

Sabit Adanur, Ph.D. | AJU Faculty

Paper Machine Clothing

Second Edition



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Paper Machine Clothing

Second Edition

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Pressing

The press section is the next part of the paper machine after the forming section. The most important functions of pressing are to increase sheet solid consistency in order to ensure adequate drying capacity, to consolidate the sheet, and enable web runnability in the early dryer sections. Increased sheet consistency increases wet strength and improves sheet consolidation and fiber-to-fiber bonding which increases sheet strength. This typically improves runnability and reduces press to dryer draw. Pressing can also have a significant impact on quality parameters such as smoothness, ink absorption, bulk, and moisture profile. The fabrics in this section are called press fabrics or press felts. The term "fabric" has a broader meaning; "felt" is a type of fabric which is made of individual fibers only, i.e., no yarn in the fabric structure. Nevertheless, the terms "press fabric" and "press felt" are used interchangeably in papermaking. Although it depends on sheet grade and paper machine, typical sheet consistency at the beginning of the press section is 20% fiber and 80% water and at the end of the press section is 45% fiber and 55% water. At the end of the press section, the sheet is transferred to the dryer section.

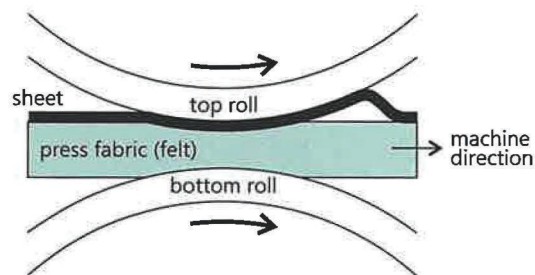


FIGURE 3.1. Schematic of simple press nip.

During pressing, the sheet is compressed between one or two fabrics and either two rolls, or a roll and a mated extended "shoe" in the press nip to squeeze water from inside the web and out of the felt fibers. Figure 3.1 shows this process in a plain press nip. Increased compression increases water removal [1-3].

The main functions of a press fabric are to support and convey the sheet through the press section, press water from the sheet, provide a medium to accept the water, maintain or impart sheet quality properties, and to drive undriven rolls. The fabric should provide proper protection for the sheet to resist crushing, shadow marking and groove marking. The amount of water that the felt can absorb and the water flow resistance are affected by the void volume (volume that is not occupied by fibers or yarns) and air and water permeability of the fabric. Low flow resistance and the ability to maintain void volume under load are important during operation. Important press fabric properties include pressure uniformity, adequate void volume, required permeability, proper compressibility, batt/base ratio, compaction resistance, abrasion resistance, strength, contaminant resistance, heat and chemical resistance.

Many machine variables can significantly impact pressing. A high sheet basis weight increases the water that must be handled by the press. A higher sheet temperature lowers water viscosity and increases sheet solids. High press impulse (kPa.sec, psi.sec), the product of mean nip pressure (kPa, psi) and nip dwell time (usually measured in ms), increases total water removal and press solids. Press impulse is also the quotient of press nip linear load (kN/m) divided

3.2 Press Fabrics

3.2.1 Press Fabric Functions

Once stock leaves the headbox, the general requirement of the paper machine is to increase the fiber consistency of the sheet from 0.2-1.5% to 92-96%. After the forming fabric, the cost of additional water removal is far less in the press section than the dryer section. Mechanically removing water in the press section by increasing nip pressures is far less costly than consuming energy in the dryer section. Therefore, the value of efficient press fabric performance cannot be overemphasized.

Water removal is not the only function of the press fabric. In general, the press fabric must:

1. Accept the water that is expressed from the sheet in the press nip.
2. Provide the proper protection for the sheet to:
 - Resist sheet crushing (rupturing the sheet due to excessive hydraulic pressures).
 - Resist shadow mark (water flow mark in the sheet caused by the difference in hydraulic pressure between the land area and open area in a vented roll cover).
 - Resist groove mark (water flow mark in the sheet caused by the difference in hydraulic pressure between the land area and open area in a grooved roll cover).
 - Resist base fabric mark (imprint of base fabric).
3. Present the proper surface to the sheet so that the necessary degree of smoothness or finish requirement is imparted to the grade of paper being manufactured. This is particularly critical on paper or board that is to be printed.
4. Transport and carry the sheet. In case of closed draws, transfer the sheet from one position to another.
5. Provide desirable durability in terms of strength, resistance to mechanical abrasion, chemical degradation, and fill-up from contaminants transferred from the sheet.
6. Drive non-driven rolls in the press section.

3.2.2 Construction of Press Fabrics

Press fabrics, in general, consist of two basic components as shown in Figure 3.5: the base fabric and the batt.

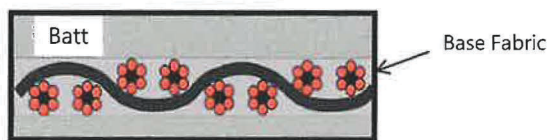


FIGURE 3.5. Typical press fabric structure.

The Base Fabric

Press fabrics are made of 100% synthetics, primarily polyamide (nylon) polymers. Base fabrics are constructed with cabled monofilament, single monofilaments (solid or hollow), or plied multifilament yarns (Figure 3.6).

With the increased use of recycled fibers in the paper stock, the use of plied multifilament yarns has greatly been reduced. Multifilament yarns tend to trap contaminants and are therefore more difficult to keep clean.



FIGURE 3.6. Yarn types.

Each yarn type has properties that influence the operational characteristics of the press fabric. They are designed into the weave of the base fabric to affect sheet quality, water removal performance, runnability, ease of cleaning and ease of installation.

Primary characteristics of the commonly used yarns are given in Table 3.2.

TABLE 3.2. Characteristics of Multifilament and Monofilament Yarns Used in Press Fabrics.

Multifilament	Monofilament
Less durable	More durable
Supple	Stiffer than multifilament
Compressible	Resists compression
Higher elongation	Less stretch than multifilament
Low resistance to chemical attack	Better resistance to chemical attack
Poor cleanability	Easier to clean

The base fabric may have a single-layer construction (one layer of MD yarns and one layer of CD yarns), a woven multilayer construction (multiple layers of MD yarns with only one layer of CD yarns), or a laminated, multiple base construction with multiple layers of both. The advantage of the multiple base construction design is that the base layers can be of different designs. They may vary in yarn count, yarn size, weave pattern, etc. For example, the top base layer can be very fine to impart the desired sheet properties and the bottom layers can be coarser in order to provide the necessary water handling properties. Laminated fabrics allow a wider range of base fabric pressure uniformity and low batt/base ratio, which is critical for open and clean operation. As paper machine speeds increase, the nip residence time decreases and better surface contact between the sheet and press fabric becomes a requirement.

The fabrics can be endless or joined with a seam. The yarn type selection and weave pattern of the base fabric are engineered to manipulate pressure uniformity, flow resistance, void volume, and compression properties. In practice, the basic classifications of press fabrics are: conventional (endless) designs, stratified (laminated) designs, and seamed fabrics. Figure 3.7 shows a few of the main types of base fabrics used in press fabrics.

Depending on construction, base fabric weight can range from 300 gsm (1.0 oz/ft²) for a single-layer base to 1099 gsm (3.6 oz/ft²) for a triple-layer or four-layer base. Total finished fabric weight can range from 1068 gsm (3.5 oz/ft²) to 2136 gsm (7.0 oz/ft²).

It should be noted that single-layer base products are quickly becoming inadequate on most paper machine applications. They simply are not durable enough to withstand the forces generated on modern machines.

Seamed fabrics have shown a substantial increase in usage since their introduction in the late 1980s. In North America, approximately 75% of all press fabrics used are seamed, and that proportion continues to grow as seam technology has proven suitable for more applications. The use of seamed fabrics in Asia and Europe is less prevalent. The primary factors for the increase in use of seamed products are safety, reduced installation time and, in some cases, improved press fabric performance. There are basically two major types of seamed products (Figure 3.8): conventionally woven base, and laminated, multiaxial base (multiaxial in that the base layers are slightly angled to one another).

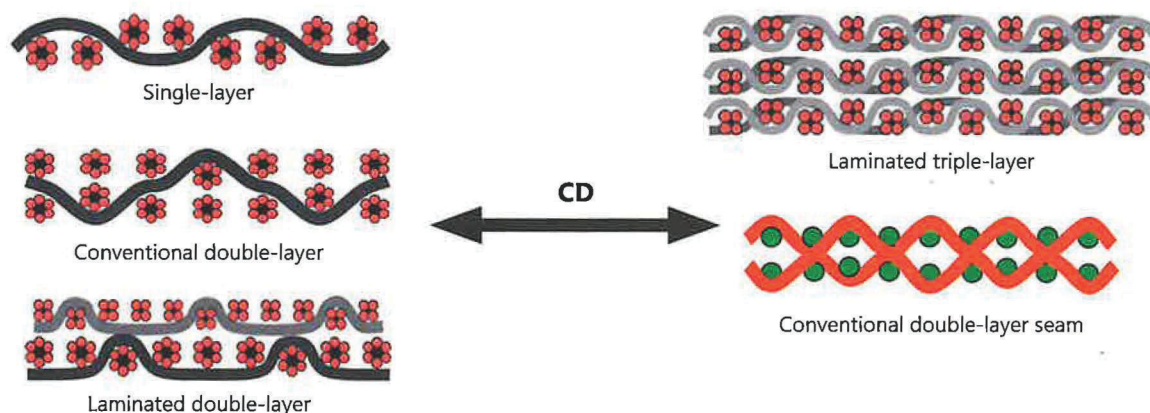


FIGURE 3.7. Major types of base structures.

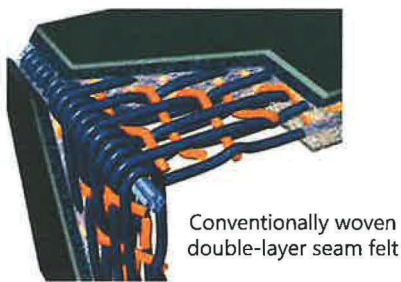


FIGURE 3.8. Seamed press fabrics.

Conventionally woven seam bases are woven endless on traditional weaving looms with the seam loops formed on one edge during the weaving process (Figure 3.9). Conventionally woven seam bases have multiple layers of MD yarns with only one layer of CD yarns that are interwoven to lock the structure together.



FIGURE 3.9. Conventionally woven seam base.

Unlike conventionally woven bases, multi-axial bases are woven flat, similar to forming and dryer fabrics. Multi-axial bases are woven on high-speed, fully computerized weaving looms. The product quality and production rates are far superior to that of a conventional weaving loom.

Multi-axial weaving looms produce approximately 1.0-meter-wide panels of base material. The panels are then bonded together to a width suitable for any paper machine. The bonding of the base panels creates a slight spiral orientation of the base material (Figure 3.10). Multi-axial base angles vary between $\sim 1\text{--}3^\circ$ depending on fabric length and seamed or endless construction. Multiple base layers are laminated together with each layer angled in the opposite direction from the previous layer.

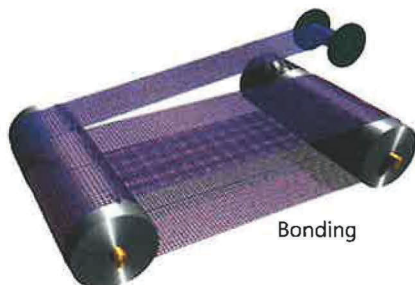


FIGURE 3.10. Multi-axial base production.

Forming the seam loops on a multi-axial base is also a different process compared to conventionally woven seamed felts. The seam loops on multi-axial products are not formed during the weaving process. After the base structure is completely bonded, the loops are formed by the removal of CD yarns on two opposite ends (180° apart) of the base. This leaves an opening in the weave pattern where the MD yarns can mesh together to form the loop. The number of CD yarns removed is dependent upon the desired length of the loops; longer loops if faster installation is the papermaker's top priority and smaller loops if mark resistance is more important (Figure 3.11).

The Batt

The process by which the batt is locked to the base fabric is called needling. The batt is first carded into a uniform web and then is applied in a series of layers onto the base fabric. The web and base fabric are fed through zones on



FIGURE 3.11. Seam loop formation on multi-axial base.

Many factors influence the selection process of the fiber denier (diameter). These include:

1. Pressure uniformity requirements
2. Water handling requirements
3. Break-in time (the time necessary for the paper machine to return to normal operating conditions)
4. Available Uhle box vacuum
5. Sheet control issues such as drop-offs, blowing, and sheet stealing
6. Fiber shedding propensity
7. Filling propensity
8. Bleed-through propensity

Fibers with different deniers can be blended or applied in stratified layers for desired performance attributes. Figure 3.14 shows the most common means of batt application. Figure 3.15 shows cross-sections of actual finished press fabrics.



Same denier batt throughout fabric



Fine denier cap over coarse fibers

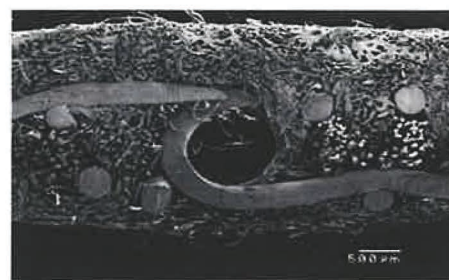


Extra fine cap over medium denier intermediate layer with coarse fibers surrounding base fabric

FIGURE 3.14. Various batt applications.



← CD →



← MD →

Seamed felt with
MD yarns forming the loops

FIGURE 3.15. Cross-sections of finished press fabrics.

3.2.3 Manufacturing of Press Fabrics

Due to the needling process, the manufacture of press fabrics is different than forming or drying fabrics. Figure 3.16 shows the major manufacturing steps for press fabrics. The diagram shows all three methods of producing base fabrics: conventional weaving, multiaxial weaving, and nonwoven base formation.

Yarn Winding and Warping

Yarns used to create base fabrics typically arrive at the manufacturing facility on large spools. They must then be transferred either onto bobbins that are inserted in shuttles for conventional weaving, or onto canisters (drums) to be put onto the back of conventional looms as warp beams (Figures 3.17 and 3.18).



FIGURE 3.17. Bobbin winding.

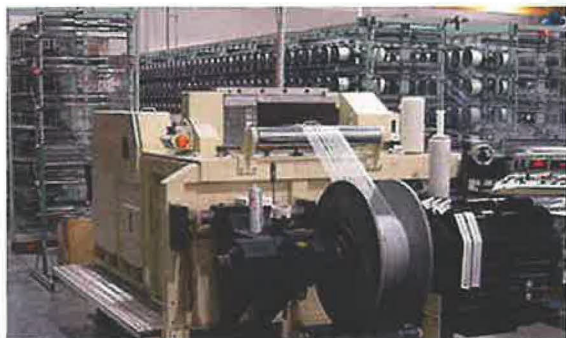


FIGURE 3.18. Warping.



FIGURE 3.19. Conventionally woven base.



FIGURE 3.20. Endless weaving loom.

Conventional Weaving

Endless fabrics are woven in a loop with the filling yarn forming the length of the fabric and the warp yarns forming the width. Fabric length will be twice the reed width (Figure 3.19 and see Figure 2.22 for view of reed in a loom). Woven loop seam fabrics are woven similar to an endless fabric; however, loops are formed at the ends of the fabric. Some looms for endless weaving are as wide as 31 m (102 ft) (Figure 3.20).

Multiaxial Weaving

Much of multiaxial weaving technology is described in Section 3.2.2 explaining the production of multiaxial seamed felts. In addition to seamed bases, multiaxial bases can also be endless (the step of forming the loops is bypassed).

Nonwoven Base Structure with Yarns Oriented in only One Direction (Knuckle-Free)

In this type of design, the base fabric is not a woven fabric but is formed by two or more, completely separate uncrimped yarn layers. The yarns are encapsulated within a fibrous membrane. Figure 3.21 shows a nonwoven base material.

The top illustration in Figure 3.22 shows a triple-layer no-crimp felt structure and the bottom shows a double-layer base structure with one layer of nonwoven material laminated on top of one layer of woven material. Such nonwoven structures are excellent in providing pressure uniformity due to the absence of weaving knuckles. The generally low void volume of these fabrics has also been applied successfully where immediate nip dewatering is desired for the quickest break-in.



FIGURE 3.21. Nonwoven base material.