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sinker in stitch transfer by moving beyond the hook. Eliminating the lateral transfer spring provides for precise stitch centering, even during transfer op-

erations. It can have a high hook with relatively large yarn space, making it suitable for use with multi-gauge knitted fabrics.

Flat knitting machines knit technical textiles

It is widely known that computer-controlled CMS flat knitting machines produce fashion knitwear and are able to cope with complex techniques such as color jacquard, cable structures and intarsia. However, the technical concept and comprehensive software of the latest generation of flat knitting machines by Stoll GmbH, Reutlingen/Germany, open up a wider and extremely interesting production scope.

The CMS 340 knit and wear fully automatically produces shape-knitted panels and ready-to-wear knitted garments, eliminating the need for any further manual making-up processes. The previous manual making-up stages: cutting, sewing, binding off, setting buttonholes etc. are now performed by the CMS flat knitting machine.

CMS flat knitting machines are also able to manufacture stitch accumulations, use the wedge technique, fabric on fabric, inlay and shot technique, as well as using multi-gauges techniques and producing all forms of multi-dimensional fabrics.

Another field of application for flat knitting technology of major significance nowadays is that of "Technical knitted fabrics". From the beginning of the 80s, this sector has gained steadily in importance to become a substantial growth market. The innovative engineering and unique design features of the CMS, such as controlled movable sinkers, open up outstanding scope for the manufacture of technical knitted fabrics and extremely versatile solutions in the field of technical textiles.

For the production of technical knitted fabrics, CMS flat knitting machines are available with a needle area of up to 2440 mm. Depending on the gauge of between 3 and 18 n.p.i., this means up to 1,728 needles per needle bed. With individual electronic selection, each needle is able to independently start, knit or transfer stitches.

Productivity is enhanced by the action of the carriage, which moves only over the needle area required for the actual knitting process, processing the yarn or other material fed by the yarn feeders to the selected needles. In conjunction with narrowing and widening of stitches, this technique permits the production of knitted

articles in any required shape and with welt. The racking device permits the rows of needles to be shifted relative to each other by up to 10 cm for stitch crossover and laying of threads.

The product range of Stoll encompasses computer-controlled, fully automatically operating flat knitting machines with between two and six knitting systems. The maximum knitting output at 1.2 m/s is up to approx. 8,000 stitches/s in the six-system machine. A special feature of the CMS flat knitting machine are controlled movable sinkers for each row of needles. These are able to hold down the loops, so permitting stitch formation without fabric takedown. This facility also opens up scope for the production of three-dimensional technical knitted fabrics using a wide range of materials.

Technical knitted products

As well as on flat knitting machines, nowadays technical textiles are also produced on warp and circular knitting machines. Using different operating methods, these fundamentally different machine types are capable of producing varying types of technical knitted structures with different characteristics for their own specific fields of application. Fields of application for "technical knitted fabrics" are extremely comprehensive and include, for instance: industry, aerospace and automotive engineering, geology, medicine, protective clothing, technical home textiles.

Manufacture/processing of knitted fabrics on flat knitting machines

Knitted fabrics produced on flat knitting machines offer very good draping capabilities. This is due on the one hand to the stitch-forming principle used to pro-

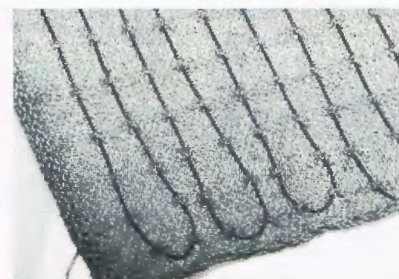


Fig. 1 Inlay technique, demonstrated by an inlaid wire cable

duce flat knitted fabrics. A stitch comprises thread laid in a ring formation which is held by the surrounding stitches. This characteristic permits the fabric to be stretched in any direction. Another facility of this technique is that each individual stitch or group of stitches can be formed in varying sizes, so allowing a product to be knitted selectively to address a particular elasticity or other characteristic requirement. Even fabrics produced using high-strength materials will always retain this elastic property.

As a result, it is clear that in a fabric with no weft or inlay thread in bonded fiber materials, it will never be possible to achieve the highest modulus of elasticity. Knitted fabrics are accordingly also characterized by their high stretch properties, i.e. low tensile strength and resulting higher absorption of energy in case of excess strain. The stretch properties of the fabric are such that they even permit, in conjunction with thermoplastics, subsequent deformation or deep drawing within certain limits.

Combined knitted fabric constructions and knitted fabric reinforcement

The stretch properties of knitted fabrics can be easily influenced or even eliminated in the x direction. To achieve this effect, weft threads are laid over the last knitted course. These weft or filler threads lie in the X direction, so preventing the fabric from being stretched in this direction. Using this technique, a high degree of tensile strength can be achieved in bonded fiber fabric. The number of weft threads can be increased so that only a minimal section of the knitted fabric encloses the packages of weft threads.

By providing for a controlled, variable progression of the yarn carrier laying the weft thread, it is possible to alternate between areas with weft threads and those without also in the x direction (Intarsia principle). In addition, the weft thread technique can be varied from one course to the next, or areas with a high proportion of weft threads can be combined with a lower proportion of weft threads (Fig.1).

Different materials can be combined using different yarn feeders, and the knitted and reinforced areas themselves varied in shape. The weft thread can, for example, be used as a planned reinforcement in tapes or drive belts.

Shaped articles and multi-dimensional knitted fabrics

The capacity for shaped and multi-dimensional knitting with welt is one of the main benefits to be gained from the flat

knitting machine. A fabric panel can be widened by adding stitches (needles) at the selvedge. It is narrowed by knitting with fewer needles and transferring the stitches to needles positioned further towards the inside of the fabric. By knitting, narrowing, widening and using the wedge technique, it is possible to produce two or three-dimensional shapes.

In order to produce three-dimensional fabrics on a flat knitting machine, further knitting processes are required. If, for example, the needles periodically knit additional stitches only in the central area of a knitted fabric, while the needles at the two selvages do not knit, a raised, i.e. three-dimensional area is created in the center. This type of additional knitted area can also be produced at the selvedge by, if we stick to this example, having the selvedge needles knit additional stitches while the needles in the center are idle.

Convex or concave shapes are achieved by knitting ellipse-shaped segments using the wedge technique, whereby a considerably greater number of stitches is knitted in the center than at the edge of the segments. Attention must be paid here to ensure that the initial courses and end courses of each segment are linked to each other by a row of stitches (Fig. 2).

If several of these segments are produced, for example, a knitted half-sphere is produced. If this is followed by knitting a tube using the starting course of the first segment and the end course of the last segment, a seamless knitted stocking is obtained of the type used, for example, for prostheses.

It is also possible to form rectangular knitted corners. The CMS flat knitting machine is practically even capable of producing knitted boxes. If the selvedge needles remain periodically idle at the edge of a knitted fabric, and if they then gradually begin to knit again, a corner shape is formed in the fabric. If four of these corners are created in the fabric, a

box is produced. This technique is used, for example, in deep-drawn articles with edges.

Wide spectrum of applications through different materials

Stoll CMS flat knitting machines for technical knitted fabrics are capable of processing, depending on their field of application: elastomers, thermoplastics, glass and ceramic fibers, carbon fibers, metal wires, natural fibers and other synthetic yarns, also in composite form.

- Metal knitted fabrics

New fields of application for metal knitted fabrics have been opened up over the past two decades, for example with catalytic converters and filters, but also in the fields of heating engineering. The oil industry, glass and ceramic manufacture, the automotive engineering industry all purchase metal knitted fabrics and articles with special purpose-oriented



Fig. 2 Structure for protection helmet, made of aramid and glass fibers



Fig. 3 Wire knit fabrics, made of various metallic materials and wire versions

characteristics (Fig. 3).

All metal threads can be processed, including precious metals in different thickness - also in metal alloys. Filament metal threads, stable fiber metal threads, wrapped materials including also synthetic monofilaments. Wire knitted fabrics used for the filtration, heating or transformation of different media, catalytic filters for distillation plants and gas washing plants as demisters.

All the metal knitted fabrics produced for these purposes are knitted to the required shape in one piece with partial openings and reinforcements. This not only saves time, it also reduces cutting waste, processing requirements, material input and scrap.

- Medical technology

In the field of medical technology, fully fashioned support and compression bandages can be produced for use in the medical or sports sector.

Complex shaped bandages are knitted in accordance with all currently applicable standards in a single piece using the CMS flat knitting machine. The knitting process can also be designed to integrate special medically required characteristics. In order to stabilize a knee joint, for example, openings are knitted into knee bandages to permit the insertion of silicone rings. Another example here are leg compression bandages, which can be individually produced on CMS flat knitting machines with the compression point located in a specific area. This can be achieved both by knitting the same material with a different stitch density, or by changing the material used during production (Fig. 4).

- Composite material products

The manufacture of composite material products can be highly labor-intensive in some cases. Individual plies have to be cut to size on a ply-by-ply basis, carefully inserted in the press, fixed and then built up. Often special press moulds are required which are highly labor-intensive

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and expensive to produce in the first place.

Modern flat knitting technology offers a number of clear production advantages in this field, which cannot be realized using different textile-related manufacturing processes. Highly complex components, for instance, can be three-dimensionally knitted in a single work process (Fig. 5).

Other highly complex components made of composite materials can also be manufactured in a single work process - for example three-dimensional spherically curved articles featuring all the necessary reinforcement areas and openings. An intrinsically pre-stabilized semi-finished article with extremely good draping and deep-drawing capability is achieved which can be inserted in a forming tool in one or more layers without major handling problems and resin-treated. Thermoplastics can be integrated in the form of threads during the knitting process. The facility for pre-stabilization offers the advantage that additional fixing points are no longer necessary and no making-up processes are required.

- Upholstery fabrics and seat covers for the automotive and furniture industry

Seats designed according to ergonomic findings for the automotive and furniture industry call for complex and costly upholstery techniques. A higher proportion of wool is required in the seat surface area, for instance, in order to create optimum material breathing properties and dissipation of body moisture. The sides, in contrast, can be produced using yarns with different properties or colors. In addition, in automobile seat covers, the safety-relevant functionality of the side back has to be taken into consideration. This calls for elaborate manufacturing techniques, complex sewing processes and cutting waste.

If we make use of three-dimensional knitting techniques as an alternative, it is possible instead to produce seat covers



Fig. 4 Knee brace with integrated pockets for soft pads and reinforcement splints

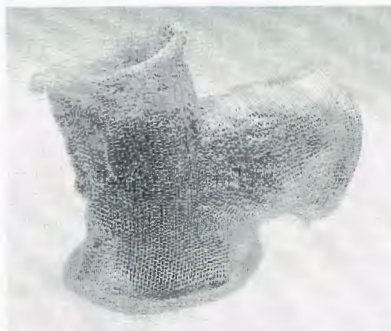


Fig. 5 Knitted to shape tube connection of glass fibers

in any required form on the CMS flat knitting machine, for example producing convex areas by joining segments using the wedge technique. The fitted covers emerge from the machine with excellent

processing and draping properties. On principle, all known knitting techniques and patterns, including a woven look, and any type of material can be integrated into the seat covers.

Wear resistance, stretch properties or sideback functions in predetermined locations are planned into the fabric, retaining and reinforcing elements are knitted in. The production process itself is so flexible that the design, shape and color as well as the pattern of the seat cover can be changed as required from one article to the next. It is also possible to integrate seat heating systems in conductive materials into car seat covers using laying or knitting techniques. Using the online link between the flat knitting machines and the patterning computer, it is even possible to automatically produce individual customer patterns in batch sizes as small as 1.

- Project processing of technical knitted articles and application advice

The fields of application for technical textiles produced using Stoll CMS flat knitting machines are varied, and new applications are being developed all the time. CMS flat knitting machines are capable of producing finished, geometrically complex two and three-dimensional parts precisely in any required shape and with the required technical characteristics.

Karl Mayer: Kalitherm patent

On 17th June, 1999 Karl Mayer Malimo GmbH, Chemnitz, Germany acquired the know-how for the production of non-woven fabrics based on the Kunit process by the contract of know-how, patent and trademarks. By conclusion of the contract, the rights for the German patent applications DE 195 34 252 of 18th September 1995 and DE 196 04 726 have been acquired as well as the applications with the European patent office comprising the protection rights for Germany, France, Great Britain, Ita-

ly, Spain and Sweden, furthermore the foreign application for USA, Japan, South Korea and Brazil.

Having acquired this know-how and the respective protection rights, Karl Mayer Malimo is able to offer an effective alternative for the substitution of foamed material as backing upholstery material. The measures for the successful translation of the results in the market out of the EU project, called "recyclable upholstery fabrics" have been included.

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MELLIAND
TEXTILBERICHTE GMBH
D-60264 Frankfurt am Main
Phone: 069 - 75 95 - 16 52
Fax: 069 - 75 95 - 16 50