Warp knitting

The two types of warp knitting are raschel, made with latch needles, and tricot, using bearded needles.

Raschel

Coarser yarns are generally used for raschel knitting, and there has recently been interest in knitting staple yarns on these machines. In the Raschel machine, the needles move in a ground steel plate, called the trick plate. The top of this plate, the verge, defines the level of the completed loops on the needle shank. The loops are prevented from moving upward when the needle rises by the downward pull of the fabric and the sinkers between the needles. Guide bars feed the yarn to the needles. In a knitting cycle, the needles start at the lowest point, when the preceding loop has just been cast off, and the new loop joins the needle hook to the fabric. The needles rise, while the new loop opens the latches and ends up on the shank below the latch. The guide bars then swing through the needles, and the front bar moves one needle space sideways. When the guide bar swings back to the front of the machine, the front bar has laid the thread on the hooks. The needles fall, the earlier loops close the latch to trap the new loops, and the old loops are cast off. Raschels, made in a variety of forms, are usually more open in construction and coarser in texture than are other warp knits.

Tricot

Tricot, a warp knit made with two sets of threads, is characterized by fine ribs running vertically on the fabric face and horizontally on its back. The tricot knitting machine makes light fabrics, weighing less than four ounces per square yard. Its development was stimulated by the invention of the so-called FNF compound needle, a sturdy device that later fell into disuse but that made possible improved production speeds. Although approximately half of the tricot machines in current use make plain fabrics on two guide bars, there is increasing interest in pattern knitting. In this type of knitting, the warp-knitting cycle requires close control on the lateral bar motion, achieved by control chains made of chunky metal links.

Special effects in warp knits

The scope of warp knitting has been extended by the development of procedures for laying in nonknitted threads for colour, density, and texture effects (or inlaying), although such threads may also be an essential part of the structure. For example, in the form called "zigzagging across several pillars," the ground of most raschel fabrics, the front bar makes crochet chains, or "pillars," which are connected by zigzag inlays.

An extension of conventional warp knitting is the Co-We-Nit warp-knitting machine, producing fabrics with the properties of both woven and knitted fabrics. The machines need have only two warp-forming warps and provision for up to eight interlooped warp threads between each chain of loops. These warp threads are interlaced with a quasiweft, forming a fabric resembling woven cloth on one side.

Other interlaced fabrics

Net and lace making

The popularity of handmade laces led to the invention of lace-making machines. The early models required intricate engineering mechanisms, and the development of the modern lace industry originated when a machine was designed to produce laces identical with Brussels lace. In the Heathcot, or bobbinet, machine, warp threads were arranged so that the threads moved downward as the beams unwound. Other threads were wound on thin, flat spools or bobbins held in narrow carriages that could move in a groove or comb in two rows. The carriages carrying the bobbins were placed on one side of the vertical warp threads and given a pendulum-like motion, causing them to pass between the warp threads. The warp threads were then moved sideways, so that on the return swing each bobbin thread passed around one of them. Then the warp threads moved sideways in the opposite direction, thus completing a wrapping movement. In addition, each row of bobbins was moved by a rack-and-pinion gearing, one row to the left and one to the right. As these movements continued, the threads were laid diagonally across the fabric as the warp was delivered. Improvements on the Heathcot machine followed through the 19th century: Nottingham-lace machines, used primarily for coarse-lace production, employ larger bobbins, and the pattern threads are wound independently on section spools; in another type, the Barmens machine, threads on king bobbins on carriers are plaited together, sometimes with warp threads.

Schiffli lace, a type of embroidery, is made by modern machines, evolved from a hand version, using needles with points at each end. Several hundred needles are placed horizontally, often in two rows, one above the other. The fabric to be embroidered is held vertically in a frame extending the full width of the machine, and the needles, supplied with yarn from individual spools, move backward and forward through the fabric. At each penetration a shuttle moves upward and interlaces yarn with the needle loop. Movement of both fabric and needles is controlled by Jacquard systems.

Many types of machine-made laces are made, frequently with geometrically shaped nets forming their backgrounds. Formerly made only of cotton, they are now frequently made from synthetic fibre yarns. Bobbinet lace, essentially a hexagonal net, is used as a base for appliqué work for durable non-run net hosiery, and, when heavily sized, for such materials as millinery and veilings. Barmens lace has a fairly heavy texture and an angular pattern; flowing lines, heavy outline cords, and fine net backgrounds are not usually made on Barmens machines.

The introduction of light-resistant polyester yarns led to a revival of Nottingham machine-made curtains. Leavers lace is available in an infinite variety of patterns, since the manufacturing technique allows use of almost any type of yarn. The high strength and comparatively low cost of synthetic fibre yarns has made sheer laces widely available.

Net, an open fabric having geometrically shaped, open meshes, is produced with meshes ranging from fine to large. Formerly made by hand, the various types are now made on knitting machines. Popular types include bobbinet, made with hexagonal-shaped mesh and used for formal gowns, veils, and curtains, and tulle, a closely constructed fine net having similar uses. Fishnet, a coarse type with knots in four corners forming the mesh formerly made by fishermen, is now a popular machine-made curtain fabric.

Braiding or plaiting

Braid is made by interlacing three or more yarns or fabric strips, forming a flat or tubular narrow fabric. It is used as trimming and for belts and is also sewn together to make hats and braided rugs. Plaiting, usually used synonymously with braiding, may be used in a more limited sense, applying only to a braid made from such materials as rope and straw.

Noninterlaced fabrics

With the exception of felt, nonwoven materials are in the early stages of development. There is controversy about the precise meaning of the term *nonwoven*, but one authority defines nonwoven fabrics as textile fabrics made of a fibrous layer having randomly laid or oriented fibres or threads.

Felt

Felts are a class of fabrics or fibrous structures obtained through the interlocking of wool, fur, or some hair fibres under conditions of heat, moisture, and pressure. Other fibres will not felt alone but can be mixed with wool, which acts as a carrier. Three separate industries manufacture goods through the use of these properties. The goods produced are wool felt, in rolls and sheets; hats, both fur and wool; and woven felts, ranging from thin billiard tablecloths to heavy industrial fabrics used for dewatering in the manufacture of paper. Felts of the nonwoven class are considered to be the first textile goods produced, and many references may be found to felts and their uses in the histories of ancient civilizations. The nomadic tribes of north central Asia still produce felts for clothing and shelter, utilizing the primitive methods handed down from antiquity.

Bonding

Several methods for making nonwoven materials are now firmly established, and others are being developed.

In adhesive bonding, fabrics are made by forming a web of fibres, applying an adhesive, then drying and curing the adhesive. The web can be produced by a garnett machine or a conventional card, several layers being piled up to obtain the required thickness. Such webs are weak across the width, but this does not limit their use for certain end products. A more uniform product results from cross laying the web. Other machines, such as the Rando-Webber, lay down the fibres by an airstream.

derivatives, or natural rubber—or, alternatively, may be carried on a mesh screen through a bath of latex, the excess being squeezed out by a pair of rollers. Adhesives may also be applied as a foam or a fine powder. Thermoplastic fibres can be incorporated in the blend and on heating will bond together, giving strength to the mass of fibres.

Mechanically bonded nonwoven products (or fibre-bonded nonwovens) are webs strengthened by mechanical means. The web, sometimes reinforced by a thin cotton scrim in the middle or by texturized yarns distributed lengthwise through it, is punched by barbed needles mounted in a needle board. The fibres in the web are caught up by the needle barbs, and the resulting increased entanglement yields a compact product sufficiently strong for many purposes. Modern needle-felting or punching machines perform 900 punches per minute, and selection of appropriate needles is based on the fibre being processed and the desired product.

The Arachne machine, the best known unit for stitch bonding, operates much like a warp-knitting machine. Fibrous web is fed into the machine, and stitches are made by a series of needles placed about eight millimetres apart, giving the web longitudinal strength; lateral strength is provided by the fibre interactions. The products are attractive for many purposes and can be improved by treatment with polyester resins to increase their wear resistance and with thermosetting precondensates to reduce their tendency to pill (e.g., to form small tangles). A new device attached to the Arachne machine permits introduction of weft ends at every single course, making colour effects possible. Araloop machines yield loop-pile fabric suitable for towels and floor coverings.

Three sewing-knitting machines were invented in East Germany in 1958. In the Malimo machine process, warp yarns are placed on top of filling yarns and stitched together by a third yarn. The Maliwatt machine interlaces a web of fibres with a sewing thread, giving the effect of parallel seams. The Malipol machine produces a one-sided pile fabric by stitching loop pile through a backing fabric. A new British process makes double-sided terry fabric, called Terrytuft, by inserting pile yarn into a backing and knotting it into position.

Webs made of yarns having a core of one polymer and an outer sheath of another material having a lower softening point may be lightly pressed and then heated to an appropriate temperature. The core yarn will “spot weld” together at the junction points, binding the mass of fibres together. Products made in this way find uses as industrial fabrics, coatings, and interlinings.

Laminating

The joining of one fabric to another by an adhesive such as natural rubber has long been practiced in rainwear manufacture. Composite materials were later joined by bonding a layer of polyurethane or other foam to a conventional textile fabric. The two components were stuck together by flame bonding or by an adhesive in the form of a continuous coating, in spots, or as a powder. This laminating process has been extended to the joining of two layers of fabric. Each fabric layer can be quite thin, and the amount and type of adhesive are chosen to add only minimum stiffening. Such materials offer a variety of applications. A coating fabric, for example, may be joined to a lining; dimensionally stable composites can be made from cloth layers that are in themselves dimensionally unstable. Acetate knitted fabrics are frequently used as backing material in laminates.

Textile finishing processes

Basic methods and processes

The term *finishing* includes all the mechanical and chemical processes employed commercially to improve the acceptability of the product, except those procedures directly concerned with colouring. The objective of the various finishing processes is to make fabric from the loom or knitting frame more acceptable to the consumer.
Finishing processes include preparatory treatments used before additional treatment, such as bleaching prior to dyeing; treatments, such as glazing, to enhance appearance; sizing, affecting touch; and treatments adding properties to enhance performance, such as preshrinking. Newly formed cloth is generally dirty, harsh, and unattractive, requiring considerable skill for conversion into a desirable product. Before treatment, the unfinished fabrics are referred to as gray goods, or sometimes, in the case of silks, as greige goods.

Finishing formerly involved a limited number of comparatively simple operations evolved over the years from hand methods. The skill of English and Scottish finishers was widely recognized, and much British cloth owed its high reputation to the expertise of the finisher. More sophisticated modern finishing methods have been achieved through intense and imaginative research.

Preparatory treatments

It is frequently necessary to carry out some preparatory treatment before the application of other finishing processes to the newly constructed fabric. Any remaining impurities must be removed, and additives used to facilitate the manufacturing process must also be removed. Bleaching may be required to increase whiteness or to prepare for colour application. Some of the most frequently used preparatory processes are discussed below.

Burling and mending

Newly made goods, which frequently show imperfections, are carefully inspected, and defects are usually repaired by hand operations. The first inspection of woollen and worsted fabrics is called perching. Burling, mainly applied to woollen, worsted, spun rayon, and cotton fabrics, is the process of removing any remaining foreign matter, such as burrs and, also, any loose threads, knots, and undesired slubs. Mending, frequently necessary for woollens and worsteds, eliminates such defects as holes or tears, broken yarns, and missed warp or weft yarns.

Scouring

When applied to gray goods, scouring removes substances that have adhered to the fibres during production of the yarn or fabric, such as dirt, oils, and any sizing or lint applied to warp yarns to facilitate weaving.

Bleaching

Bleaching, a process of whitening fabric by removal of natural colour, such as the tan of linen, is usually carried out by means of chemicals selected according to the chemical composition of the fibre. Chemical bleaching is usually accomplished by oxidation, destroying colour by the application of oxygen, or by reduction, removing colour by hydrogenation. Cotton and other cellulosic fibres are usually treated with heated alkaline hydrogen peroxide; wool and other animal fibres are subjected to such acidic reducing agents as gaseous sulfur dioxide or to such mildly alkaline oxidizing agents as hydrogen peroxide. Synthetic fibres, when they require bleaching, may be treated with either oxidizing or reducing agents, depending upon their chemical composition. Cottons are frequently scoured and bleached by a continuous system.

Mercerization

Mercerization is a process applied to cotton and sometimes to cotton blends to increase lustre (thus also enhancing appearance), to improve strength, and to improve their affinity for dyes. The process, which may be applied at the yarn or fabric stage, involves immersion under tension in a caustic soda (sodium hydroxide) solution, which is later neutralized in acid. The treatment produces permanent swelling of the fibre.

Drying

Water, used in various phases of textile processing, accumulates in fabrics, and the excess moisture must eventually be removed. Because evaporative heating is costly, the first stage of drying uses mechanical methods to remove as much moisture as possible. Such methods include the use of centrifuges and a continuous method employing vacuum suction rolls. Any remaining moisture is then removed by evaporation in heated dryers. Various types of dryers operate by conveying the relaxed fabric through the chamber while festooned in loops, using a frame to hold the selvages taut while the fabric travels through the chamber, and passing the fabric over a series of hot cylinders. Because overdrying may produce a harsh hand, temperature, humidity, and drying time require careful control.

Finishes enhancing appearance

Treatments enhancing appearance include such processes as napping and shearing, brushing, singeing, beetling, decating, tentering, calendering or pressing, moiréing, embossing, creping, glazing, polishing, and optical brightening.

Napping and shearing

Napping is a process that may be applied to woollens, cottons, spun silks, and spun rayons, including both woven and knitted types, to raise a velvety, soft surface. The process involves passing the fabric over revolving cylinders covered with fine wires that lift the short, loose fibres, usually from the weft yarns, to the surface, forming a nap. The process, which increases warmth, is frequently applied to woollens and worsteds and also to blankets.

Shearing cuts the raised nap to a uniform height and is used for the same purpose on pile fabrics. Shearing machines operate much like rotary lawn mowers, and the amount of shearing depends upon the desired height of the nap or pile, with such fabrics as gabardine receiving very close shearing. Shearing may also be applied to create stripes and other patterns by varying surface height.

Brushing

This process, applied to a wide variety of fabrics, is usually accomplished by bristle-covered rollers. The process is used to remove loose threads and short fibre ends from smooth-surfaced fabrics and is also used to raise a nap on knits and woven fabrics. Brushing is frequently applied to fabrics after shearing, removing the cut fibres that have fallen into the nap.

Singeing

Also called gassing, singeing is a process applied to both yarns and fabrics to produce an even surface by burning off projecting fibres, yarn ends, and fuzz. This is accomplished by passing the fibre or yarn over a gas flame or heated copper plates at a speed sufficient to burn away the protruding material without scorching or burning the yarn or fabric. Singeing is usually followed by passing the treated material over a wet surface to assure that any smoldering is halted.

Beetling

Beetling is a process applied to linen fabrics and to cotton fabrics made to resemble linen to produce a hard, flat surface with high lustre and also to make texture less porous. In this process, the fabric, dampened and wound around an iron cylinder, is passed through a machine in which it is pounded with heavy wooden mallets.

Decating

Decating is a process applied to woollens and worsteds, synthetic and blended fibre fabrics, and various types of knits. It involves the application of heat and pressure to set or develop lustre and softer hand and to even the set and grain of certain fabrics. When applied to double knits it imparts crisp hand and reduces shrinkage. In wet decating, which gives a subtle lustre, or bloom, fabric under tension is steamed by passing it over perforated cylinders.

Tentering, crabbing, and heat-setting

These are final processes applied to set the warp and weft of woven fabrics at right angles to each other, and to stretch and set the fabric to its final dimensions. Tentering stretches width under tension by the use of a tenter frame, consisting of chains fitted with pins or clips to hold the selvages of the fabric, and travelling on tracks. As the fabric passes through the heated chamber, creases and wrinkles are removed, the weave is straightened, and the fabric is dried to its final size. When the process is applied to wet wools it is called crabbing; when applied to synthetic fibres it is sometimes called heat-setting, a term also applied to the permanent setting of pleats, creases, and special surface effects.

Calendering

Calendering is a final process in which heat and pressure are applied to a fabric by passing it between heated rollers, imparting a flat, glossy, smooth surface. Lustre increases when the degree of heat and pressure is increased. Calendering is applied to fabrics in which a smooth, flat surface is desirable, such as most cottons, many linens and silks, and various synthetic fabrics. In such fabrics as velveteen, a flat surface is not desirable, and the cloth is steamed while in tension, without pressing. When applied to wool, the process is called pressing and employs heavy heated metal plates to steam and press the fabric. Calendering is not usually a permanent process.

Moiréing, embossing, glazing and ciréing, and polishing are all variations of the calendering process. Moiré is a wavy or "watered" effect imparted by engraved rollers that press the design into the fabric. The process, applied to cotton, acetate, rayon, and some ribbed synthetic fabrics, is only permanent for acetates and resin-treated rayons. Embossing imparts a raised design that stands out from the background and is achieved by passing the fabric through heated rollers engraved with a design. Although embossing was formerly temporary, processes have now been developed to make this effect permanent.

Glazing imparts a smooth, stiff, highly polished surface to such fabrics as chintz. It is achieved by applying such stiffeners as starch, glue, shellac, or resin to the fabric and then passing it through smooth, hot rollers that generate friction. Resins are now widely employed to impart permanent glaze. Ciré (from the French word for waxed) is a similar process applied to rayons and silks by the application of wax followed by hot calendering, producing a metallic high gloss. Ciré finishes can be achieved without a sizing substance in acetates, which are thermoplastic (e.g., can be softened by heat), by the application of heat.

Polishing, used to impart sheen to cottons without making them as stiff as glazed types, is usually achieved by mercerizing the fabric and then passing it through friction rollers.

Creping

A crepe effect may be achieved by finishing. In one method, which is not permanent, the cloth is passed, in the presence of steam, between hot rollers filled with indentations, producing waved and puckered areas. In the more permanent caustic soda method, a caustic soda paste is rolled onto the fabric in a patterned form, or a resist paste may be applied to areas to remain unpuckered, and the entire fabric is then immersed in caustic soda. The treated areas shrink, and the untreated areas pucker. If the pattern is applied in the form of stripes, the effect is called plissé; an allover design produces blister crepe.

Optical brightening

Optical brightening, or optical bleaches, are finishes giving the effect of great whiteness and brightness because of the way in which they reflect light. These compounds contain fluorescent colourless dyes, causing more blue light to be reflected. Changes in colour may occur as the fluorescent material loses energy, but new optical whiteners can be applied during the laundering process.

Finishes enhancing tactile qualities

Finishes enhancing the feel and drape of fabrics involve the addition of sizing, weighting, fulling, and softening agents, which may be either temporary or permanent.

Sizing

Sizing, or dressing, agents are compounds that form a film around the yarn or individual fibres, increasing weight, crispness, and lustre. Sizing substances, including starches, gelatin, glue, casein, and clay, are frequently applied to cottons and are not permanent.

Weighting

Weighting, in the processing of silk, involves the application of metallic salts to add body and weight. The process is not permanent but can be repeated.

Fulling

Also called felting or milling, fulling is a process that increases the thickness and compactness of wool by subjecting it to moisture, heat, friction, and pressure until shrinkage of 10 to 25 percent is achieved. Shrinkage occurs in both the warp and weft, producing a smooth, tightly finished fabric that may be so compact that it resembles felt.

Softening

Making fabrics softer and sometimes also increasing absorbency involves the addition of such agents as dextrin, glycerin, sulfonated oils, sulfated tallow, and sulfated alcohols.

Finishes improving performance

The performance of fabrics in use has been greatly improved by the development of processes to control shrinkage, new resin finishes, and new heat-sensitive synthetic fibres.

Durable press

Durable press fabrics have such characteristics as shape retention, permanent pleating and creasing, permanently smooth seams, and the ability to shed wrinkles, and thus retain a fresh appearance without ironing. Such fabrics may be safely washed and dried by machine. These useful characteristics are imparted by a curing process. Depending upon composition and desired results, fabrics may be precured, a process in which a chemical resin is added, the fabric is dried and cured (baked), and heat is applied by pressing after garment construction; or fabrics may be postcured, a process in which resin is added, the fabric is dried, made into a garment, pressed, and then cured.

Wash-and-wear was an early durable press process employing chemical treatment and curing of fabrics; at least light ironing was required to restore appearance. Later, however, processes were developed that allowed such fabrics to regain smoothness after home machine washing at moderate temperature, followed by tumble drying.

Crease resistance

Crease, or wrinkle, resistance is frequently achieved by application of a synthetic resin, such as melamine or epoxy.

Soil release

Soil release finishes facilitate removal of waterborne and oil stains from fabrics such as polyester and cotton blends and fabrics treated for durable press, which usually show some resistance to stain removal by normal cleaning processes. Other finishes have been developed that give fabrics resistance to water and oil stains.

Antistatic finishes

The accumulation of static electricity in such synthetic fibres as nylon, polyesters, and acrylics produces clinging, which may be reduced by application of permanent antistatic agents during processing. Consumers can partially reduce static electricity by adding commercial fabric softeners during laundering.

Antibacterial and antifungus finishes

Antibacterial finishes are germicides applied to fabrics to prevent odours produced by bacterial decomposition, such as perspiration odours, and also to reduce the possibility of infection by contact with contaminated textiles. Fabrics may also be treated with germicides to prevent mildew, a parasitic fungus that may grow on fabrics that are not thoroughly dried. Both mildew and rot, another form of decay, may also be controlled by treatment with resins.

Moth-repellent treatments

Wool and silk are subject to attack by moths but may be made moth repellent by the application of appropriate chemicals either added in the dye bath or applied to the finished fabric.

Waterproofing and water repellence

Waterproofing is a process applied to such items as raincoats and umbrellas, closing the pores of the fabric by application of such substances as insoluble metallic compounds, paraffin, bituminous materials, and drying oils. Water-repellent finishes are surface finishes imparting some degree of resistance to water but are more comfortable to wear because the fabric pores remain open. Such finishes include wax and resin mixtures, aluminum salts, silicones, and fluorochemicals.

Flameproof, fireproof, and fire-resistant finishes

Flameproof fabrics are able to withstand exposure to flame or high temperature. This is achieved by application of various finishes, depending upon the fabric treated, that cause burning to stop as soon as the source of heat is removed. Fireproofing is achieved by the application of a finish that will cut off the oxygen supply around the flame. Fire-resistant finishes cause fabrics to resist the spread of flame.

Dyeing and printing

Dyeing and printing are processes employed in the conversion of raw textile fibres into finished goods that add much to the appearance of textile fabrics.

Dyeing

Most forms of textile materials can be dyed at almost any stage. Quality woollen goods are frequently dyed in the form of loose fibre, but top dyeing or cheese dyeing is favoured in treating worsteds. Manufacturers prefer piece dyeing, which allows stocking of white goods, reducing the risk of being overstocked with cloth dyed in colours that have not been ordered.

The dye used depends on the type of material and the specific requirements to be met. For some purposes, high lightfastness is essential; but for others it may be inconsequential. Factors considered in dye selection include fastness to light, reaction to washing and rubbing (crocking), and the cost of the dyeing process. Effective preparation of the material for dyeing is essential.

Types of dyes

Textile dyes include acid dyes, used mainly for dyeing wool, silk, and nylon; and direct or substantive dyes, which have a strong affinity for cellulose fibres (*see* table). Mordant dyes require the addition of chemical substances, such as salts, to give them an affinity for the material being dyed. They are applied to cellulosic fibres, wool, or silk after such materials have been treated with metal salts. Sulfur dyes, used to dye cellulose, are inexpensive but produce colours lacking brilliance. Azoic dyes are insoluble pigments formed within the fibre by padding, first with a soluble coupling compound and then with a diazotized base. Vat dyes, insoluble in water, are converted into soluble colourless compounds by means of alkaline sodium hydrosulfite. Cellulose absorbs these colourless compounds, which are subsequently oxidized to an insoluble pigment. Such dyes are colourfast. Disperse dyes are suspensions of finely divided insoluble, organic pigments used to dye such hydrophobic fibres as polyesters, nylon, and cellulose actates.