**Textile Technology**

**Warp Knitting**

**INTRODUCTION**

Machine warp knitting is a more recent development than weft knitting (page 185). The looped structure is formed between multiple yarns running lengthways (wales), as opposed to a single yarn across the width of the fabric (courses), as is the case in weft knitting. Each needle is fed with one or more yarns. So a long-sleeved t-shirt may consist of up to 5,000 ends, depending on the machine gauge. With each stitch, the yarn is tracked from side to side by the guide bar and so intermeshes with neighbouring yarns to produce a cohesive knitted structure.

With each stitch being formed by a separate yarn, a range of interlocked, inserted yarn and open structures may be produced. And it can be made in a range of densities, from heavy cloth to fine lace. By combining different loop patterns, net may be incorporated into a solid ground, such as used to make upholstery and seamless sportswear. warp knitting...
used to make nets and lace employed in a wide range of applications, from sports use to lingerie to shoe uppers, medical products and upholstery.

RELATED TECHNOLOGIES

Warp knitting is not as straightforward to design as it appears, and while warp-knitted fabrics may be joined by lock stitching (page 335). Both weft and warp knitting are capable of producing seamless garments in a single operation. A significant advantage of warp knitting is the design opportunities of openwork structures. For example, lightweight garments with localized stretch, support and breathability are produced in a single operation from multiple yarns. In addition to creating openwork structures in a solid ground, the two may be combined in a single sheet to create a honeycomb layer on top of the ground, known as semi-breakthrough.

Warp knitting is faster than weaving and capable of producing larger widths, making it more economical. However, with regard to lace, there is a wider range of design opportunities, owing to the different loop structures. Machines fitted with independently controlled guide bars (jacquard) are capable of producing very complex and intricate patterns similar to Leavers lace (page 108).

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Warping

In preparation for warp knitting, filament yarn is wound onto cones. From a creel, 256 ends are gathered together with a fine comb (image 1). The yarn is coated with a layer of synthetic oil (natural yarns are coated with paraffin wax as it passes over a roll (image 2). The coating reduces friction between the yarns and so improves knitting efficiency.

It takes roughly an hour to fill a beam (image 3). The northern Italian company Cifra uses machines with 3 m (9.8 ft) beds. Six beams are required to cover the length of the bed (image 4). The double-bed machines use up to three beams on either side, so 16 in total.

Each end is carefully threaded through the machine and into the guide bar (image 5). It is a delicate process and can take several operators half a day or more to replace the yarns on a machine (image 6). Therefore, Cifra warp knits all of its garments in plain white and dyes the finished items if colour is required. Using two different types of yarn, such as polyester and nylon, means that two different colours can be achieved with dyeing (page 240).

of yarn that are affected by different types of dye, multicoloured patterns can be achieved.

MATERIALS

Man-made filament yarns (page 50) are the most commonly utilized, owing to the high consistency required, although staple and novelty yarns are also used. Frequently used filament yarns include silk, nylon, polyester, polypropylene (PP), polyethylene (PE), viscose and elastane. Technical yarns are warp knitted for high-performance applications, such as composite-laminated structures. These include carbon, aramid and glass.

COSTS

Warp knitting is a very rapid process, able to produce hundreds of courses per minute. It is possible to produce wide lengths of fabric or several narrow strips. In this way, a single machine may be capable of producing several garments at once, further reducing cycle time.

The high consistency of yarn required increases costs slightly.

Setting up the machine takes longer than weft knitting if the yarns need to be changed, because each needle is fed with a separate end. Knitting a single colour and piece dyeing finished garments saves time and cost by reducing machine downtime.

ENVIRONMENTAL IMPACTS

Like weft knitting, this is an efficient process and generates very little waste. Producing garments in a single operation removes pattern cutting and sewing, further reducing or even eliminating waste completely. Warp-knitted spacer fabrics are used in place of polymer foams, such as polyurethane (PU) in cushioning applications.

The source of yarn is important; natural yarns should be from sustainable sources and processed with consideration for people and the environment. The amount of recycled content in synthetic yarns varies according to the type of plastic and the supplier.
## Seamless Warp Knitting

Seamless garments are produced on raschel jacquard machines. The fabric is made up of pillar stitches, underlapped and overlapped with inserted yarn. With this technique, openwork structures are seamlessly combined with plain fabric to make fitted garments (Image 1). Plain white yarn, in this case polyester, is fed from the beams into the guide bars (Image 2). These are fine-gauge machines with 24 needles per 25.4 mm (1 in.). The more needles per inch, the lower the diameter of yarn that can be knitted and the higher the density of fabric that can be produced.

Each guide bar moves through three actions with each stitch. When the needle has cleared the previous loop the guide bars move forwards (Image 3). Each guide bar is independently computer-guided. They move sideways and pass the yarn around a designated needle, either in front or behind (Image 4). The needle is pulled downwards, catching the yarns placed in front and forming a stitch (Image 5). The second bed of needles rises up and the sequence is repeated in reverse.

The process is very rapid: up to 600 courses are completed every minute and the knitted item is drawn downwards under tension (Image 6). The finished garment emerges from the machine and is ready to be dyed (Image 7).

Garments are checked to make sure the knitting process is running without errors (Image 8). A long-sleeved t-shirt like this comprises around 1,322,000 stitches and a single one out of place will show up on the finished product. It is made oversize to allow for shrinkage during dyeing and finishing. The outline is knitted into the garment and the waste is removed (Image 9).

## Warp Knitting with Novelty Yarn

Yarns are inserted for decorative and functional reasons. In this case, a gold-metallized yarn is being inserted into jacquard-knitted hosiery (Image 1). The yarn would be too fragile to knit as part of the loop structure and so is inserted into the loops as an additional warp.

The fancy yarn is introduced from the front on both sides of the machine (Image 2). It is knitted into the fabric and the finished item is drawn away under tension (Image 3). The areas that will be open are visible as long slots. This is how they are knitted: a needle is missed out for a given number of courses and so a window is formed. Once the fabric has relaxed the openwork structure is revealed.

On this narrow-bed knitting machine eight pairs of stockings are knitted simultaneously (Image 4).