, process and equipment 150 for making fibrous structures according to the present disclosure comprises supplying an aqueous dispersion of fibers (a fibrous furnish) to a headbox 152 which can be of any design known to those of skill in the art. The aqueous dispersion of fibers can include wood and non-wood fibers, northern softwood kraft fibers ("NSK"), eucalyptus fibers, southern softwood kraft (SSK) fibers, Northern Hardwood Kraft (NHK) fibers, acacia, bamboo, straw and bast fibers (wheat, flax, rice, barley, etc.), corn stalks, bagasse, abaca, kenaf, reed, synthetic fibers (PP, PET, PE, bico version of such fibers), regenerated cellulose fibers (viscose, lyocell, etc.), and other fibers known in the papermaking art, including short fibers having an average length less than 1.0 mm (Average Short Fiber Length-ASFL) and including long fibers having an average length greater than 1.0 mm, from about 1.2 mm to about 3.5 mm, or from about 3 mm to about 10 mm (Average Long Fiber Length-ALFL). Depending on the non-wood fibers being used, they may be in the long fiber range of length. For instance, bamboo can have a length from 1.1 to 2.0 mm and sunn hemp is

even longer, it can have a length from 2.8 to 3.0 mm and sisal hemp can have a length from 2.5 to 2.7 mm. Kenaf can have a length from 2.7 to 3.0 mm, abaca can have a length from 4.0 to 4.3 mm. This becomes significant when short fibers like eucalyptus are replaced with longer non-wood fibers.

From the headbox 152, the aqueous dispersion of fibers can be delivered to a foraminous member 154, which can be a Fourdrinier wire, to produce an embryonic fibrous web 156. Furnish mixes may be useful in the present disclosure may be from about 20% to about 50% short fibers and from about 40% to about 100% long fibers, specifically including all 1% increments between the recited ranges.

The foraminous member 154 can be supported by a breast roll 158 and a plurality of return rolls 160 of which only two are illustrated. The foraminous member 154 can be propelled in the direction indicated by directional arrow 162 by a drive means, not illustrated, at a predetermined velocity, V_1. Optional auxiliary units and/or devices commonly associated with fibrous structure making machines and with the foraminous member 154, but not illustrated, comprise forming boards, hydrofoils, vacuum boxes, tension rolls, support rolls, wire cleaning showers, and other various components known to those of skill in the art.

After the aqueous dispersion of fibers is deposited onto the foraminous member 154, the embryonic fibrous web 156 is formed, typically by the removal of a portion of the aqueous dispersing medium by techniques known to those skilled in the art. Vacuum boxes, forming boards, hydrofoils, and other various equipment known to those of skill in the art are useful in effectuating water removal. The embryonic fibrous web 156 can travel with the foraminous member 154 about return roll 160 and can be brought into contact with a papermaking belt 164 in a transfer zone 136, after which the embryonic fibrous web travels on the papermaking belt 164. While in contact with the papermaking belt 164, the embryonic fibrous web 156 can be deflected, rearranged, and/or further dewatered. Depending on the process, mechanical and fluid pressure differential, alone or in combination, can be utilized to deflect a portion of fibers into the deflection conduits of the papermaking belt. For example, in a through-air drying process a vacuum apparatus 176 can apply a fluid pressure differential to the embryonic web 156 disposed on the papermaking belt 164, thereby deflecting fibers into the deflection conduits of the deflection member. The process of deflection may be continued with additional vacuum pressure 186, if necessary, to even further deflect and dewater the fibers of the web 184 into the deflection conduits of the papermaking belt 164.

The papermaking belt 164 can be in the form of an endless belt. In this simplified representation, the papermaking belt 164 passes around and about papermaking belt return

rolls 166 and impression nip roll 168 and can travel in the direction indicated by directional arrow 170, at a papermaking belt velocity V_2, which can be less than, equal to, or greater than, the foraminous member velocity V_1. In the present disclosure, the papermaking belt velocity V_2 is less than foraminous member velocity V_1 such that the partially-dried fibrous web is foreshortened in the transfer zone 136 by a percentage determined by the relative velocity differential between the foraminous member and the papermaking belt. Associated with the papermaking belt 164, but not illustrated, can be various support rolls, other return rolls, cleaning means, drive means, and other various equipment known to those of skill in the art that may be commonly used in fibrous structure making machines.

The papermaking belts 164 of the present disclosure can be made, or partially made, according to the process described in U.S. Patent No. 4,637,859, issued Jan. 20, 1987, to Trokhan, and having the patterns of cells as disclosed herein.

The fibrous web 192 can then be creped with a creping blade 194 to remove the web 192 from the surface of the Yankee dryer 190 resulting in the production of a creped fibrous structure 196 in accordance with the present disclosure. As used herein, creping refers to the reduction in length of a dry (having a consistency of at least about 90% and/or at least about 95%) fibrous web which occurs when energy is applied to the dry fibrous web in such a way that the length of the fibrous web is reduced and the fibers in the fibrous web are rearranged with an accompanying disruption of fiber-fiber bonds. Creping can be accomplished in any of several ways as is well known in the art, as the doctor blades can be set at various angles. The creped fibrous structure 196 is wound on a reel, commonly referred to as a parent roll, and can be subjected to post processing steps such as calendaring, tuft generating operations, embossing, and/or converting. The reel winds the creped fibrous structure at a reel surface velocity, V_4.

The papermaking belts of the present disclosure can be utilized to form discrete elements and a continuous/substantially continuous network (*i.e.*, knuckles and pillows) into a fibrous structure during a through-air-drying operation. The discrete elements can be knuckles and can be relatively high density relative to the continuous/substantially continuous network, which can be a continuous/substantially pillow having a relatively lower density. In other examples, the discrete elements can be pillows and can be relatively low density relative to the continuous/substantially continuous network, which can be a continuous/substantially continuous knuckle having a relatively higher density. In the example detailed above, the fibrous structure is a homogenous fibrous structure, but such papermaking process may also be adapted to manufacture layered fibrous structures, as is known in the art. As discussed above, the fibrous structure can be embossed during a converting operating to produce the embossed fibrous structures of the present disclosure.

Formation

An area of particular interest is formation of the fibrous structure. This is an area where, as evidenced in the detailed description, so many sustainable sanitary tissue products fail and the art does not disclose how to achieve well-formed fibrous structures comprising bamboo and/or other sustainable non-wood fibers. Formation of non-wood fibers can be challenging due to their morphology, which differs from wood fibers. For instance, bamboo fibers, which may be considered flexible (relative to their length/width ratio versus certain wood fibers and versus their length/width ratio versus certain non-wood fibers such as straw fibers (e.g., wheat straw)) often flocculate in the headbox, which can result in a heterogeneously formed sheet. The inventors of the present disclosure have found ways of overcoming these challenges so that adding bamboo fibers into the fibrous structure, even at high(er) inclusion levels, can result in products having good formation as evidenced by inventive formation index values, as well as by tensile ratio values disclosed herein. It should also be appreciated that the better a sheet's formation, the better its coverage. Such is important, of course, because formation and coverage directly impact hand protection for sanitary tissue products. Details are in the specification below.

As described above, in part, fibers are delivered to and diluted in the headbox. All other things being constant, increasing the dilution of the headbox (decreasing headbox consistency) results in improved formation. Without being bound by theory, one reason for this could be that as the headbox consistency decreases, the fibrous particles in the headbox have less interactions with each other as they flow through the headbox. Because fibers (wood and non-wood) are generally ribbon-like in cross section, if that fiber is allowed to rotate in all three axes then it creates a sphere. This sphere of fibers can be referred to as the swept volume of the fiber. As the headbox consistency increases, assuming perfectly homogenous distribution of fibers in the solution, the spheres of swept volume begin to come closer together, eventually overlapping. As the spheres overlap more and more, the fibers have a higher probability of interacting with each other, creating flocculation, which results in a more heterogeneously formed sheet. This is also referred to as poor formation.

The jet-to-wire ("jet/wire") ratio is known in the art as a velocity ratio between the speed of the jet exiting the headbox and the speed of the wire(s) upon which the jet impinges. The main ways to adjust the jet/wire ratio are (1) to increase the flow rate through the headbox in a fixed headbox geometry, while keeping wire speed constant, (2) to increase the wire speed while keeping the headbox flow and geometry constant, (3) to decrease the flow rate through the headbox in a fixed headbox geometry, while keeping the wire speed constant, or (4) to decrease the wire speed

while keeping the headbox flow and geometry constant. Method (1) observes the incompressible fluid dynamic concept of continuity, which says that if the volumetric flow through a fixed area increases, the velocity must increase – the opposite is true for Method (3). For Methods (2) and (4), again via continuity, results in the jet velocity being constant while the wire velocity increases or decreases, respectively. This jet/wire ratio also affects the tensile ratio of the subsequently formed sheet. This mechanism is via fiber orientation on the wire as the fibers are deposited. It is generally known that the higher the speed difference is between the jet/wire (either a jet much faster or a jet much slower), the higher the tensile ratio will be, and that there will be a minimum tensile ratio between the extremes. For this reason, it may be desirable that fibrous structures of the present disclosure have certain tensile ratios, described in more detail below. Fiber orientation can also impact the formation of the sheet through increased heterogeneity of the substrate.

Finally, one of the major costs of papermaking is energy. Pumps, especially fan pumps, consume large amounts of power via the work of increasing the pressure of a volumetric flow (known as PV work). Lowering the flow through the headbox (thereby increasing the consistency and decreasing the jet/wire at constant throughput and headbox geometry) will lower the production costs for the papermaker. Additionally, all other things being equal, less headbox dilution would result in less drying energy and overall water consumption, which are significant cost elements in an increasingly resource constrained world.

Therefore, the papermaker strives to balance these competing priorities. Upon recent experimentation, it has surprisingly been found that the relationships between jet/wire, tensile ratio, and formation are different for non-wood fibers than they are for wood fibers. More specifically, the tensile ratios disclosed below may be achieved by, at least in part, by a jet flow that is slower than a forming wire speed.

As discussed previously in this section, creating premium levels of quality (softness, absorption, strength, bulk characteristics, etc.) toilet tissue by using high coarseness bamboo in the furnish mix is a challenge. It is generally known that substrates with a very even fiber distribution (good formation) are consumer preferred. One reason is that the even distribution of fibers is pleasing to the eye. Another reason is that the even distribution of fibers means that, at a given basis weight, there is a higher minimum fiber coverage area of the sheet, as there are less heavy and light spots of the sheet, contributing to better hand protection. Better formation also equates to better absorbency characteristics through better pore connectivity and pore volume distributions. In most conventional wet press processes, having an even formation lends to better tensile efficiency, allowing for a stronger sheet at a given basis weight. In through-air-drying, sheets are produced that have higher bulk properties. Through conservation of volume, at a given basis

weight, a through-air-dried sheet with higher bulk would tend to have a lower formation index than a conventional wet press sheet at similar basis weights and fiber compositions.

Another way to improve formation index is to choose fibers that allow for high coverage (i.e., fibers with low coarseness and wide fiber widths). Bamboo, for instance, is known in the art as a fiber with potential for tissue making use. However, the morphology of the bamboo fiber (high levels of fines, broad fiber length distribution, high coarseness, high fibrillation, etc.) make for a fiber that drains poorly, making it particularly unsuited for through-air-drying machines due to high energy costs associated with the drying of the nascent fiber web. The high coarseness of bamboo, as well as its wide fiber width, make for poorer fiber coverage than sheets that are comprised mainly of eucalyptus. This also leads to a lower formation index than eucalyptus or other high fiber coverage sheets. Thus, toilet tissue sheets that are comprised mostly of eucalyptus fibers, which are short, narrow, and exhibit low coarseness have improved fiber coverage in the sheet and a higher formation index. As the papermaker uses higher levels of bamboo inclusion, one is necessarily replacing the eucalyptus fibers with longer, wider, and coarser bamboo fibers. The fiber coverage in the substrate decreases, and the formation index decreases as well. This is not only true for bamboo, but many of the other non-woods. Surprisingly, the inventors of the present disclosure have discovered that decreasing the tensile ratio of structured fibrous structures comprising non-woods improves the formation index of said fibrous structures. This is the exact opposite of non-structured fibrous structures, in which increasing the tensile ratio improves the formation index. Without being bound by theory, it is thought that the interplay of fiber distribution on the wire, deformation of the sheet into a patterned fabric, and subsequent differential drying and creping of the resultant sheet, at least in part, results in this counterintuitive relationship.

A majority of webs comprising bamboo are made on conventional wet press machines. These machines generate webs of low caliper, and when converted into finished product rolls result in either low bulk and hard rolls or high bulk and extremely soft rolls. A few instances of products can be found comprising bamboo that are made on through-air-dried machines. These examples exhibit a lower formation index and also exhibit other non-consumer preferred characteristics, like low volumetric PVD absorption in the 2.5-160 um range. It is therefore surprising that a low formation index substrate can be made with a coarse non-wood fiber, such as bamboo, and still be able to meet standards for premium quality tissue.

The inventors of the present disclosure have surprisingly shown that substrates comprising non-woods (e.g., bamboo, abaca, etc.) can be created that still maintain strong consumer appeal despite their lower formation indices. As described in greater detail herein, non-wood fibers may be run in a continuous papermaking process at high percentage inclusions

of non-wood to form webs. These webs may then be pressed on a structured fabric, creating zones of differential density, which may, in part, contribute to the preferred characteristics of the resulting "structured" fibrous structures. Structured fibrous structures may be achieved using various papermaking processes such as, for example, TAD, fabric crepe, NTT, QRT, creped TAD and UCTAD.

Additionally, preferred characteristics may be achieved, at least in part, through jet/wire velocity adjustments, varying levels of foreshortening at the wire/belt interface wire/belt interface and at creping, through creping geometry changes, and the judicious placement of high and low density zones in the substrate.

Fractionation

It is generally known that substrates comprised of virgin wood pulps are consumer preferred. The substrate developer undergoes a very deliberate process when choosing the fibers that they want to include in their substrate. Generally, for soft and strong tissue products, a blend of low coarseness, low length eucalyptus fibers are included for softness, while low coarseness softwood fibers, for example, NSK fibers, are included for strength, but still permitting good flexibility. In order to maintain the correct ratios of strength, softness, and flexibility, the substrate developer will vary chemistry inclusion, fiber composition by layers, and refining of the wood pulp. Choices in any of these variables (and more) will affect the resultant substrate characteristics, making the substrate more or less consumer desirable.

It is also generally known that non-wood fibers often have different characteristics than wood fibers. Fiber morphology characteristics such as length, cell wall thickness, width, Runkle Ratio, kink, curl, fibrillation, and other characteristics can vary significantly from non-wood to non-wood, as well as compared to wood pulps. It is, therefore, a current problem to develop sanitary tissue products having premium characteristics when utilizing non-wood fibers that have non-premium morphologies.

In order to address this problem, non-wood fibers may be passed through a hydrocyclone and separated in to two different streams and described as "accepts" and "rejects." Despite this nomenclature, both outgoing streams can still be used by the substrate developer via different layering schemes. When passing non-woods through a fractionation unit, one important way that the unit separates the fibers is by degree of fibrillation. Since many non-woods are more fibrillated than wood fibers, choosing to place the less fibrillated non-wood stream close to the consumer may result in a more premium, wood fiber-like experience. Furthermore, it has been observed that less the fibrillated non-wood fraction ends up located in the reject stream, which is

usually reserved for longer, denser, and more coarse fibers. Traditional thinking would be to place this reject stream away from the consumer-facing layer, but the inventors of the present disclosure have surprising found that the better option is to place the reject stream to the consumer-facing layer. Without being bound by theory, it is believed that the hydrodynamic differences of fiber fibrillation overcome the hydrodynamic differences of fiber density and length. With fiber fibrillation being dominant, the more fibrillated fibers will follow the majority of the fluid and be carried to the accept portion of the cyclone. The coarser, longer, and less fibrillated fibers will concentrate on the peripheral wall of the cyclone and preferentially go towards the reject stream at the bottom of the cyclone. Yet, these "reject" fibers have better mobility, lower bonding, and are more wood-like due to their lower degree of fibrillation. Using non-wood rejects in the consumer-facing layer can, thus, result in a sanitary tissue product that has premium characteristics (e.g. softness).

Once-dried Non-wood Fibers

The challenges associated with non-wood fiber morphology are further complicated by using once-dried (versus never-dried, which comprise greater than about 45% water content) fibers in the paper-making process. Although never-dried and once-dried fibers are chemically similar, they differ greatly in their physical properties. Never-dried fiber walls contain much more water per unit dry mass than those of dried fibers after reslushing. Being more swollen, the never-dried walls are more flexible or conformable. In contrast, the walls of once-dried (and rewetted or reslushed or repulped) fibers are stiff (compared to never-dried fibers). Significant changes in the papermaking properties of fibers occur with water removal as the walls become progressively more rigid and less conformable. Table 6 shows the fiber characteristic differences between non-wood fibers that are never-dried and that have been once-dried; see also, for example: A.M.Scallan and G.V.Laivins, The mechanism of hornification of wood pulps in Products of Papermaking, Trans. of the Xth Fund. Res. Symp. Oxford, 1993, (C.F.Baker, ed.), pp 1235–1260, FRC, Manchester, 2018. DOI: 10.15376/frc.1993.2.1235, at page 1242 (Effect of Temperature) states: "Drying-and-reslushing at 25 C dropped the breaking length from 7.3 km for the virgin sheet down to 2.7 km. Raising the drying temperature to 105°and to 150°C further lowered the breaking length to 1.6 and 0.6 km. From this study it is apparent that the major reduction in sheet strength is due to water removal and that heat causes an additional reduction which is much smaller in magnitude." The same article further states: "Only a few investigations have been carried out, designed to separate the effects of temperature and water removal during drying . Lyne and Gallay avoided this problem by heating without drying; in their

experiments wet handsheets were heated to 95 °C for three minutes in an atmosphere saturated with water vapour before air drying (19). The tensile strength of the sheet was lowered by 14% when compared to that of an unheated control. The result shows that the heat treatment led to a reduction in the extent of interfibre bonding which they attributed to a loss of swelling of the pulp upon heating." Table 6 also illustrates that never-dried fibers bond to each other better than once-dried fibers. To overcome the effects of temperature and water removal, strength in the web (e.g., sanitary tissue product) may be achieved by temporary and/or permanent wet strength, dry strength additives, furnish blend ratios (e.g., softwood-to-hardwood ratios), process manipulations (refining, formation, calendaring, creping, etc.), etc.

While it may be desirable to use never-dried fibers (see, for example, the following publications assigned to Essity Hygiene and Health Aktiebolag: WO2023282811A1, WO2023282812A1, WO2023282813A1, WO2023282818A1), such requires the pulping facility to be close to the paper-making facility as wet fibers are too expensive to ship. Because this proximity is often impractical, the inventors of the present application used non-wood fibers that were at least once-dried and overcame not only the challenges associated with non-wood fibers, but also overcame the challenges of the non-wood fibers having been at least once-dried at the pulping facility and then shipped as dried sheets before incorporating the fibers into the paper-making process. That is, the non-wood fibers disclosed herein were reslushed from dried sheets before they were sent to a headbox in the paper-making process. Further, on a single fiber basis, the fiber length of once-dried non-wood fibers in the finished product (e.g., sanitary tissue product) will normally be shorter than never-dried non-wood fibers due to the extra processing necessary to rewet once-dried non-wood fibers. These shorter fibers have a materially different characteristics, which, among other things, will impact the strength of the final product.

When using once-dried non-wood pulp, the unit of pulp is typically in a bale, a sheet, or a block, which comprises less than about 45%, 40%, 35%, 25%, 15%, 10%, 5%, or 2% of water (water content). The unit of once-fired non-wood pulp may then be placed into a repulping unit to be repulped (also called reslushed or rewetted). The repulped non-wood fibers may then be further refined or may be sent directly to a headbox. As referenced above, the reslushed non-wood fibers will likely be stiffer (versus like fibers that were never-dried) due to hornification.

Another benefit of using once-dried fibers instead of never-dried fibers is that once-dried fibers bond less during the paper-making process and are thus less connected, which results in a softer sanitary tissue product, which allows the sanitary tissue product to be more cloth-like and more desirable. For instance, once-dried fibers of the present disclosure may have a breaking length of less than about 2700 m, less than about 2000 m, less than about 1700 m, less than about

1600 m, less than about 1400 m, less than about 1250 m, less than about 1100 m, less than about 900 m, less than about 750 m, or less than about 450 m, while never-dried fibers tend to have higher breaking lengths, such as greater than about 2700 m, greater than about 2800 m, greater than about 3000 m, greater than about 3200 m, or greater than about 3500 m, specifically reciting all 1 m increments within the above-recited ranges of this paragraph and all ranges formed therein or thereby.

Further, once-dried fibers of the present disclosure may have a breaking length ratio (which is the breaking length (m) according to the Breaking Length Test Method divided by the length weighted fiber length (microns) according to the Fiber Length, Width, Coarseness, and Fiber Count Test Method) of less than about 3.25 m/micron, less than about 2.7 m/micron, less than about 2.5 m/micron, less than about 2.0 m/micron, less than about 1.8 m/micron, less than about 1.6 m/micron, less than about 1.5 m/micron, less than about 1.0 m/micron, less than about 0.6 m/micron, or less than about 0.5 m/micron, while never-dried fibers tend to have higher breaking length ratios, such as greater than about 3.0 m/micron, greater than about 3.5 m/micron, greater than about 4.0 m/micron, greater than about 5.0 m/micron, or greater than about 6.0 m/micron, specifically reciting all 0.1 m/micron increments within the above-recited ranges of this paragraph and all ranges formed therein or thereby.

In light of the paragraphs of this Section (Once-dried Non-wood Fibers), a desirable process for making sanitary tissue products of the present disclosure may comprise: re-slushing pulp comprising non-wood fibers prior to sending the pulp to a headbox; forming a web comprising the non-wood fibers; creating zones of differential densities in the web; and creping the web. The once-dried non-wood pulp may be introduced into a repulping unit prior to the step of re-slushing the pulp. The once-dried non-wood pulp comprises non-wood fibers having a water content of less than about 10%, 20%, or 40%. The once-dried non-wood pulp may be in the form of a bale, a sheet, or a block. The non-wood fibers may be selected from the group consisting of bamboo, abaca, and mixtures thereof. The web may be treated with permanent or temporary wet strength. This process of making sanitary tissue products of the present disclosure may further include harvesting non-wood fibers and pulping the non-wood fibers and drying the non-wood fibers. The non-wood fibers may be dried (using, for example a pulp drier (e.g., from Andritz, Valmet, etc.)) at a facility other than a destination paper-making facility (i.e., where the pulp will be used to make the sanitary tissue products, including paper towels, toilet tissue, and/or facial tissue. The dried non-wood fibers may then be shipped to a destination paper-making facility. The shipping distance may be greater than: about 25, about 50, about 75, about 100, about 200, about 500, about 1,000 miles to reach the destination paper-making facility. In

some instances, the dried non-wood fibers may be shipped as far as from Asia (e.g., China) to North America (e.g., US).

STRUCTURES OF THE PRESENT DISCLOSURE

"Fiber" as used herein means an elongate physical structure having an apparent length greatly exceeding its apparent diameter, i.e., a length to diameter ratio of at least about 10. Fibers having a non-circular cross-section and/or tubular shape are common; the "diameter" in this case may be considered to be the diameter of a circle having cross-sectional area equal to the cross-sectional area of the fiber. More specifically, as used herein, "fiber" refers to fibrous structure-making fibers. The present disclosure contemplates the use of a variety of fibrous structure-making fibers, such as, for example, naturally-occurring fibers (wood and non-wood), synthetic (human-made) fibers, and/or any other suitable fibers, and any combination thereof.

"Fibrous structure" as used herein means a structure that comprises a plurality of fibers. In one example, a fibrous structure according to the present disclosure means an orderly arrangement of fibers within a structure in order to perform a function. A bag of loose fibers is not a fibrous structure in accordance with the present disclosure. The terms "web," "fibrous web," "embryonic web," and "embryonic fibrous web" are used to describe the web that is in the process of becoming the fibrous structure. Further, fibrous structures may be rolled, interleaved, perforated, and/or packaged to form final product(s), such as a sanitary tissue product.

"Non-woven fibrous structure" as used herein means a fibrous structure wherein fibers forming the fibrous structure are not orderly arranged by weaving and/or knitting the fibers together. In other words, non-woven fibrous structures do not include textiles, garments, and/or apparel. The non-woven fibrous structures of the present disclosure are disposable (i.e., typically thrown away after one or two uses—unlike clothes, rags, cloths, etc.).

"Ply" or "Plies" as used herein means an individual fibrous structure optionally to be disposed in a substantially contiguous, face-to-face relationship with other plies, forming a multiple ply fibrous structure. It is also contemplated that a single fibrous structure can effectively form two "plies" or multiple "plies", for example, by being folded on itself. A ply may comprise multiple layers. Multiple plies may, for example be formed as follows: fibrous structure of the present disclosure may be combined with one or more additional fibrous structures, which is the same or different from the fibrous structures of the present disclosure to form a multi-ply sanitary tissue product; said additional fibrous structure may be combined with the fibrous structure of the present disclosure by any suitable means.

"Sanitary tissue product" as used herein means a soft, low density (i.e., <about 0.25 g/cm^3) fibrous structure useful as a wiping implement for post-urinary and post-bowel movement cleaning (toilet tissue), for otorhinolaryngological discharges (facial tissue), and multi-functional absorbent and cleaning uses (absorbent towels and napkins). The sanitary tissue product may be convolutedly wound upon itself about a core or without a core to form a roll of sanitary tissue product. Further, the fibrous structure making up the sanitary tissue product may be perforated to form interconnected sheets. Sanitary tissue products may consist of fibers having an average length of less than about 1 inch; further sanitary tissue products may not comprise any fibers (or filaments) having a length greater than 1 inch. Sanitary tissue products may be formed according to a wet-laid process as illustrated in FIGS. 6A-C.

"Clothlike" as used herein relates to the feel of the non-woven fibrous structure to a consumer, the appearance of the non-woven fibrous structure to a consumer, and/or the performance (e.g., absorbency, strength, durability, etc.) of the non-woven fibrous structure during use by a consumer.

"Lint" as used herein means any material that originated from a fibrous structure according to the present disclosure that remains on a surface after which the fibrous structure and/or sanitary tissue product has come into contact. The lint value of a fibrous structure and/or sanitary tissue product comprising such fibrous structure is determined according to the Lint Test Method described herein.

"Differential density," as used herein, means a fibrous structure and/or sanitary tissue product that comprises one or more regions of relatively low fiber density, which are referred to as pillow regions, and one or more regions of relatively high fiber density, which are referred to as knuckle regions. In one example, a fibrous structure of the present disclosure comprises a surface comprising a surface pattern comprising a continuous knuckle region and a plurality of discrete pillow regions that exhibit different densities, for example, one or more of the discrete pillow regions may exhibit a density that is different (e.g., 30% different) than the density of the continuous knuckle region.

"Densified," as used herein means a portion of a fibrous structure and/or sanitary tissue product that is characterized by regions of relatively high fiber density (knuckle regions).

"Non-densified," as used herein, means a portion of a fibrous structure and/or sanitary tissue product that exhibits a lesser density (one or more regions of relatively lower fiber density) (pillow regions) than another portion (for example a knuckle region) of the fibrous structure and/or sanitary tissue product.

"Dry fibrous structure" as used herein means that the fibrous structure exhibits a water content (% moisture) of less than 20% and/or less than 15% and/or less than 10% and/or less than 7% and/or less than 5% and/or less than 3% and/or less than 1% to 0% and or to greater than 0%. Water content (% moisture) of a fibrous structure is measured using an Ohaus MB45 moisture balance, or an equivalent instrument, set to a drying temperature of 130°C, with moisture determined after the weight changes less than 1mg in 60 seconds (A60 hold time). Dry fibrous structures of the present disclosure may exhibit a water content (% moisture) of from about 0.0001% to about 20% and/or from about 0.001% to about 15% and/or from about 0.001% to about 12% and/or from about 0.001% to about 10% and/or from about 0.001% to about 7% and/or from about 0.001% to about 5%, by weight of the dry fibrous structure.

"Stacked product(s)" as used herein include fibrous structures, paper, and sanitary tissue products that are in the form of a web and cut into distinct separate sheets, where the sheets are folded (e.g., z-folded or c-folded) and may be interleaved with each other, such that a trailing edge of one is connected with a leading edge of another. Common examples of stacks of folded and/or interleaved sheets include facial tissues and napkins.

"Percent (%) difference," "X% difference," or "X% different" is calculated by: subtracting the lower value (e.g., common intensive property value) from the higher value (e.g., common intensive property value) and then dividing that value by the average of the lower and higher values, and then multiplying the result by 100.

"Within X%" or "within X percent" is calculated by the following non-limiting example: If first and second sanitary tissue products have a common intensive property (e.g., lint), and if a second lint value of the second sanitary tissue product is 10, then "within 25%" of the second lint value is calculated as follows for this example: multiplying 10 (the second lint value) by 25%, which equals 2.5, and then adding 2.5 to 10 (the second lint value) and subtracting 2.5 from 10 (the second lint value) to get a range, so that "within 25%" of the second lint value for this example means a lint value of or between 12.5 and 7.5). The absolute value of "X% change" can be used to determine if "within X%" is satisfied; for example can also be determined by using the absolute For example, if "X% change" is -25%, then a "within 25%" is satisfied, but if "X% change" is -25%, a "within 20%" is not satisfied.

"Percent (%) change," "X% change," or "X% change" is calculated by: subtracting the reference value (e.g., common intensive property value of a sustainable sanitary tissue product) from the comparative value (e.g., common intensive property value of a sanitary tissue product) and then dividing by the reference value, and then multiplying the result by 100. For example, if a reference value is 18 (e.g., a basis weight of a sustainable sanitary tissue product) and the

comparative value is 31 (e.g., a basis weight of a soft sanitary tissue product), then 18 should be subtracted from 31, which equals 13, which should be divided by 18, which equals 0.722, which should be multiplied by 100, which equals 72.2% change.

Fibrous structures of the present disclosure may be used to make sanitary tissue products, including paper towels, bath tissues, napkins, and facial tissues. The fibrous structures can be single-ply or multi-ply and may comprise cellulosic pulp fibers.

Fibrous structures of the present disclosure may be selected from the group consisting of: through-air-dried fibrous structures, differential density fibrous structures, differential basis weight fibrous structures, wet laid fibrous structures, air laid fibrous structures, conventional dried fibrous structures, creped or uncreped fibrous structures, patterned-densified or non-patterned-densified fibrous structures, compacted or uncompacted, especially high bulk uncompacted, fibrous structures, other nonwoven fibrous structures comprising synthetic or multicomponent fibers, homogeneous or multilayered fibrous structures, double re-creped fibrous structures, uncreped fibrous structures, co-form fibrous structures and combinations thereof.

As shown in FIGS. 3A-3C, fibrous structures and/or sanitary tissue products of the present disclosure may comprise a surface that comprises undulations (e.g., knuckles 20 and pillows 22) and/or embossments (e.g., 32, 34). FIGS. 16A and 16B illustrate embossments 32 (where each line and dot illustrated in FIGS. 16A and 16B is an embossment) that may be desirable for use with fibrous structures 10 of the present disclosure.

Fibrous structures of the present disclosure may be air laid and may be selected from the group consisting of thermal bonded air laid (TBAL) fibrous structures, latex bonded air laid (LBAL) fibrous structures and mixed bonded air laid (MBAL) fibrous structures.

Fibrous structures of the present disclosure may exhibit a substantially uniform density or may exhibit differential density regions; in other words, regions of high density compared to other regions within the patterned fibrous structure. Typically, when a fibrous structure is not pressed against a cylindrical dryer, such as a Yankee dryer, while the fibrous structure is still wet and supported by a through-air-drying fabric or by another fabric or when an air laid fibrous structure is not spot bonded, the fibrous structure typically exhibits a substantially uniform density. Differential density regions may contribute to the softness of the fibrous structures of the present disclosure (especially when compared to conventional wet press). As a particular example, the fibrous structures of the present disclosure may comprise knuckles and pillows, which can contribute to softness. Softness may be further enhanced when pillows are disposed on a consumer-facing surface of the fibrous structure, such as a consumer-facing surface of a sanitary tissue product.

As shown in FIGS. 4A, C, and E, fibrous structures of the present disclosure may comprise knuckles 20 and pillows 22, which is one way of achieving differential density. FIG. 5 shows a portion of the pattern on the mask 14 used to make a papermaking belt (not particularly shown, but of the type shown in FIG. 17) that is capable of making the sanitary tissue 12 shown in FIG. 3A. The sanitary tissue 12 of FIG. 3A exhibits a pattern of knuckles 20 and pillows 22 that were formed by discrete cured resin knuckles 20 on a papermaking belt, and which correspond to the white areas, *i.e.*, the cells 24, of the mask 14 shown in FIG. 5.

As depicted in the exemplary fibrous structure shown in FIG. 3A, and more clearly depicted through the masks shown in FIG. 5, the fibrous structures of the present disclosure may have a pattern of discrete knuckles and a continuous/substantially continuous pillow region. However, in other examples the fibrous structures may also have a pattern of discrete pillows and a continuous/substantially continuous knuckle regions.

As shown in FIGS. 4A-F, the fibrous structure may have first and second consumer-facing sides 50. It may be desirable that pillow regions face outwardly, indicated by directional arrow 51, such that the user of the fibrous structure feels the pillows with their skin. It should be understood, that depending on the type of process used to make the fibrous structure, for multi-ply fibrous structures, the consumer-facing side may be the either fabric-side-out ("FSO") or wire-side-out (WSO). For typical TAD, such as illustrated in FIG. 6A, "fabric side" means the side that touches the TAD fabric (164) and "wire side" means the side that touches the forming wire/forming fabric (154); for UCTAD, such as illustrated in FIG. 6B, "sides" are determined in the TAD section, where the "fabric" side touches the TAD fabric (164) and the "air" side does not. For a process like the one illustrated by FIG. 6A, the relevance of whether the consumer-facing side of the fibrous structure is wire side (WSO) or is fabric side (FSO) is whether a flatter surface (non-pillow-facing-outward surface) is desired, or whether a pillow-facing-outward surface is desired. When pillows face outwardly, TS7 values decrease (versus when knuckles are on the consumer-facing surface).

The fibrous structures of the present disclosure may be pattern densified. A pattern densified fibrous structure is characterized by having a relatively high-bulk field of relatively low fiber density and an array of densified zones (regions) of relatively high fiber density. The high-bulk field is alternatively characterized as a field of pillow zones (regions). The densified zones (regions) are alternatively referred to as knuckle zones (regions). The densified zones (regions) may be discretely spaced within the high-bulk field or may be interconnected, either fully or partially, within the high-bulk field.

The fibrous structures of the present disclosure may be uncompacted, non-pattern-densified. The fibrous structure may be of a homogenous or multi-layered construction. The fibrous

structure may be made with a fibrous furnish that produces a single layer embryonic fibrous web or a fibrous furnish that produces a multi-layer embryonic fibrous web.

The fibrous structures of the present disclosure may comprise any suitable ingredients known in the art. Nonlimiting examples of suitable ingredients that may be included in the fibrous structures include permanent and/or temporary wet strength resins, dry strength resins (e.g., Carboxy Methyl Cellulose (CMC)), softening agents, wetting agents, lint resisting agents, absorbency-enhancing agents, immobilizing agents, especially in combination with emollient lotion compositions, antiviral agents including organic acids, antibacterial agents, polyol polyesters, antimigration agents, polyhydroxy plasticizers, opacifying agents, bonding agents, debonding agents, colorants, and mixtures thereof. Such ingredients, when present in the fibrous structure of the present disclosure, may be present at any level based on the dry weight of the fibrous structure. Such ingredients, when present, may be present at a level of from about 0.001 to about 50%, and/or from about 0.001 to about 20%, and/or from about 0.01 to about 5%, and/or from about 0.03 to about 3%, and/or from about 0.1 to about 1.0% by weight, on a dry fibrous structure basis. It may be desirable to use one or a combination of said suitable ingredients on a fibrous structure comprising non-wood fibers, such as, for example, certain lotion(s) on a fibrous structures comprising bamboo, where the lotion improves softness or at least improves the perception of softness and may further decrease lint.

Non-wood Fibers

As used herein the term "non-wood fiber(s)" or "non-wood content" means naturally-occurring fibers derived from non-wood plants, including animal fibers, mineral fibers, plant fibers and mixtures thereof, and specifically excluding non-naturally-occurring fibers (e.g., synthetic fibers). Animal fibers may, for example, be selected from the group consisting of: wool, silk and other naturally-occurring protein fibers and mixtures thereof. The plant fibers may, for example, be obtained directly from a plant. Nonlimiting examples of suitable plants include cotton, cotton linters, flax, sisal, abaca, hemp, hesperaloe, jute, bamboo, bagasse, kudzu, corn, sorghum, gourd, agave, loofah, trichomes, seed-hairs, wheat, and mixtures thereof.

Non-wood fibers of the present disclosure may be derived from one or more non-wood plants of the family Asparagaceae. Suitable non-wood plants may include, but are limited to, one or more plants of the genus Agave such as A. tequilana, A. sisalana and A. fourcroyde, and one or more plants of the genus Hesperaloe such as H. funifera, H. parviflora, H. nocturna, H. Changi, H. tenuifolia, H. engelmannii, and H. malacophylla. Further, the non-wood fibers of the present disclosure may be prepared from one or more plants of the of the genus Hesperaloe such

as H. funifera, H. parviflora, H. nocturna, H. chiangii, H. tenuifolia, H. engelmannii, and H. malacophylla.

As used herein the term "wood fiber(s)" or "wood content" means fibers derived from both deciduous trees (hereinafter, also referred to as "hardwood") and coniferous trees (hereinafter, also referred to as "softwood") may be utilized. Wood fibers may be short (typical of hardwood fibers) or long (typical of softwood fibers). Nonlimiting examples of short fibers include fibers derived from a fiber source selected from the group consisting of Acacia, Eucalyptus, Maple, Oak, Aspen, Birch, Cottonwood, Alder, Ash, Cherry, Elm, Hickory, Poplar, Gum, Walnut, Locust, Sycamore, Beech, Catalpa, Sassafras, Gmelina, Albizia, Anthocephalus, and Magnolia. Nonlimiting examples of long fibers include fibers derived from Pine, Spruce, Fir, Tamarack, Hemlock, Cypress, and Cedar.

As used herein the term "synthetic fiber(s)" or "synthetic content" means fibers human-made fibers, and specifically excludes "wood fibers" and "non-wood fibers." Synthetic fibers can be used, in combination with non-wood fibers (e.g., bamboo) in the fibrous structures of the present disclosure. Synthetic fibers may be polymeric fibers. Synthetic fibers may comprise elastomeric polymers, polypropylene, polyethylene, polyester, polyolefin, polyvinyl alcohol and nylon, which are obtained from petroleum sources. Additionally, synthetic fibers may be polymeric fibers comprising natural polymers, which are obtained from natural sources, such as starch sources, protein sources and/or cellulose sources may be used in the fibrous structures of the present disclosure. The synthetic fibers may be produced by any suitable methods known in the art.

Fibrous structure(s), web(s) that form the fibrous structure(s), layer(s) of a fibrous structure(s) (including at least one of or each of a first and a second layer of a ply), and/or sheet(s) of a fibrous structure may comprise at least about 5%, about 10%, about 15%, about 20%, about 30%, about 35% about 40%, about 50%, about 75%, about 80%, or about 100% non-wood content, or from about 5% to about 15%, from about 10% to about 30%, from about 20% to about 40%, from about 30% to about 50%, from about 40% to about 60%, from about 50% to about 70%, from about 55% to about 95%, from about 65% to about 85%, from about 60% to about 80%, from about 70% to about 90%, from about 80% to about 100%, from about 90% to about 100%, from about 95% to about 100%, or from about 97.5% to about 100% non-wood content (e.g., bamboo, abaca, hemp, etc.), specifically reciting all 0.1% increments within the above-recited ranges of this paragraph and all ranges formed therein or thereby.

Bamboo

Generally, the "bamboo," "bamboo fibers," "bamboo content," or "bamboo fiber content" incorporated into fibrous structure(s) of the present disclosure are fibrous materials derived from any bamboo species. More particularly, the bamboo fiber species may be selected from the group consisting of: *Acidosasa* sp., *Ampleocalamus* sp., *Arundinaria* sp., *Bambusa* sp., *Bashania* sp., *Borinda* sp., *Brachystachyum* sp., *Cephalostachyum* sp., *Chimonobambusa* sp., *Chusquea* sp., *Dendrocalamus* sp., *Dinochloa* sp., *Drepanostachyum* sp., *Eremitis* sp., *Fargesia* sp., *Gaoligongshania* sp., *Gelidocalamus* sp., *Gigantocloa* sp., *Guadua* sp., *Hibanobambusa* sp., *Himalayacalamus* sp., *Indocalamus* sp., *Indosasa* sp., *Lithachne* sp., *Melocanna* sp., *Menstruocalamus* sp., *Nastus* sp., *Neohouzeaua* sp., *Neomicrocalamus* sp., *Ochlandra* sp., *Oligostachyum* sp., *Olmeca* sp., *Otatea* sp., *Oxytenanthera* sp., *Phyllostachys* sp., *Pleioblastus* sp., *Pseudosasa* sp., *Raddia* sp., *Rhipidocladum* sp., *Sasa* sp., *Sasaella* sp., *Sasamorpha* sp., *Schizostachyum* sp., *Semiarundinaria* sp., *Shibatea* sp., *Sinobambusa* sp., *Thamnocalamus* sp., *Thyrsostachys* sp., *Yushania* sp. and mixtures thereof.

The bamboo fibers may be from temperate bamboos of the *Phyllostachys* species, for example *Phyllostachys heterocycla pubescens*, also known as Moso Bamboo. However, it is to be understood that the compositions disclosed herein, unless otherwise stated, are not limited to containing any one bamboo fiber and may comprise a plurality of fibers of different species. For example, the composition may comprise a bamboo from a *Phyllostachys heterocycla pubescens* and a bamboo from a different species such as, for example, *Phyllostachys bambusoides*.

Bamboo fibers for use in the webs, fibrous structures, and products of the present disclosure may be produced by any appropriate methods known in the art. The bamboo fibers may be pulped bamboo fibers, produced by chemical processing of crushed bamboo stalk. The chemical processing may comprise treating the crushed bamboo stalk with an appropriate alkaline solution. The skilled artisan will be capable of selecting an appropriate alkaline solution. Bamboo fiber may also be produced by mechanical processing of crushed bamboo stalk, which may involve enzymatic digestion of the crushed bamboo stalk. Although bamboo fiber may be produced by any appropriate methods known in the art, a desirable method for manufacturing the bamboo pulp may be as a chemical pulping method such as, but not limited to, kraft, sulfite or soda/AQ pulping techniques.

Bamboo fibers of the present disclosure may be bamboo pulp fibers and may have an average fiber length of at least about 0.8 mm. When blends of fibers from various bamboo species are employed, it is noted that blends may comprise two or more species of bamboo, or may comprise three or more species of bamboo, such that the average fiber length is at least about 1.1 mm, at least about 1.5 mm, or from about 1.1 to about 2 mm. Fibrous structure(s), web(s) that form the fibrous structure(s), layer(s) of a fibrous structure(s) (including at least one of or each of

a first and a second layer of a ply), and/or sheet(s) of a fibrous structure may comprise at least about 5%, about 10%, about 15%, about 20%, about 30%, about 35%, about 40%, about 50%, about 75%, about 80%, or about 100% bamboo content, or from about 5% to about 15%, from about 10% to about 30%, from about 20% to about 40%, from about 30% to about 50%, from about 40% to about 60%, from about 50% to about 70%, from about 60% to about 80%, from about 70% to about 90%, from about 80% to about 100%, from about 90% to about 100%, from about 95% to about 100%, or from about 97.5% to about 100% bamboo content, specifically reciting all 0.1% increments within the above-recited ranges of this paragraph and all ranges formed therein or thereby.

Bamboo fibers may be more desirable to use than other non-wood fibers, such as various straws (e.g., wheat straw) for multiple reasons, one being that bamboo fibers are generally longer than straw fibers, which results in fibrous structures comprising bamboo fibers being stronger (without using strength enhancing chemistry or process manipulations) than like fibrous structures comprising shorter straw fibers.

Abaca

Generally, the "abaca," "abaca fibers," "abaca content," or "abaca fiber content" incorporated into fibrous structure(s) of the present disclosure are fibrous materials derived from Musa textilis (a species of banana native to the Philippines). Abaca may also be referred to as Manilla hemp, Cebu hemp, Davao hemp, Banana hemp or Musa hemp and can be used to derive abaca cellulose fibers.

Abaca may have a fiber coarseness of greater than 16 mg/100 m (or less than 20 mg/100 m) and a fiber length of 2.5 mm, 2.6 mm, 2.7 mm, 2.8 mm or more. Beyond abaca, sunn hemp, kenaf, and sisal hemp may have these characteristics.

Abaca comprises characteristics that can make it challenging (especially at higher incorporation levels) for incorporating into sanitary tissue products of the present invention as it is better known for being used to produce thin, strong, and porous paper capable of withstanding hard use.

Fibrous structure(s), web(s) that form the fibrous structure(s), layer(s) of a fibrous structure(s) (including at least one of or each of a first and a second layer of a ply), and/or sheet(s) of a fibrous structure may comprise at least about 5%, about 10%, about 15%, about 20%, about 30%. about 40%, about 50%, about 75%, about 80%, or about 100% abaca content, or from about 5% to about 15%, from about 10% to about 30%, from about 20% to about 40%, from about 30% to about 50%, from about 40% to about 60%, from about 50% to about 70%, from about 60% to

about 80%, from about 70% to about 90%, from about 80% to about 100%, from about 90% to about 100%, from about 95% to about 100%, or from about 97.5% to about 100% abaca content, specifically reciting all 0.1% increments within the above-recited ranges of this paragraph and all ranges formed therein or thereby.

Abaca fibers may be more desirable to use than other non-wood fibers, such as various straws (e.g., wheat straw) for multiple reasons, one being that abaca fibers are generally longer than straw fibers, which results in fibrous structures comprising abaca fibers being stronger (without using strength enhancing chemistry or process manipulations) than like fibrous structures comprising shorter straw fibers. Further, abaca's length, width, and coarseness make it a more suitable softwood replacement, its higher fibrillation increases specific surface area of the fiber and its carboxyl groups make it better for attaching strength chemistries.

Hemp

Generally, the "hemp," "hemp fibers," "hemp content," or "hemp fiber content" incorporated into fibrous structure(s) of the present disclosure may be made up of hemp cellulose fibers derived from the plants cannabis sativa or cannabis sativa indica. The hemp cellulose fibers may be processed to a particulate fiber pulp.

Hemp cellulose fibers may be derived from one or more of the plant sources cannabis, cannabis sativa, cannabis sativa indica, Agava Sisalana (i.e., Sisal hemp).

Cannabis is a genus of flowering plants that includes three different species, Cannabis sativa, Cannabis indica, and Cannabis ruderalis. The cannabis stalk (or stem) consists of an open cavity surrounded by an inner layer of core fiber, often referred to as hurd, and an outer layer referred to as the bast. Bast fibers are roughly 20% of the stalk mass and the hurd 80% of the mass. Cannabis bast fibers have a large range in length and diameter, but on average are very long with medium coarseness; suitable for making textiles, paper, and nonwovens. The hurd consists of very short, bulky fibers, typically 0.2-0.65 mm in length.

Fibrous structure(s), web(s) that form the fibrous structure(s), layer(s) of a fibrous structure(s) (including at least one of or each of a first and a second layer of a ply), and/or sheet(s) of a fibrous structure may comprise at least about 5%, about 10%, about 15%, about 20%, about 30%. about 40%, about 50%, about 75%, about 80%, or about 100% abaca content, or from about 5% to about 15%, from about 10% to about 30%, from about 20% to about 40%, from about 30% to about 50%, from about 40% to about 60%, from about 50% to about 70%, from about 60% to about 80%, from about 70% to about 90%, from about 80% to about 100%, from about 90% to about 100%, from about 95% to about 100%, or from about 97.5% to about 100% hemp content,

specifically reciting all 0.1% increments within the above-recited ranges of this paragraph and all ranges formed therein or thereby.

Bagasse

Generally, the "bagasse," "bagasse fibers," "bagasse content," or "bagasse fiber content" incorporated into fibrous structure(s) of the present disclosure may be made up of "sugar cane bagasse" - the dry pulpy residue left after the extraction of juice from sugar cane or sorghum stalks to extract their juice. Agave bagasse is similar, but is the material remnants after extracting blue agave sap.

Fibrous structure(s), web(s) that form the fibrous structure(s), layer(s) of a fibrous structure(s) (including at least one of or each of a first and a second layer of a ply), and/or sheet(s) of a fibrous structure may comprise at least about 5%, about 10%, about 15%, about 20%, about 30%. about 40%, about 50%, about 75%, about 80%, or about 100% abaca content, or from about 5% to about 15%, from about 10% to about 30%, from about 20% to about 40%, from about 30% to about 50%, from about 40% to about 60%, from about 50% to about 70%, from about 60% to about 80%, from about 70% to about 90%, from about 80% to about 100%, from about 90% to about 100%, from about 95% to about 100%, or from about 97.5% to about 100% bagasse content, specifically reciting all 0.1% increments within the above-recited ranges of this paragraph and all ranges formed therein or thereby.

Flax

Generally, the "flax," "flax fibers," "flax content," or "flax fiber content" incorporated into fibrous structure(s) of the present disclosure may be made up of Linum usitatissimum, in the family Linaceae. Flax fiber is extracted from the bast beneath the surface of the stem of the flax plant.

Fibrous structure(s), web(s) that form the fibrous structure(s), layer(s) of a fibrous structure(s) (including at least one of or each of a first and a second layer of a ply), and/or sheet(s) of a fibrous structure may comprise at least about 5%, about 10%, about 15%, about 20%, about 30%. about 40%, about 50%, about 75%, about 80%, or about 100% abaca content, or from about 5% to about 15%, from about 10% to about 30%, from about 20% to about 40%, from about 30% to about 50%, from about 40% to about 60%, from about 50% to about 70%, from about 60% to about 80%, from about 70% to about 90%, from about 80% to about 100%, from about 90% to about 100%, from about 95% to about 100%, or from about 97.5% to about 100% flax content,

specifically reciting all 0.1% increments within the above-recited ranges of this paragraph and all ranges formed therein or thereby.

Cotton

Generally, the "cotton," "cotton fibers," "cotton content," or "cotton fiber content" incorporated into fibrous structure(s) of the present disclosure may be made up of cotton linters, which are fine, silky fibers that adhere to the seeds of the cotton plant after ginning. These curly fibers typically are less than 1⁄8 inch (3.2 mm) long. The term also may apply to the longer textile fiber staple lint, as well as the shorter fuzzy fibers from some upland species.

Fibrous structure(s), web(s) that form the fibrous structure(s), layer(s) of a fibrous structure(s) (including at least one of or each of a first and a second layer of a ply), and/or sheet(s) of a fibrous structure may comprise at least about 5%, about 10%, about 15%, about 20%, about 30%. about 40%, about 50%, about 75%, about 80%, or about 100% abaca content, or from about 5% to about 15%, from about 10% to about 30%, from about 20% to about 40%, from about 30% to about 50%, from about 40% to about 60%, from about 50% to about 70%, from about 60% to about 80%, from about 70% to about 90%, from about 80% to about 100%, from about 90% to about 100%, from about 95% to about 100%, or from about 97.5% to about 100% cotton content, specifically reciting all 0.1% increments within the above-recited ranges of this paragraph and all ranges formed therein or thereby.

Morphology

Because non-wood fibers can have high coarseness, they may have poor surface feel and might not mold very well, thus may not have desirable caliper and bulk. Part of this dynamic is that certain non-woods, like bamboo, for instance, is often wider than the wood fibers it is used to replace. Further, bamboo also has a smaller lumen and thicker cell wall versus woods of same fiber width (i.e., a higher Runkel Ratio (i.e., ratio of twice the cell wall thickness to the diameter of the lumen), even greater than 1.0), so non-wood (e.g., bamboo) fibers can behave more stiffly, especially when using wood fiber knowledge. For these reasons, it may be desirable to spread apart knuckles and/or increase molding forces (pick-up shoe (molding vacuum)) and/or increase speed differential at transfer. With these differences, if nothing is done (i.e., if no adjustments are made for incorporating non-woods), caliper drops, and/or roll bulk drops, and/or the sheet is less compressible, and/or the sheet get stiffer (in-plane and/or bending).

Layers

As shown in FIGS. 4A-4F, and as described in Table A, a ply of fibrous structures of the present disclosure may be homogeneous or may be layered. If layered, a ply of the fibrous structures may comprise at least two, at least three, least four, and/or at least five layers. The fibrous structures may comprise a single ply, or two, three plies, four, or five plies.

As used herein, the term "layer" means a plurality of strata of fibers, chemical treatments, or the like, within a ply. As used herein, the terms "layered," "multi-layered," and the like, refer to fibrous sheets prepared from two or more layers of aqueous papermaking furnish which may be comprised of different fiber types. The layers may be formed from the deposition of separate streams of dilute fiber slurries, upon one or more endless foraminous screens. If the individual layers are initially formed on separate foraminous screens, the layers may be subsequently combined (while wet) to form a layered composite web. Naturally-occurring (e.g., wood and certain non-woods) and/or non-naturally (e.g., synthetic) occurring fibers can also be present in the fibrous structures, as will be disclosed in greater detail below. FIG. 4A illustrates a first ply 53 and a second ply 53 of a fibrous structure 10. Each of the plies may comprise 2 layers 55. The plies may be joined together 57 via adhesive, an emboss, or the like. The pillows 22 may face outwardly 51 toward the consumer-facing side 50 of the fibrous structure 10. Knuckles 20 may face inwardly toward the product-facing side 52 of the fibrous structure10, which is more commonly associated with process and equipment such as disclosed in FIG. 6A. As illustrated in FIG. 4A, both plies 53 are FSO. FIG. 4B is similar to FIG. 4A, except that the fibrous structure 10 does not have distinct knuckle 20 and pillow 22 regions or zones, which is more commonly associated with process and equipment such as disclosed in FIGS. 6A and 6B. FIGS. 4B and 4C are much like FIGS. 4A and 4B, respectively, except that each ply comprises 3 layers 55. FIG. 4E illustrates a single ply comprising 3 layers and is representative of a fibrous structure resulting form process and equipment such as disclosed in FIGS. 6B and 6C; as such, the fibrous structure 10 does not have distinct knuckle 20 and pillow 22 regions or zones. FIG. 4F is like FIG. 4A, except that it comprises 3 plies and, ply 53''' is FSO and has outwardly-facing 51 pillows 22, while ply 53 is WSO and has outwardly-facing 51 knuckles. FIG. 4F may, alternatively, have both plies 53 and 53''' FSO or both plies WSO; and both plies 53 and 53''' may have outwardly-facing 51 pillows 22 or both plies may have outwardly-facing 51 knuckles 20 - these FSO/WSO alternatives and pillow/knuckle alternatives are also true for FIG. 4A and 4C.

It may be desirable to dispose the highest fiber count (million fibers/g) in a most consumer-facing layer of a ply comprising non-wood fibers. A higher fiber count (versus other layer(s) in a ply) may be done in combination with outwardly facing pillows of a consumer-facing side of a fibrous structure of a sanitary tissue product. The outwardly-facing pillow region of a layer (e.g.,

55a) may comprise a higher fiber count than an adjacent region of an adjacent layer (e.g., 55b). Further, a pillow may have a greater basis wight than an adjacent knuckle. Alternatively, a knuckle may have a greater basis weight than an adjacent pillow.

PROPERTIES OF FIBROUS STRUCTURE(S)

Fibrous structure(s), web(s) that form the fibrous structure(s), layer(s) of a fibrous structure(s) (including at least one of or each of a first and a second layer of a ply), and/or sheet(s) of a fibrous structure(s) as disclosed herein, particularly including various inventive non-wood inclusions, even including greater than 80% non-woods by weight of the fibrous structure, and even including 100% non-woods by weight of the fibrous structure, may have one or a combination of the following properties: a VFS of greater than about 5.5 g/g, greater than about 6.0 g/g, greater than about 7.0 g/g, from about 3 g/g to about 20 g/g, from about 4 g/g to about 18 g/g, from about 5 g/g to about 16 g/g, from about 6 g/g to about 14 g/g, from about 8 g/g to about 12 g/g, or from about 5 g/g to about 6 g/g, specifically reciting all increments of 0.01 g/g within the above-recited ranges and all ranges formed therein or thereby;

an HFS of greater than about 13 g/g, or greater than about 14 g/g, or greater than about 15 g/g, or greater than about 16 g/g, or greater than about 16.5 g/g, or greater than about 17 g/g, or greater than about 17.5 g/g, or greater than about 18 g/g, or greater than about 18.5, g/g or greater than about 19 g/g, or greater than about 20 g/g, or greater than about 21 g/g, or from about 4 g/g to about 30 g/g, from about 6 g/g to about 28 g/g, from about 8 g/g to about 26 g/g, from about 10 g/g to about 24 g/g, from about 12 g/g to about 22 g/g, from about 13 g/g to about 20, from about 14 g/g to about 18 g/g, from about 13 g/g to about 15 g/g, or from about 13 g/g to about 14 g/g, specifically reciting all increments of 0.1 g/g within the above-recited ranges and all ranges formed therein or thereby;

a stack compressibility of greater than about 40 mils/(log(g/in^2)), greater than about 41 mils/(log(g/in^2)), greater than about 45 mils/(log(g/in^2)), greater than about 50 mils/(log(g/in^2)), from about 25 mils/(log(g/in^2)) to about 100 mils/(log(g/in^2)), from about 30 mils/(log(g/in^2)) to about 75 mils/(log(g/in^2)), from about 40 mils/(log(g/in^2)) to about 50 mils/(log(g/in^2)), from about 41 mils/(log(g/in^2)) to about 48, or from about mils/(log(g/in^2)) to about 48 mils/(log(g/in^2)), specifically reciting all increments of 0.1 mils/(log(g/in^2)) within the above-recited ranges and all ranges formed therein or thereby;

an MD wet peak elongation of greater than about 18%, greater than about 20%, from about 10% to about 30%, from about 14% to about 25%, from about 18% to about 22%, or from about

18% to about 20%, specifically reciting all increments of 0.1% within the above-recited ranges and all ranges formed therein or thereby;

a CD wet peak elongation of greater than about 12%, from about 5% to about 30%, from about 10% to about 25%, from about 12% to about 20%, or from about 12% to about 15%, specifically reciting all increments of 0.1% within the above-recited ranges and all ranges formed therein or thereby;

an MD wet peak TEA of greater than about 21 g*in/in^2, greater than about 22 g*in/in^2, from about 15 g*in/in^2 to about 50 g*in/in^2, from about 20 g*in/in^2 to about 40 g*in/in^2, from about 21 g*in/in^2 to about 30 g*in/in^2, or from about 21 g*in/in^2 to about 25 g*in/in^2, specifically reciting all increments of 1 g*in/in^2 within the above-recited ranges and all ranges formed therein or thereby;

a CD wet peak TEA of greater than about 7 g*in/in^2, from about 6 g*in/in^2 to about 40 g*in/in^2, from about 6.5 g*in/in^2 to about 30 g*in/in^2, from about 7 g*in/in^2 to about 20 g*in/in^2, or from about 7.5 g*in/in^2 to about 15 g*in/in^2, or from about 8 g*in/in^2 to about 12 g*in/in^2, specifically reciting all increments of 0.5 g*in/in^2 within the above-recited ranges and all ranges formed therein or thereby;

a CD elongation (dry) of greater than about 5%, of greater than about 8%, of greater than about 12%, of greater than about 13.5%, or from about 5% to about 25%, from about 10% to about 20%, from about 12 % to about 18%, from about 13% to about 17%, or from about 14% to about 16%, specifically reciting all increments of 0.5% within the above-recited ranges and all ranges formed therein or thereby;

a CD TEA of greater than about 35 in-g/in^2, of greater than about 32 in-g/in^2, or from about 5 in-g/in^2 to about 100 in-g/in^2, from about 15 in-g/in^2 to about 75 in-g/in^2, from about 25 in-g/in^2 to about 50 in-g/in^2, from about 32 in-g/in^2 to about 45 in-g/in^2, from about 33 in-g/in^2 to about 40 in-g/in^2, from about 34 in-g/in^2 to about 38 in-g/in^2, specifically reciting all increments of 1 in-g/in^2 within the above-recited ranges and all ranges formed therein or thereby;

a dry CD tensile modulus / dry CD tensile peak load (derived from the appropriate of: 1) Dry Elongation, Tensile Strength, TEA and Modulus Test Methods for Toilet Paper, 2) Dry Elongation, Tensile Strength, TEA and Modulus Test Methods for Paper Towels, or 3) Dry Elongation, Tensile Strength, TEA and Modulus Test Methods for Facial Tissue) less than about 5.0 g/g, less than about 4.5 g/g, less than about 4.0 g/g, less than about 3.5 g/g, less than about 3.0 g/g, from about 5.0 g/g to about 2.5 g/g, from about 4.0 g/g to about 2.0 g/g, or from about 3.5 g/g to about 1.5 g/g, specifically reciting all increments of 0.1 g/g within the above-recited ranges and all ranges formed therein or thereby;

a wet CD tensile modulus / wet CD tensile peak load less than about 5.0 g/g, less than about 4.5 g/g, less than about 4.25 g/g, less than about 4.0 g/g, less than about 3.75 g/g, less than about 3.5 g/g, less than about 3.25 g/g, less than about 3.0 g/g, less than about 2.5 g/g, less than about 2 g/g, from about 5.0 g/g to about 2.5 g/g, from about 4.0 g/g to about 2.0 g/g, or from about 3.5 g/g to about 1.5 g/g, specifically reciting all increments of 0.1 g/g within the above-recited ranges and all ranges formed therein or thereby;

a CD modulus (dry) of less than about 2000 g/cm, of less than about 2400 g/cm, of less than about 2500 g/cm, of less than about 3270 g/cm, or from about 200 g/cm to about 5000 g/cm, or from about 1000 g/cm to about 4500 g/cm, or from about 2000 g/cm to about 4000 g/cm, or from about 3000 g/cm to about 4000 g/cm, or from about 3270 g/cm to about 3800 g/cm, or from about 3300 g/cm to about 3700 g/cm, or from about 3350 g/cm to about 3600 g/cm, or from about 3400 g/cm to about 3500 g/cm, specifically reciting all increments of 1 g/cm within the above-recited ranges and all ranges formed therein or thereby;

an MD modulus (dry) of less than about 3360 g/cm, or less than about 1750 g/cm or from about 500 g/cm to about 6000 g/cm, or from about 1000 g/cm to about 5000 g/cm, or from about 2000 g/cm to about 4000 g/cm, or from about 3000 g/cm to about 4000 g/cm, or from about 3360 g/cm to about 3800 g/cm, or from about 3400 g/cm to about 3700 g/cm, or from about 3450 g/cm to about 3600 g/cm, or from about 3500 g/cm to about 3600 g/cm, specifically reciting all increments of 1 g/cm within the above-recited ranges and all ranges formed therein or thereby;

a TS7 of less than about 40.00 dB V^2 rms , or less than about 30.00 dB V^2 rms, or less than about 22.00 dB V^2 rms, or less than about 20.00 dB V^2 rms, or less than about 24.00 dB V^2 rms, or less than about 15.00 dB V^2 rms, or less than about 14.00 dB V^2 rms, or less than about 10.00 dB V^2 rms, or less than about 8.00 dB V^2 rms, or greater than about 5.00 dB V^2 rms, or between about 3.00 dB V^2 rms and about 40.00 dB V^2 rms ("between about 'X' and about 'X'" is used interchangeably with "from about 'X' to about 'X'"), or between about 3.00 dB V^2 rms and about 20.00 dB V^2 rms, or between about 4.00 dB V^2 rms and about 30 dB V^2 rms, or between about 15.00 dB V^2 rms and about 30.00 dB V^2 rms, or between about 5.00 dB V^2 rms and about 20.00 dB V^2 rms, or between about 6.00 dB V^2 rms and about 14 dB V^2 rms, or between about 7.00 dB V^2 rms and about 12.00 dB V^2 rms, or between about 8.00 dB V^2 rms and about 11.50 dB V^2 rms, or between about 9.0 dB V^2 rms and about 11.00 dB V^2 rms, or between about 9.50 dB V^2 rms and about 10.50 dB V^2 rms, between about 9.50 dB V^2 rms and about 10.00 dB V^2 rms, between about 15 dB V^2 rms and about 17 dB V^2 rms, or between about 15 dB V^2 rms and about 16 dB V^2 rms, specifically reciting all increments of 0.01 dB V^2 rms within the above-recited ranges and all ranges formed therein or thereby;

a compressive slope of less than about 14.0 mil/g, or less than about 3.0 mil/g, or less than about 4.0 mil/g, or less than about 5.0 mil/g, or less than about 6.0 mil/g, or less than about 7.0 mil/g, or less than about 8.0 mil/g, or less than about 9.0 mil/g, or greater than about 12.0 mil/g 8, or greater than about 11.0 mil/g, or greater than about 12.0 mil/g, or between about 4.0 mil/g and about 10.0 mil/g, or between about 8.0 mil/g and about 12.0 mil/g, or between about 6 mil/g and about 14.0 mil/g, or between about 8.0 mil/g and about 14 mil/g, or between about 7.5 mil/g and about 11 mil/g, or between about 12.0 mil/g and about 3.0 mil/g, or between about 11.0 mil/g and about 5.0 mil/g ,or between about 10.0 mil/g and about 4.0 mil/g, or between about 8.0 mil/g and about 5.0 mil/g, specifically reciting all increments of 0.01 mil/g within the above-recited ranges and all ranges formed therein or thereby;

a formation index of less than about 170, or less than about 90, or less than about 65, or greater than about 30, or greater than about 50, or between about 55 and about 165, or between about 55 and about 85, or between about 60 and about 80, or between about 65 and about 75, specifically reciting all increments of 0.1 within the above-recited ranges and all ranges formed therein or thereby;

a coverage of less than about 10 fiber layers (making up a layer 55 of a ply 53), or less than about 9 fiber layers, or less than about 8 fiber layers, or less than about 7 fiber layers, or less than about 6 fiber layers, or less than about 5 fiber layers, or less than about 4 fiber layers, or greater than about 2 fiber layers, or greater than about 4.75 fiber layers, or greater than about 5 fiber layers, or greater than about 5,25 fiber layers, or greater than about 5.5 fiber layers, or greater than about 5.75 fiber layers, or greater than about 6 fiber layers, or greater than about 6.25 fiber layers, or greater than about 6.5 fiber layers, or greater than about 7 fiber layers, or greater than about 7.25 fiber layers, or greater than about 7.5 fiber layers, or greater than about 7.75 fiber layers, or greater than about 8 fiber layers, or greater than about 8.25 fiber layers, or greater than about 8.5 fiber layers, or greater than about 9 fiber layers, or between about 2 and about 10 fiber layers, or between about 4 and about fiber 9 fiber layers, or between about 5 and about fiber 8 fiber layers, or between about 4 and about fiber 7 fiber layers, specifically reciting all increments of 1 fiber layer within the above-recited ranges and all ranges formed therein or thereby;

a coarseness (according to the Coverage and Fiber Count Test Method) of less than about 0.35 mg/m, or less than about 0.30 mg/m, or less than about 0.25 mg/m, or less than about 0.20 mg/m, or greater than about 0.13 mg/m, or greater than about 0.14 mg/m, or greater than about 0.15 mg/m, or greater than about 0.16 mg/m, or greater than about 0.17 mg/m, or between about 0.15 mg/m and about 0.35 mg/m, or between about 0.15 mg/m and about 0.30 mg/m, or between about 0.16 mg/m and about 1.7 mg/m, or between about 0.15 mg/m and about 0.17 mg/m, or

between about 0.15 mg/m and about 0.20 mg/m, or between about 0.25 mg/m and about 0.26 mg/m, or between about 0.22 mg/m and about 0.3 mg/m, or between about 0.19 mg/m and about 0.32 mg/m, specifically reciting all increments of 0.01 mg/m within the above-recited ranges and all ranges formed therein or thereby;

a lint value of less than about 11, or less than about 10, or less than about 9, or less than about 8, or less than about 7, or less than about 6, or less than about 5, or greater than about 0.5, greater than about 4.1, greater than about 6, or between about 0.5 and about 11, or between about 0.7 and about 11, or between about 7.5 and about 10.5, or between about 4 and about 5.5, or between about 6.3 and about 7.7, or between about 3 and about 10, or between about 4 and about 9, or between about 5 and about 8, or between about 6 and about 8, specifically reciting all increments of 0.01 (Hunter L value) within the above-recited ranges and all ranges formed therein or thereby;

a fiber length of less than about 4 mm, of less than about 3 mm, of less than about 2.3 mm, or less than about 2.2 mm, or less than about 2.1 mm, or less than about 2.0 mm, or less than about 1.9 mm, or less than about 1.5 mm, or less than about 1.4, or greater than about 0.7, or greater than about 1, or greater than about 2 mm or between about 0.6 mm and about 2.4 mm, or between about 0.7 mm and about 2.2 mm, or between about 0.8 mm and about 2 mm, or between 2.5 mm and 3.7 mm, or between about 0.9 mm and about 1.8 mm, or between about 1 mm and about 1.6 mm, or between about 1.1 mm and about 1.5 mm, or between about 1.1 mm and about 1.4 mm, or between about 1.1 mm and about 1.3 mm, specifically reciting all increments of 0.01 mm within the above-recited ranges and all ranges formed therein or thereby;

a fiber width of less than about 31 um, or less than about 28 um, or less than about 25 um, or less than about 22 um, or less than about 20 um, or greater than about 8 um, or between about 7 um and about 32 um, or between about 8 um and about 31 um, or between about 10 um and about 28 um, or between about 12 um and about 26 um, or between about 14 um and about 24 um, or between about 16 um and about 22 um, or between about 22 um and about 27 um, or between about 25 um and about 31 um, or between about 15 um and about 19 um, or between about 18 um and about 20 um, or between about 7.5 um and about 9.5 um, specifically reciting all increments of 0.1 um within the above-recited ranges and all ranges formed therein or thereby;

a fiber length/width ratio (according to the Fiber Length, Width, Coarseness, and Fiber Count Test Method) of less than about 190, or less than about 180, or less than about 170, or less than about 160, or less than about 150, or less than about 140, or less than about 130, or less than about 120, or less than about 110, or less than about 106, or less than about 100, or less than about 75, or less than about 50, or greater than about 40, or between about 190 and about 35, or between

about 185 and about 40, or between about 175 and about 50, or between about 150 and about 75, or between about 125 and about 100, specifically reciting all increments of 1 within the above-recited ranges and all ranges formed therein or thereby;

a fiber count (length average) of less than about 30 fibers/g, or less than about 25 fibers/g, or less than about 20 fibers/g, or less than about 16 fibers/g, or less than about 15 fibers/g, or less than about 14 fibers/g, or less than about 13 fibers/g, or less than about 10 fibers/g, or greater than about 3 fibers/g, or between about 2.75 fibers/g and about 5 fibers/g, or between about 3 fibers/g and about 35 fibers/g, or between about 3.5 fibers/g and about 30 fibers/g, or between about 5 fibers/g and about 25 fibers/g, or between about 10 fibers/g and about 20 fibers/g, or between about 10 fibers/g and about 15 fibers/g, specifically reciting all increments of 0.1 fibers/g within the above-recited ranges and all ranges formed therein or thereby;

a fiber count (number average) of less than about 30 fibers/g, or less than about 25 fibers/g, or less than about 20 fibers/g, or less than about 16 fibers/g, or less than about 15 fibers/g, or less than about 14 fibers/g, or less than about 13 fibers/g, or less than about 10 fibers/g, or greater than about 3 fibers/g, or greater than about 8.9 fibers/g, or between about 3 fibers/g and about 35 fibers/g, or between about 3.5 fibers/g and about 30 fibers/g, or between about 5 fibers/g and about 25 fibers/g, or between about 10 fibers/g and about 20 fibers/g, or between about 10 fibers/g and about 15 fibers/g, specifically reciting all increments of 0.1 fibers/g within the above-recited ranges and all ranges formed therein or thereby;

fiber count-area (C(n)) of greater than about 800 million/m^2, greater than about 830 million/m^2, greater than about 850 million/m^2, greater than about 900 million/m^2, greater than about 950 million/m^2, greater than about 1,000 million/m^2, or less than about 1,050 million/m^2, less than about 950 million/m^2, or from about 800 million/m^2 to about 1,000 million/m^2, from about 850 million/m^2 to about 975 million/m^2, specifically reciting all increments of 1 million/m^2 within the above-recited ranges and all ranges formed therein or thereby;

fiber count-area (C(l)) of greater than about 260 million/m^2, greater than about 280 million/m^2, greater than about 300 million/m^2, greater than about 350 million/m^2, greater than about 400 million/m^2, greater than about 450 million/m^2, greater than about 500 million/m^2, greater than about 525 million/m^2, or less than about 530 million/m^2, less than about 500 million/m^2, less than about 400 million/m^2, or from about 260 million/m^2 to about 530 million/m^2, from about 260 million/m^2 to about 400 million/m^2, from about 260 million/m^2 to about 400 million/m^2, specifically reciting all increments of 1 million/m^2 within the above-recited ranges and all ranges formed therein or thereby;

a tensile ratio (also called "dry tensile ratio," see the Dry Elongation, Tensile Strength, TEA and Modulus Test Methods below) of less than about 4.5, or less than about 4, or less than about 3.5, or less than about 3, or less than about 2.5, or less than about 2.1, or less than about 2, or less than about 1.9, or less than about 1.7, or greater than about 0.5, or greater than about 1.3, or greater than about 1.6, or greater than about 2, or greater than about 2.5, or between about 0.4 and about 0.5, or between about 0.5 and about 4.5, or between about 1.1 and about 1.6, or between about 1.25 and about 3, or between about 1.8 and about 2.4, or between about 1 and about 3, or between about 1.2 and about 2.1, or between about 1.5 and about 2, or between about 1.7 and about 2, specifically reciting all increments of 0.01 within the above-recited ranges and all ranges formed therein or thereby;

an Emtec TS750 of greater than about 10 dB V^2 rms, or greater than about 20 dB V^2 rms, or greater than about 40 dB V^2 rms, or greater than about 47.7 dB V^2 rms, or greater than about 50 dB V^2 rms, or greater than about 75 dB V^2 rms, or less than about 115 dB V^2 rms, or less than about 20 dB V^2 rms, or less than about 40 dB V^2 rms, or less than about 45 dB V^2 rms, or less than about 60 dB V^2 rms, or less than about 80 dB V^2 rms, or between about 10 dB V^2 rms and about 120 dB V^2 rms, or between about 14 dB V^2 rms and about 113 dB V^2 rms, or between about 14 dB V^2 rms and about 75 dB V^2 rms, or between about 50 dB V^2 rms and about 112 dB V^2 rms, or between about 15 dB V^2 rms and about 50 dB V^2, or between about 16 dB V^2 rms and about 40 dB V^2, or between about 20 dB V^2 rms and about 30 dB V^2, or between about 25 dB V^2 rms and about 35 dB V^2, or between about 40 dB V^2 rms and about 55 dB V^2, specifically reciting all increments of 1 dB V^2 rms within the above-recited ranges and all ranges formed therein or thereby;

a slip stick of greater than about 235, or greater than about 270 greater than about 300, or greater than about 350, or greater than about 400, or greater than about 500, or greater than about 600, or greater than about 700, greater than about 800, or greater than about 900, or less than about 435, or less than about 605, or less than about 1000, or between about 230 and about 1400, or between about 235 and about 435, or between about 235 and about 605, or between about 280 and about 965, or between about 300 and about 800, or between about 350 and about 500, or between about 400 and about 600, specifically reciting all increments of 10 within the above-recited ranges and all ranges formed therein or thereby;

a density of a first zone (a first region) or a pillow zone may be different than a density of a second zone (a second region or a knuckle zone), which is adjacent to the first zone, such that the density of a second zone (a second region or a knuckle zone) may be 5%, 10%, 15%, 20%, 30%, 40%, 50%, 75%, 100%, 125%, 150%, 175%, or 200% greater than the first zone (first region or pillow zone), specifically reciting all increments of 0.01% within the above-recited ranges and all

ranges formed therein or thereby (the Micro-CT Intensive Property Measurement Method can be used to determine density of an area of interest);

a Runkel Ratio of greater than about 1, or greater than about 2, or greater than about 3, or greater than about 5, or greater than about 6, or greater than about 7, or less than about 10, between about 0.5 and about 10, or between about 1 and about 8, or between about 1.5 and about 6.5, specifically reciting all increments of 0.1 within the above-recited ranges and all ranges formed therein or thereby;

a 2.5-160 micron PVD desorption of less than about 1600 mg, or less than about 1550 mg, or less than about 1500 mg, or less than about 1400 mg, or less than about 1300 mg, or less than about 1200 mg, or less than about 1100 mg, or less than about 1000 mg, or less than about 900 mg, or less than about 800 mg, or less than about 700 mg, or less than about 600 mg, or greater than about 550 mg, or between about 550 mg and about 1600 mg, or between about 600 mg and about 1550 mg, or between about 700 mg and about 1550 mg, or between about 825 mg and about 1550 mg, or between about 850 mg and about 1500 mg, or between about 900 mg and about 1400 mg, or between about 1000 mg and about 1200 mg, specifically reciting all increments of 1 mg within the above-recited ranges and all ranges formed therein or thereby;

a 2.5-160 micron PVD absorption of less than about 1200 mg, or less than about 1100 mg, or less than about 1000 mg, or less than about 900 mg, or greater than about 400 mg, or greater than about 800 mg, or greater than about 825 mg, or between about 400 mg and about 1200 mg, or between about 500 mg and about 1200 mg, or between about 600 mg and about 1200 mg, or between about 700 mg and about 1200 mg, or between about 800 mg and about 1200 mg, or between about 900 mg and about 1100 mg, specifically reciting all increments of 1 mg within the above-recited ranges and all ranges formed therein or thereby;

a VFS of greater than about 4 g/g, or greater than about 5.5 g/g, or greater than about 6.0 g/g, or greater than about 7.0 g/g, or greater than about 7.3 g/g, or greater than about 7.5 g/g, or greater than about 8 mg, or greater than about 8.5 g/g, or greater than about 9 g/g, or greater than about 9.5 g/g, or greater than about 10 g/g, or greater than about 10.5 g/g, or greater than about 11 g/g, or greater than about 11.5 g/g, or greater than about 12 g/g, or greater than about 12.5 g/g, or less than about 13 g/g, or between about 4 g/g and about 15 g/g, or between about 5 g/g and about 11 g/g, or between about 10 g/g and about 15 g/g, or between about 7 g/g and about 13 g/g, or between about 7.5 g/g and about 13 g/g, or between about 8 g/g and about 13 g/g, or between about 9 g/g and about 13 g/g, or between about 10 g/g and about 13 g/g, or between about 10.5 g/g and about 12.5 g/g, or between about 10 g/g and about 12 g/g, or between about 10.5 g/g and about

11.5 g/g, reciting all increments of 0.1 g/g within the above-recited ranges and all ranges formed therein or thereby;

a residual water of less than about 10%, less than about 9%, less than about 7%, less than about 5%, less than about 4%, less than about 3.5%, from about 1% to about 20%, from about 2% to about 18%, from about 3% to about 16%, from about 4% to about 14%, from about 5% to about 12%, from about 6% to about 10%, from about 1% to about 3%, or from about 1% to about 2%, specifically reciting all increments of 0.1% within the above-recited ranges and all ranges formed therein or thereby;

a basis weight of at least about 48 g/m^2(i.e., gsm), of between about 10 g/m^2 and about 100 g/m^2, or between about 10 g/m^2 and about 45 g/m^2, between about 20 g/m^2 and about 40 g/m^2, or between about 24 g/m^2 and about 40 g/m^2, or between about 30 g/m^2 and about 32 g/m^2, or between about 40 g/m^2 and about 65 g/m^2, or between about 45 g/m^2 and about 60 g/m^2, or between about 50 g/m^2 and about 58 g/m^2, or between about 50 g/m^2 and about 55 g/m^2, or between about 50 g/m^2 and about 75 g/m^2, specifically reciting all increments of 0.1 g/m^2 within the above-recited ranges and all ranges formed therein or thereby;

a density (based on measuring caliper at 95 g/in^2) of less than about 0.60 g/cm^3 and/or less than about 0.30 g/cm^3 and/or less than about 0.20 g/cm^3 and/or less than about 0.10 g/cm^3 and/or less than about 0.07 g/cm^3 and/or less than about 0.05 g/cm^3 and/or from about 0.01 g/cm^3 to about 0.20 g/cm^3 and/or from about 0.02 g/cm^3 to about 0.10 g/cm^3, specifically reciting all increments of 0.001 g/cm^3 within the above-recited ranges and all ranges formed therein or thereby;

a bulk (also called "dry bulk," based on measuring caliper at 95 g/in^2) of greater than about 1.67 cm^3/g and/or greater than about 3.33 cm^3/g and/or greater than about 5.00 cm^3/g and/or greater than about 10.00 cm^3/g and/or greater than about 14.29 cm^3/g and/or greater than about 15.0 cm^3/g and/or greater than about 18.0 cm^3/g and/or greater than about 20.00 cm^3/g and/or from about 100.00 cm^3/g to about 5.00 cm^3/g and/or from about 50.00 cm^3/g to about 10.00 cm^3/g, specifically reciting all increments of 0.01 cm^3/g within the above-recited ranges and all ranges formed therein or thereby (Note: This is distinct from "Dry Bulk Ratio" and "Resilient Bulk.");

an SST (absorbency rate) of greater than about 0.3 $g/sec^{0.5}$, or greater than about 0.4 $g/sec^{0.5}$, or greater than about 0.45 $g/sec^{0.5}$, or greater than about 0.5 $g/sec^{0.5}$, or greater than about 0.75 $g/sec^{0.5}$, or greater than about 1.0 $g/sec^{0.5}$, or greater than about 1.60 $g/sec^{0.5}$, or greater than about 1.65 $g/sec^{0.5}$, or greater than about 1.70 $g/sec^{0.5}$, or greater than about 1.75 $g/sec^{0.5}$, or greater than about 1.80 $g/sec^{0.5}$, or greater than about 1.82 $g/sec^{0.5}$, or greater than about 1.85 $g/sec^{0.5}$, or greater

than about 1.88 g/sec$^{0.5}$, or greater than about1.90 g/sec$^{0.5}$, or greater than about 1.95 g/sec$^{0.5}$, or greater than about 2.00 g/sec$^{0.5}$, or between about 1.60 g/sec$^{0.5}$ and about 2.50 g/sec$^{0.5}$, between about 1.0 g/sec$^{0.5}$ and about 2.0 g/sec$^{0.5}$, or between about 2.0 g/sec$^{0.5}$ and about 2.50 g/sec$^{0.5}$, or between about 0.3 g/sec$^{0.5}$ and about 0.7 g/sec$^{0.5}$, or between about 1.0 g/sec$^{0.5}$ and about 1.50 g/sec$^{0.5}$, or between about 0.3 g/sec$^{0.5}$ and about 0.9 g/sec$^{0.5}$, or between about 1.65 g/sec$^{0.5}$ and about 2.50 g/sec$^{0.5}$, or between about 1.70 g/sec$^{0.5}$ and about 2.40 g/sec$^{0.5}$, or between about 1.75 g/sec$^{0.5}$ and about 2.30 g/sec$^{0.5}$, or between about 1.80 g/sec$^{0.5}$ and about 2.20 g/sec$^{0.5}$, or between about 1.82 g/sec$^{0.5}$ and about 2.10 g/sec$^{0.5}$, or between about 1.85 g/sec$^{0.5}$ and about 2.00 g/sec$^{0.5}$, specifically reciting all increments of 0.1 g/sec$^{0.5}$ within the above-recited ranges and all ranges formed therein or thereby;

a plate stiffness of greater than about 0.3 N*mm, or greater than about 0.5 N*mm, or greater than about 1.0 N*mm, or greater than about 2.0 N*mm, or greater than about 4.0 N*mm, or greater than about 6.0 N*mm, or greater than about 8.0 N*mm, or greater than about 12.0 N*mm, or greater than about 12.5 N*mm, or greater than about 13.0 N*mm, or greater than about 13.5 N*mm, or greater than about 14 N*mm, or greater than about 14.5 N*mm, or greater than about 15 N*mm, or greater than about 15.5 N*mm, or greater than about 16 N*mm, or greater than about 16.5 N*mm, or greater than about 17 N*mm, or between about 0.3 N*mm and about 20 N*mm, or between about 1 N*mm and about 20 N*mm, or between about 2 N*mm and about 20 N*mm, or between about 4 N*mm and about 20 N*mm, or between about 6 N*mm and about 20 N*mm, or between about 8 N*mm and about 20 N*mm, or between about 10 N*mm and about 20 N*mm, or between about 12 N*mm and about 20 N*mm, or between about 12.5 N*mm and about 20 N*mm, or between about 13 N*mm and about 20 N*mm, or between about 13.5 N*mm and about 20 N*mm, or between about 14 N*mm between about 20 N*mm, or between about 14.5 N*mm and about 20 N*mm, or between about 15 N*mm and about 20 N*mm, or between about 15.5 N*mm and about 20 N*mm, or between about 16 N*mm and about 20 N*mm, or between about 16.5 N*mm and about 20 N*mm, or between about 17 N*mm and about 20 N*mm, specifically reciting all increments of 0.1 N*mm within the above-recited ranges and all ranges formed therein or thereby;

a resilient bulk of greater than about 25 cm^3/g, or greater than about 29 cm^3/g, or greater than about 40 cm^3/g, or greater than about 50 cm^3/g, or greater than about 60 cm^3/g, or greater than about 62 cm^3/g, or greater than about 75 cm^3/g, or greater than about 85 cm^3/g, or greater than about 90 cm^3/g, or greater than about 95 cm^3/g, or greater than about 100 cm^3/g, or greater than about 102 cm^3/g, or greater than about 105 cm^3/g, or between about 29 cm^3/g and about 112 cm^3/g, or between about 29 cm^3/g and about 103 cm^3/g, or between about 40 cm^3/g and about 100 cm^3/g,

or between about 50 cm^3/g and about 75 cm^3/g, or between about 55 cm^3/g and 70 cm^3/g, or between about 85 cm^3/g and about 110 cm^3/g, or between about 90 cm^3/g and about 110 cm^3/g, or between about 95 cm^3/g and about 110 cm^3/g, or between about 100 cm^3/g and about 110 cm^3/g, specifically reciting all increments of 1 cm^3/g within the above-recited ranges and all ranges formed therein or thereby;

a total wet tensile of greater than about 50 g/in, or greater than about 75 g/in, or greater than about 100 g/in, or greater than about 200 g/in, or greater than about 300 g/in, or greater than about 400 g/in, or greater than about 450 g/in, or greater than about 470 g/in, or greater than about 500 g/in, or greater than about 550 g/in, or greater than about 600 g/in, or greater than about 650 g/in, or greater than about 700 g/in, or greater than about 750 g/in, or greater than about 758 g/in, or greater than about 800 g/in, or greater than about 850 g/in, or greater than about 900 g/in, or greater than about 2278.or between about 350 g/in and about 475 g/in, or between about 420 g/in and about 440 g/in, or between about 100 g/in and about 640 g/in, or between about 300 g/in and about 1000 g/in, or between about 400 g/in and about 900 g/in, or between about 500 g/in and about 900 g/in, or between about 550 g/in and about 900 g/in, or between about 600 g/in and about 900 g/in, or between about 650 g/in and about 900 g/in, or between about 700 g/in and about 900 g/in, specifically reciting all increments of 10 g/in within the above-recited ranges and all ranges formed therein or thereby;

a total wet tensile (Finch) of greater than about between about 10 g/in and about 125 g/in, or between about 20 g/in and about 55 g/in, or between about 30 g/in and about 100 g/in, or between about 10 g/in and about 65 g/in, specifically reciting all increments of 1 g/in within the above-recited ranges and all ranges formed therein or thereby;

a dry burst (peak load) strength of greater than about 250 g, or greater than about 400 g, or greater than about 600 g, or greater than about 800 g, or greater than about 1000 g, or greater than about 1200 g, or greater than about 1300 g, or greater than about 1400 g, or between about 250 g and about 1500 g, or between about 400 g and about 1500 g, or between about 600 g and about 1500 g, or between about 800 g and about 1450 g, or between about 1000 g and about 1400 g;

a wet burst (peak load) strength of greater than about 3 g, greater than about 5 g, or greater than about 10 g, or greater than about 20 g, or greater than about 50 g, or greater than about 55 g, or greater than about 75 g, or greater than about 100 g, or greater than about 115 g, or greater than about 150 g, or greater than about 177 g, or greater than about 200 g, or greater than about 300 g, or greater than about 350 g, or greater than about 400 g, or greater than about 450 g, or greater than about 478 g, or greater than about 500 g, or greater than about 550 g, or greater than about 600 g, or between about 20 g and about 530 g, or between about 3 g and about 22 g, or between about 25

g and about 52 g, or between about 230 g and about 525 g, or between about 180 g and about 525 g, or between about 200 g and about 700 g, or between about 350 g and about 600 g, or between about 350 g and about 550 g, or between about 400 g and about 550 g, or between about 400 g and about 525 g, or between about 50 g and about 220 g, or between about 50 g and about 60 g, or between about 50 g and 55 g, specifically reciting all increments of 10 g within the above-recited ranges and all ranges formed therein or thereby;

a flexural rigidity (avg.) of greater than about 40 mg-cm, greater than about 75 mg-cm, greater than about 175 mg-cm, 100, greater than about 125 mg-cm, greater than about 150 mg-cm, greater than about 175 mg-cm, greater than about 200 mg-cm, or greater than about 700 mg-cm, or greater than about 800 mg-cm, or greater than about 900 mg-cm, or greater than about 1000 mg-cm, or greater than about 1100 mg-cm, or greater than about 1200 mg-cm, or greater than about 1300 mg-cm, or greater than about 1400 mg-cm, or greater than about 1500 mg-cm, or greater than about 1600 mg-cm, or greater than about 1700 mg-cm, or between about 40 mg-cm and about 200 mg-cm, or between about 60 mg-cm and about 150 mg-cm, or between about 80 mg-cm and about 125 mg-cm, or between about 80 mg-cm and about 100 mg-cm, or between about 700 mg-cm and about 1800 mg-cm, or between about 800 mg-cm and about 1600 mg-cm, or between about 900 mg-cm and about 1400 mg-cm, or between about 1000 mg-cm and about 1350 mg-cm, or between about 1050 mg-cm and about 1350 mg-cm, or between about 1100 mg-cm and about 1350 mg-cm, or between about 1100 mg-cm and about 1300 mg-cm, specifically reciting all increments of 10 mg-cm within the above-recited ranges and all ranges formed therein or thereby;

a dry caliper of greater than about 4.0 mils, or greater than about 10.0 mils, or greater than about 15.0 mils, or greater than about 20.0 mils, or than about 26.0 mils, or than about 28.0 mils, or greater than about 40 mils, or greater than about 55 mils, or between about 4.0 mils and about 27.0 mils, or between about 18.0 mils and about 24.0 mils, or between about 45.0 mils and about 51.0 mils, or between about 29 mils and about 33.0 mils, or between about 19.0 mils and about 43.0 mils, or about 26.0 mils and about 80.0 mils, or between 40.0 mils and 60.0 mils, or between about 50 and about 60 mils, specifically reciting all increments of 0.10 mils within the above-recited ranges and all ranges formed therein or thereby;

a wet caliper of greater than about 8.0 mils, or greater than about 10.0 mils, or greater than about 15.0 mils, or greater than about 17.0 mils, or greater than about 26 mils, or between about 10.0 mils and about 33.0 mils, or between about 15.0 mils and about 25.0 mils, or between about 8.0 mils and about 20.0 mils, or between about 26.0 mils and about 70.0 mils, or between about 26.0 mils and about 40.0 mils, specifically reciting all increments of 0.10 mils within the above-recited ranges and all ranges formed therein or thereby;

a total dry tensile (total tensile) of greater than about 250 g/in, or greater than about 400 g/in, or greater than about 500 g/in, or greater than about 700 g/in, or greater than about 800 g/in, or greater than about 1000 g/in, or greater than about 1200 g/in, or greater than about 1300 g/in, or greater than about 1700 g/in, or greater than about 2278 g/in, or between about 880 g/in and about 2570 g/in, or between about 1800 g/in and about 2485 g/in, or between about 1900 g/in and about 2300 g/in, or between about 250 g/in and about 1000 g/in, or between about 400 g/in and about 580 g/in, or between about 700 g/in and about 800 g/in, or between about 275 g/in and about 1310 g/in, or about 1300 g/in and about 4000 g/in, or between about 1800 g/in and about 2800 g/in, specifically reciting all increments of 10 g/in within the above-recited ranges and all ranges formed therein or thereby;

a geometric mean (GM) dry modulus of greater than about 1000 g/cm, or greater than about 1700 g/cm, or less than about 3320 g/cm, or less than about 2500 g/cm, or less than about 2400 g/cm, or less than about 2300 g/cm, or less than about 2000 g/cm, or less than about 1500 g/cm, or less than about 1000 g/cm, or between about 1800 g/cm and about 4000 g/cm, or between about 1800 g/cm and about 3500 g/cm, or between about 3300 g/cm and about 3350 g/cm, specifically reciting all increments of 10 g/cm within the above-recited ranges and all ranges formed therein or thereby;

a wet tensile geometric mean (GM) modulus of greater than about 250 g/cm, or greater than about 375 g/cm, or between about 250 g/cm and about 700 g/cm, or between about 250 g/cm and about 525 g/cm, or between about 375 g/cm and 525 g/cm, specifically reciting all increments of 10 g/cm within the above-recited ranges and all ranges formed therein or thereby;

a CRT rate of greater than about 0.30 g/sec, or greater than about 0.5 g/sec, or greater than about 0.55 g/sec, or greater than about 0.6 g/sec, or greater than about 0.61 g/sec, or greater than about 0.65 g/sec, or greater than about 0.7 g/sec, or greater than about 0.75 g/sec, or greater than about 0.8 g/sec, or between about 0.30 g/sec and about 1.00 g/sec, or between about 0.61 g/sec and about 0.85 g/sec, specifically reciting all increments of 0.05 g/sec within the above-recited ranges and all ranges formed therein or thereby;

a CRT capacity of greater than about 10.0 g/g, or greater than about 12.5 g/g, or between about 12.5 g/g and about 23.0 g/g, or between about 16.5 g/g and about 21.5 g/g, specifically reciting all increments of 0.1 g/g within the above-recited ranges and all ranges formed therein or thereby; a kinetic CoF of greater than about 0.75, or greater than about 0.85, or between about 0.85 and about 1.30, or between about 0.77 and about 1.7, or between about 0.85 and about 1.20, specifically reciting all increments of 0.05 within the above-recited ranges and all ranges formed therein or thereby;

a dry depth of more negative than -240 um, or more negative than -255um, or more negative than -265um, or more negative than -275um, or more negative than -285um, or more negative than -295um, or more negative than -300um, or between about -240um and about -310 um, or between about -245 um and about -305 um, or between about -255 um and about -303 um, or between about -265 um and about -302 um, or between about -275 um and about -300 um, specifically reciting all increments of 20 um within the above-recited ranges and all ranges formed therein or thereby;

a moist depth of more negative than -275um, or more negative than -285 um, or more negative than -295 um, or more negative than -300 um, or more negative than -310 um, or more negative than -320 um, or more negative than -330 um, or between about -275 um and about -340 um, or between about -285 um and about -335 um, or between about -295 um and about -332 um, or between about -300 um and about -330 um, or between about -305um and about -328 um, specifically reciting all increments of 20 um within the above-recited ranges and all ranges formed therein or thereby;

a moist contact area of greater than 25%, or greater than 27%, or greater than 29%, or greater than 31%, or greater than 32%, or greater than 34%, or greater than 36%, or between about 25% and about 38%, or between about 27% and about 37%, or between about 29% and about 36%, or between about 30% and about 35%, or between about 31% and about 34%, specifically reciting all increments of 1% within the above-recited ranges and all ranges formed therein or thereby;

a dry contact area of greater than 17%, or greater than 20%, or greater than 22%, or greater than 24%, or greater than 26%, or greater than 28%, or greater than 30%, or between about 17% and about 33%, or between about 20% and about 31%, or between about 22% and about 30%, or between about 23% and about 30%, or between about 24% and about 29%, specifically reciting all increments of 1% within the above-recited ranges and all ranges formed therein or thereby;

a dry compression (at 10 g force in mils) of greater than about 30 mils, or greater than about 45 mils, or greater than about 50 mils, or greater than about 55 mils, or greater than about 60 mils, or greater than about 65 mils, or greater than about 70, or greater than about 85 mils, or between about 40 mils and about 100 mils, or between about 50 mils and about 80 mils, or between about 50 mils and about 65 mils, or between about 50 mils and about 60 mils, or between about 55 mils and about 60 mils, specifically reciting all increments of 5 mil within the above-recited ranges and all ranges formed therein or thereby;

a wet compression (at 10g force value) in mils of greater than about 30 mils, or greater than about 20 mils, or greater than about 30 mils, or greater than about 40 mils, or greater than about 50 mils, or greater than about 55, or greater than about 60 mils, or greater than about 70 mils, or between about 30 mils and about 100 mils, or between about 40 mils and about 70 mils, or between

about 45 mils and about 60 mils, or between about 47 mils and about 58 mils, or between about 50 mils and about 55 mils, specifically reciting all increments of 5 mils within the above-recited ranges and all ranges formed therein or thereby;

a dry bulk ratio of greater than about 15, or greater than about 18, or greater than about 22, or greater than about 25, or greater than about 27, or greater than about 33, or greater than about 35, or greater than about 40, or greater than about 50, or between about 15 and about 60, or between about 22 and about 50, or between about 25 and about 35, or between about 27 and about 35, or between about 27 and about 33, specifically reciting all increments of 0.5 within the above-recited ranges and all ranges formed therein or thereby;

a wet bulk ratio of greater than about 20, or greater than about 22, or greater than about 25, or greater than about 28, or greater than about 30, or greater than about 34, or greater than about 40, or greater than about 45, or greater than about 50, or greater than about 55, or between about 22 and about 50, or between about 20 and about 50, or between about 25 and about 45, or between about 28 and about 40, or between about 30 and about 34, specifically reciting all increments of 0.5 inches within the above-recited ranges and all ranges formed therein or thereby;

a wet burst strength to dry tensile ratio ("wet burst/dry tensile ratio" which is wet burst strength divided by dry tensile) of greater than about 0.05, greater than about 0.09, greater than about 0.1, greater than about 0.15, greater than about 0.18, greater than about 0.20, greater than about 0.24, or greater than about 0.26, or between about 0.05 and about 0.27, or between about 0.15 and about 0.26, or between about 0.20 and about 0.26;

a wet burst strength to dry burst strength ratio ("wet/dry burst strength ratio" which is wet burst strength divided by dry burst strength) of greater than about 0.09, or greater than about 0.10, or greater than about 0.18, or greater than about 0.19, or greater than about 0.20, or greater than about 0.30, or greater than about 0.40, or between about 0.10 and about 0.50, or between about 0.20 and about 0.48, or between about 0.30 and about 0.46, or between about 0.40 and about 0.46;a concavity ratio measurement of greater than about 0.1, or greater than about 0.15, or greater than about 0.20, or greater than about 0.25, or greater than about 0.30, or greater than about 0.35, or greater than about 0.40, or greater than about 0.45, or greater than about 0.50, or greater than about 0.55, or greater than about 1.0, or greater than about 1.25, or greater than about 1.5, or between about 0.10 and about 0.95, or between about 0.15 and about 0.90, or between about 0.20 and about 0.85, specifically reciting all increments of 0.01 within the above-recited ranges and all ranges formed therein or thereby; and/or

a packing fraction measurement of greater than about 0.05, or greater than about 0.08, or greater than about 0.10, or greater than about 0.12, or greater than about 0.15, or greater than about

0.17, or between about 0.05 and about 0.75, or between about 0.10 and about 0.80, or between about 0.15 and about 0.85, specifically reciting all increments of 0.01 within the above-recited ranges and all ranges formed therein or thereby.

Fibrous structure(s) of the present disclosure comprising non-wood fibers may have one or a combination of the above properties (disclosed in this Properties of Fibrous Structure(s) Section).

Softness

Of particular interest is softness of the fibrous structure. This is where so many sustainable sanitary tissue products fail and the art does not disclose how to achieve soft fibrous structures comprising bamboo and/or other sustainable non-wood fibers. This becomes truer as non-wood fiber inclusion increases. Surprisingly, the inventors have found that adding coarse bamboo fibers (bamboo is especially coarse versus eucalyptus) into the fibrous structure, even at high inclusion levels, and/or even disposed at a consumer-facing side of a sheet, can result in products with good softness. There are a number of ways the inventors have accomplished this, including creation of differential densities, utilizing unique layering, and/or fiber mixes. Details of such are in the specification below.

Also, surprisingly, the inventors of the present disclosure have found that they are able to deliver soft fibrous structures that have low lint values. Typically, higher lint values accompany greater softness values (e.g., TS7, TS750). Beyond the difficulties of processing fibrous structures that are linty, lint can cause unwanted debris at the point of use, which can be messy and can be aesthetically undesirable. Thus, it is of great benefit to achieve greater softness while maintaining lower lint values. Thus, the inventors have not only improved sustainable fibrous structures, but have improved the general offering of fibrous structures beyond what is otherwise available today, even including what is available on the shelf today as a high-tier offerings consisting only of wood fibers. FIG. 1A illustrates TS7 values of a sanitary tissue products of the present disclosure and FIG. 1C illustrates TS7 and lint values of sanitary tissue products of the present disclosure.

Coverage

Sanitary tissue products (e.g., bath tissue sheets) are often comprised of substantial portions of eucalyptus fibers, especially at a consumer-facing layer. Thus, as one incorporates higher levels of bamboo, one is necessarily replacing the short, narrow, and low coarseness eucalyptus fibers with longer, wider, and coarser bamboo fibers.

It is known in the art that fiber coverage is an important consideration when making premium sanitary tissue products. Fiber coverage can be thought of as the average number of

fibers that would be encountered as one travels normal to the surface of the product (i.e., travels in the z-direction). Included in the calculation of fiber coverage are fiber coarseness (mg/m), fiber width (mm), and basis weight (gsm). A contradiction that paper (fibrous structures and, more particularly, sanitary tissue products) makers contend with is how to design a strong, yet soft substrate. This has previously been achieved through the judicious choice and layering of wood-based fibers. Long and easily bonded fibers such as softwoods are used in a sheet for strength, while short, thin, and low coarseness fibers such as eucalyptus are used for softness. These short, thin, and low coarseness eucalyptus fibers also provide a high level of fiber coverage in the sheet, aiding in hand protection and other aspects of absorbency.

While the art has disclosed that low coarseness bamboo can be used in toilet tissue, the inventors of the present disclosure have, surprisingly, found that adding much higher coarseness bamboo into the sheet, even at high inclusion levels, and against the consumer (i.e., on a consumer-facing surface), can result in products with good softness and low levels of lint. The bamboo fibers tested are also wider (18.9 um) than in previous examples. These coarse and wide bamboo fibers create substrates with lower fiber coverage at a given basis weight. Further, it has been surprisingly shown that the introduction of coarser, non-wood fibers such as bamboo, which create lower fiber coverage substates, can still create products that can successfully balance the traditional strength-softness contradiction. These improvements may be achieved, at least in part, through jet/wire velocity adjustments, varying levels of foreshortening at the wire/belt interface and at creping, and through creping geometry changes.

As indicated in this section above, one key part of consumer acceptance is hand protection. One way to improve hand protection is via increased fiber coverage in the sheet. This can be done by increasing basis weight or by choosing fibers that have a high specific surface area per weight. Fiber attributes that are tied to specific surface area are length, width, and coarseness. These characteristics can be used to create a stochastic model that projects fibers as rectangles laid out as bricks. Knowing the length, width, and weight of each brick then allows one to determine how much area a given weight of fibers would cover if they were arranged perfectly flat next to each other. Dividing the coarseness by fiber width results in the g/m^2-layer value. By comparing that weight per area (g/m^2) versus the actual weight per area of a sheet can give one the number of fiber layers (coverage) expected in the sheet. Of interest, when replacing eucalyptus with bamboo, the number of fiber layers (coverage) present at a given total sheet weight decreases.

Another way to address hand protection is to have a lower density sheet. At a given basis weight, lowering the density will increase the caliper of the sheet. This higher caliper will result in the hand being farther away from the material being removed, improving hand protection.

The papermaker is always conscious of manufacturing costs while striving to make superior products. Thus, the contradiction of increased weight versus fiber choice versus density is a consideration that should be kept in mind. It has surprisingly been found that the judicious layering of non-wood and/or wood fibers in a low-density sheet will allow for good hand protection.

Further relating to judicious layering, from a product quality perspective, there is a positive correlation between softness and lint. More lint generally means that the product is perceived as softer, but too much lint is not preferred by the consumer. One or two layer sanitary tissue products may be desirable because they require less equipment (fan pumps, stock chests, etc.) and simpler (single or dual layer headboxes versus a 3 layered headbox). In a one layer embodiment, and often in a two layer non-wood containing sanitary tissue product, the non-wood will be consumer facing – so, getting the right balance of softness, as characterized by lint, is critical. Adding a third layer gives another degree of freedom to the product designer, such that they could sequester part or all of the less desirable non-wood fibers in the center or non-consumer layers. A third layer also allows the Yankee contacting layer to have lower or no non-wood fibers contacting the surface. This results in a process which is easier to run, as the non-wood fibers have less interaction with the complex chemical and physical interactions with the glue coating and creping process. So, a three layered non-wood sanitary tissue product has more degrees of freedom from a design standpoint, is easier to run from a Yankee coating standpoint, and is more complex from an equipment standpoint. A one or two layer sanitary tissue product is more difficult to properly design to meet the consumer needs and more difficult to run from a Yankee coating standpoint. However, if these hurdles of a one or two layer embodiment can be overcome, they are desirable because they are made by a less complex process.

Absorption

In the design of fibrous structures, particularly sanitary tissue products, such as paper towels, bath tissue, and facial tissue, there are many characteristics that must be met in order to make a consumer desirable product. A couple of those consumer-desired characteristics are good absorbency and hand protection.

It is believed that having high volumetric absorption capacity at relatively small pore radii is consumer preferred, especially for multi-ply products, as the water that is absorbed at those small pore sizes is tenaciously held onto by the absorbent material in the product. In multi-ply constructions, these "functional" pore sizes can be between 2.5 and 200 microns. When fluid is absorbed into these pores it tends to remain in the substrate more than fluid that is taken up by larger pores.

One typical way to increase smaller pores is replacement of coarse softwood fibers with shorter, thinner, and lower coarseness hardwoods like eucalyptus. The increase in eucalyptus may be desirably balanced with the addition of softwoods such as NSK in order to maintain acceptable strength characteristics.

Upon experimentation, it has been surprisingly shown that the introduction of coarser, non-wood fibers such as bamboo can still create a high level of 2.5-200 micron (and ranges therebetween) volumetric capacity while still maintaining acceptable strength characteristics.

Desorption

Continuing with the discussion in the previous section (Absorption), without being bound by theory, regarding desorption, it is believed that having a high volumetric desorption capacity at relatively small pore radii is consumer preferred, especially for multiply products, as the water that is desorbed at those small pore sizes is water that was initially absorbed in the functional structure itself. When a wetting fluid is absorbed into a substrate, the mechanically imparted features (those imposed while the substrate is substantially dry, such as creping or embossing) relax, partially collapsing the structure. While these mechanically imparted features are important in the consumer experience, they are not resilient after fluid insult. Desorption curves can therefore be interpreted as a good characterization of the wet structure of the material. Maximizing the 2.5-200 micron (and ranges therebetween) desorption volume will result in a sheet that has a greater "functional" absorbent volume. This is a good indicator of consumer-preferred absorbency, as water that is absorbed in the structure will be less likely to come back out of the material, better protecting the consumer from the mess.

As said in the Absorption Section above, upon experimentation, it has been surprisingly shown that the introduction of coarser, non-wood fibers such as bamboo can still create a high level of 2.5-200 micron (and ranges therebetween) volumetric capacity while still maintaining acceptable strength characteristics.

VFS

Continuing with the discussion in the three previous sections (Absorption, Desorption, and Desorption-Absorption Hysteresis), it is believed that having high vertical full sheet ("VFS") absorbent capacity in a substrate is consumer preferred for absorption and hand protection. By its nature, the VFS measurement is believed to accurately characterize how much fluid is tightly held within plies of a substrate, as fluid that is in between plies, or loosely held within a ply, will drain

out when the sheet goes to the (near) vertical position. This remaining tightly held fluid is thought to be fluid that would more slowly reach the hand of a consumer, resulting in improved hand protection.

One typical way to increase the VFS of a substrate is to create structures of low coarseness fibers, which are more prone to tightly holding onto water via a finer fiber network and pore structure. Upon experimentation, it has been surprisingly shown that the introduction of coarse, non-wood fibers such as bamboo can still create high VFS capacity substrates while still maintaining acceptable strength characteristics.

Upon experimentation, it has been surprisingly shown that the introduction of coarse, non-wood fibers such as bamboo can still create high VFS capacity substrates while still maintaining acceptable strength characteristics.

Slip-Stick

Continuing with the discussion in the four previous sections (Absorption, Desorption, Desorption-Absorption Hysteresis, and VFS), related to softness, another consumer-desired characteristic is surface smoothness/glide. It is thought that having low slip-stick values in a fibrous structure is consumer preferred, as the test is a good metric for quantifying how much "glide" a substrate has. Typical design levers for improving the slip stick of a substrate is to increase smoothness via calendaring, or to replace coarser softwood fibers with shorter, thinner, and lower coarseness hardwood fibers such as eucalyptus. The increase in eucalyptus may desirably be balanced with the addition of softwoods such as NSK in order to maintain acceptable strength characteristics.

Upon experimentation, it has been surprisingly shown that the introduction of coarse, non-wood fibers such as bamboo can still create low slip stick substrates while still maintaining acceptable strength characteristics. FIG. 1B illustrates slip-stick values of a sanitary tissue products of the present disclosure.

Absorbent and Strong (Wet)

It may be desirable for sanitary tissue products of the present disclosure, such as paper towels, to be strong when wet, while also being absorbent. This combination is often a contradiction due to the underlying physics. In order to have a strong paper towel, it must be comprised of many fibers that are strong, that are strongly bonded together, and that have been treated with a chemistry that protects the bonding between fibers when wet. A structure that is designed to maximize those characteristics, however, will not absorb quickly or to a high capacity,

as the aforementioned structure would also have minimal interplay voids, retarding water absorption into the substrate. Softwood fibers, for example, are desirous for creating such structures, due to their fiber coarseness, length, and width. This source of fiber, however, is coming under increasing environmental pressure. It is therefore desirable to develop wetlaid structures with weaker, lower coarseness, fibers that still exhibit superior strength when wet and absorbency. It has surprisingly been found that, despite the often non-desirable (i.e., non-wood have much different characteristics versus conventional wood fibers and behave much differently) characteristics of non-wood fibers, it is still possible to achieve high levels of absorbency and wet strength in a non-wood containing substrate – see, for example, FIG. 2F.

Bidirectional Strength

Given the different nature of the wetlaid papermaking process to that of a woven substrate, there are many differences in the characteristics between durable substrates and sanitary tissue products. One difference in particular is the strength and durability of durable substrates vs. sanitary tissue products: the former, being comprised of woven filaments that are ostensibly continuous, exhibit very high strength when compared to the latter, which are comprised of hydrogen bonded cellulosic fibers. Directional differences in wetlaid structures are present due to the hydrodynamics of continuous forming, the use of discrete fibers, and the nonisometric forces that are imparted on the substrate during making. Often, the weaker direction of a substrate is the CD, and improving strength and stretch characteristics in that direction improves the overall consumer experience by making the paper towel less prone to failure while in use. Ways to improve CD strength and stretch characteristics include the judicious choice of papermaking fibers, balancing the ability of the fibers to bond with their strength characteristics, process settings on the papermaking machine, such as refining or forming conditions, and the distribution of the heterogenous density zones in the sheet. Refined softwood fibers, for example, are desirous for creating such structures, due to their fiber coarseness, length, and strength. This source of fiber, however, is coming under increasing environmental pressure. It is therefore desirable to develop wetlaid substrates with weaker, shorter, or lower coarseness fibers that can still be implemented in structures that exhibit high levels of bidirectional strength. It has surprisingly been found that, despite the lower coarseness, shorter fiber length, and/or narrower width of non-wood fibers, it is still possible to achieve high levels of bidirectional strength in a non-wood containing substrate.

Bulky and Strong (Wet)