T.C.
MİLLİ EĞİTİM BAKANLIĞI

TEKSTİL TEKNOLOJİSİ

MESLEKİ YABANCI DİL (İNGİLİZCE) 1

ANKARA, 2013
Bu modül, mesleki ve teknik eğitim okul/kurumlarında uygulanan Çerçeve Öğretim Programlarında yer alan yeterlikleri kazandırmaya yönelik olarak öğrenciler rehberlik etmek amacıyla hazırlanmış bireysel öğrenme materyalidir.

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Dear Students,

The purpose of this module is to provide a common background for students who are making a study of textiles. Some students may be planning to enter one of the many career areas that require some knowledge about textiles. Others may be interested in becoming better-informed consumers. Whatever may motivate students to enter an introductory course in textiles, certain basic concepts are essential to their understanding of the subject. It is our hope that these concepts are presented in a clear, logically developed format.

The text begins with an overview of the textile industry. The majority of students are likely to begin their study of textiles without any prior knowledge of the origin, manufacture, and distribution of the wide variety of textile products they use daily. The first chapter presents an overview of the journey of textile products that begins with fiber production and goes on to manufacture of yarns or other components, to fabric production, to design, and to manufacture of the final product. It is our intention to set a context for the chapters that follow in which basic processes, rooted in science and technology, are explored in depth, beginning with the basic building blocks of fabrics: fibers. In subsequent chapters emphasis is placed on the interrelationships of fibers, yarns, fabric constructions, dyes, and finishes. What is known about each of these components is applied to the understanding of textile behavior and performance. The chapters build on each other, much as the textile structure itself is built, and summaries at various stages in the text review the properties that affect performance. We reinforce this view of analyzing component parts of a textile by case studies of particular end use products.

Diagrams and photographs have been selected with care to illustrate the concepts and processes described in the text. Many students study in parts of the country where they have no access to field trips to textile manufacturing sites; therefore, we have included photographs of various types of machinery.

Each chapter includes review questions that invite students to summarize and apply the concepts presented in the text.
LEARNING ACTIVITY-1

AIM

If suitable conditions are provided, you will be able to define the basic concepts of textile.

SEARCH

➢ Search some English materials about textile from different sources.
➢ Bring the materials to the class.
➢ Discuss about the materials.

1. BASIC CONCEPTS OF TEXTILE

1.1. General Classification Of Textile

Each day each of us makes decisions about textiles. From the simplest choice of what clothes to wear to the commitment of a major portion of the family budget to buy a new carpet, judgments about the performance, durability, attractiveness, and care of textiles are consciously or unconsciously made. The economic implications of decisions about fibers, yarns, and fabrics obviously increase if someone is involved professionally with textiles. But whether or not understanding textiles is required for personal or for professional purposes, the key to informed decision making is knowledge about fibers, yarns, fabrics, and finishes and the ways in which these are interrelated.

Textiles fulfill so many purposes in our lives that their study can be approached in a number of ways. Textiles may be seen as being purely utilitarian, in relationship to the numerous purposes they serve. On awaking in the morning, for example, we climb out from under sheets and blankets and step into slippers and a robe. We wash our faces with washcloths, dry them with towels, and put on clothing for the day. Even the bristles of our toothbrushes are made from textile fibers. If we get into a car or bus, we sit on upholstered seats; the machine moves on tires reinforced with strong Textile cords. We stand on carpets, sit on upholstered furniture, and look out of curtained windows. The insulation of our houses may be glass textile fiber. Not only are golf clubs, tennis rackets, and ski poles reinforced with textile fibers, but so are roads, bridges, and buildings. Strong, heat-resistant textile fibers in the nose cones of spaceships travel to distant planets. Physicians implant artificial arteries made of textiles or use fibers for surgery that gradually dissolve as wounds heal. Few
of our manufactured products could be made without textile conveyor belts. Even our processed roods have been filtered through textile filter paper. There is truly no aspect of modern life that is untouched by some area of textiles.

Even though we all personally experience textiles at home, at work, and at play, "usually encounter only the complete product; rarely do we deal with the individual components.

But each finished product makes a long journey from its beginnings in the laboratory or on the farm to the place where it is acquired by the ultimate consumer.

If you were to take the shirt or sweater that you are wearing at this moment and break it down into its components, you would have to work backward, taking apart the fabric structure. Most likely your garment is woven or knitted. Weaving and knitting are the two most common means of creating fabrics for apparel, although other methods do exist. Both weaving and knitting are subject to a great many possible variations, and these differences contribute to the enormous variability in appearance, drapability, texture, wrinkle recovery, durability, feel, and many other qualities of fabrics.

To take a woven or knitted structure apart requires that the fabric be unraveled into the yarns from which it was constructed. The yarns (with some few exceptions) are likely to have been made from short or long continuous fibers that are twisted together. By untwisting the yarns, it should be possible to separate the yarn into a number of small, fine, hairlike fibers. These fibers are the basic units that make up the majority of textile products encountered in apparel and home furnishings. (See Picture 1.1.)
1.1 Fabric unravels into separate yarns. Yarns untwist into individual fibers.

Fibers

Textile fibers exist in nature or are created through technology. Technical definitions of the term textile fiber such as that of the American Society for Testing and Materials (ASTM) tend to stress their dimensions: “a generic term for any one of the various types of matter that form the basic elements of a textile and that is characterized by having a length at least 100 times its diameter” (ASTM 1986).

Although this may explain how a fiber looks, some materials that do fit this definition are not suitable for use in textiles. The fibrous structure of an overcooked pot roast, for example, is obviously not suitable for use in a textile. Fibers appropriate for use in textiles must have not only fineness and flexibility but also sufficient strength and durability to withstand conditions encountered in use.

To understand and evaluate suitability of different fibers for particular products, professionals in the textile field and consumers need to understand the physical and chemical properties of fibers. Particular fibers may be suitable for use in some textile applications but not in others. Carbon fiber, excellent for use in high-technology products and sports equipment, is not useful for wearing apparel. Even among those fibers used in many apparel and home furnishing items, some are preferred for particular applications. Nylon has become synonymous with sheer women's hosiery—women may refer to their stockings as "nylons" although in fact, in the past, fibers such as silk or rayon were used to make women's dress hosiery.
On reflection, then, it is obvious that we tend to prefer some kinds of fibers for certain uses because those particular fibers offer some special advantages. For example, a particular fabric may seem to be more comfortable in warm or cool weather, may soil less easily, may dry more quickly, or may have an appearance that is best suited to a particular kind of occasion. The reasons for these differences among fibers reside in the specific properties of each fiber. If we are to have a clear understanding of the finished products and what qualities are to be expected of them, we need to know the fibers from which the product is made—and the characteristics of those fibers.

**Yarns**

Fibers alone cannot make a textile. Although it is possible to entangle groups of fibers or to bond them together in some way to create a textile (as is done with felt, for example), most of the cloth that is made into wearing apparel is formed from yarns. Yarns are assemblies of fibers twisted or otherwise held together in a continuous strand. An almost endless variety of yarns can be created by using different fibers, by twisting fibers more or less tightly, by combining two or more individual yarns to form a more complex yarn, or by giving yarns a wide range of other special treatments.

Just as different fibers will vary in their individual properties, different kinds of yarns have varying characteristics. (See Picture 1.2.) And to complicate matters still further, two yarns of the same structure will have different properties if they are made from markedly different kinds of fibers.

![Picture 1.2](image.png)

*Picture 1.2.* Fabrics made from the same fiber and in the same (plain) weave look different because different kinds of yarns are used.
Fabric Structures

Yarns must be united in some way if they are to form a cohesive structure. The transformation of individual yarns into textile fabrics can be accomplished by an individual with a pair of knitting needles, a crochet hook, or a hand loom or through the use of powerful machines that combine yarns by weaving, knitting, or stitch bonding to produce thousands of yards of completed fabrics. As with fibers and yarns, the potential for variations in the structure is enormous, and a walk through any department store will reveal to even the most casual observer the almost endless variety of textile structures produced and consumed by the public in the form of apparel or household textiles.

And, once again, if the construction being used is varied, the resulting properties will differ. Furthermore, even when the same weave or knit construction is used, the end product will be distinctive if the fiber or yarn type is varied. (See Picture 1.3.)

![Picture 1.3](image)

Picture 1.3. Fabrics made from the same fiber and from similar types of yarns look different because different types of weaves.

Coloring and Finishing

Appearance—color, pattern, or texture—is one of the major factors that lead consumers to purchase one product over another. Most textile fabrics intended for personal, household, or architectural use have been decorated in some way, by dyeing the fabric, printing designs on it, or weaving with varicolored yarns. Large segments of the textile industry are devoted to dyeing and/or printing fabrics, yarns, or fibers.

As the reader will learn, certain properties are inherent to each fiber, yarn, or fabric structure. Consumers find some of these properties desirable, while others are not valued. For example, fabrics of synthetic fibers dry quickly after laundering. Most consumers value this quality. But the same fabrics may tend to build up static electric charges, producing small electrical shocks or "static cling." Consumers do not like this quality. When a fiber, yarn, or fabric has unacceptable properties, special treatments called finishes may be applied to the fiber, yarn, or fabric to overcome undesirable properties. Finishes may be used to give to the fibers, yarns, or fabrics some properties that they do not normally possess but that will
enhance performance. Static cling can thus be decreased or overcome. Most people are familiar with durable press finishes, for example, or may have purchased upholstered furniture with soil-resistant finishes.

1.2. Yarn And Basic Concepts Of Yarn Making

- **Yarn:** A yarn is a strand of natural or man-made fibers or filaments that have been twisted or grouped together for use of weaving, knitting, or other methods of constructing textile fabric. The type of yarn manufactured will depend on the fibers selected; the texture, or hand, of the fabric to be made; and qualities such as warmth, resiliency, softness, and durability required in the fabrics end uses.

Yarn making is generally the second step in the manufacture of textile fabrics. Raw fibers arrive at the yarn manufacturers in different forms. For example, cotton is in bales, wool in fleeces; cultivated raw silk in strands and waste and wild silk in bales; flax in bundles; rayon, acetate, nylon and the other manufactured fibers on tubes, cones, cops, spools or skeins.

In general, fibers are blended or mixed before yarn manufacture actually begins. Cotton, wool, spun or waste silk, spun rayon, spun acetate, spun nylon and many of the noncellulosics are made into yarn by carding and combing with little or no spinning.

- **Carding:** separates the fibers and puts them in a filmy sheet that is funneled into a soft mass called sliver. Sheets of fiber passed between rollers that are covered with fine wires that perform a brushing function.

- **Combing:** is necessary when fine, uniform yarns are needed to give sheerness, luster, smoothness, and possibly durability.

- **Hackling:** is the process by which flax is prepared for linen yarn. The purpose of hackling is to disentangle the flax fibers and to lay them parallel.

- **Reeling and throwing:** Raw silk is the long fiber silk that is reeled from the cocoon and twisted into yarn. Several yarns are combined and twisted onto bobbins. If ply yarns required, the strands are combined and twisted together. The combining and twisting is called throwing.

- **Spinning:** The spinning operation draws out the roving (very slackly twisted sliver) and puts in the required amount of twist. The purpose of twist is to bind the fibers together and to holds in the ends of fiber. Generally speaking, the tighter twist, the stronger the yarn. This is true to a certain point; then the yarn weakens and may finally break.
1.2.1. Fibers

A fiber is a hairlike unit of raw material of which cloths are made. For example, cotton, linen, rayon, silk, wool, nylon, and polyesters. Fibers that are used in textiles can be classified under two main categories: Natural fibers and Man-made fibers.

- **Natural Fibers**

  The 'natural' classification is subdivided into fibers of vegetable, mineral, and animal origins.

- **Vegetable fibers**

  Vegetable fibers are found in the cellulosic structure of many plants. Some are on the coverings of seeds, such as cotton, kapok, and coir. Others are in the outer layer of stalks, such as linen, ramie, jute, and hemp. Some are in the leaves, such as sisal, and some are grasses and reeds.

- **Seed fibers**
  
  - **Cotton**

    Cotton is a vegetable fiber that grows from the surface of the seed. Each fiber is essentially a long thin tube of cellulose with a central feed channel, called a lumen, which runs almost the whole length of the fiber. In modern production, cotton is cultivated as an annual plant rather than letting it grow into a tree. Harvesting is easier working in this way and fiber properties are better controlled; also, cotton plants left in the ground after harvesting are subject to attack by pests. (See Figure 1.1)

    - **Kapok**

    A vegetable fiber that comes from a plant or tree grown chiefly in Java, the West Indies, Central America, India, Africa, South Asia, and Brazil, kapok is a silky fiber, finer than cotton but not as adaptable to spinning; hence, it is not used in woven cloth. Mattresses and pillows are filled with kapok. Kapok dries quickly and is serviceable for life preservers because it is buoyant and light in weight. After a season's use the kapok filling can become heavy and nonbuoyant.
This is a hard, reddish-brown fiber obtained from the outer shell of the coconut. Coir is prepared by hand or by machines with fluted iron rollers that crush the husks. Broken fibers are dried in the sun, then cleaned, and are used for mattresses. The finer grades of mattress fiber can be made into rope and cocoa matting. The stronger, coarser fibers are made into hanks and sold for brushes, primarily to the European market. From strips of leaves of the coconut palm, a thread can be made that is elastic, lightweight, and waterproof. It is used in mats, bags, hats, and slippers.

- The Bast Fibers
  - Flax

Flax (Linum usitatissimum) is an annual, herbaceous plant grown in temperate and subtropical areas. After flowering, the bolls or capsules contain up to ten seeds. The fibers occur in the bark of the stem and it is the long stemmed varieties that are used for linen. Bast stems contain bundles of fibers that act as hawsers in the fibrous layers lying beneath the bark of dicotyledenous plants. (A dicotyledon is a plant having two seed leaves.) They help hold the plant erect. The Soviet Union was the largest producer before the collapse of communism but is no longer. Some satellite countries of the former USSR, such as Slovakia, produced large quantities of flax and linen yarns, some of which were directed to the manufacture of tarpaulins and other industrial uses.
Jute fibers are obtained from two species of Corchorus, namely C. capsularis and C. olitorius. There are also a number of jute substitutes such as Bimli (from Hibiscus cannabinus) and China jute (from Abutilon theophrasti). Jute fabrics formed the 'sackcloth' of Biblical times and are now used for wrappings, bindings, etc.

Hemp

The botanical name for hemp is Cannabis sativa. Sisal and manila hems are hemp substitutes. Cultivation is not unlike that of other bast fibers and, again, the time for harvesting has to be judged carefully. The fibers are soft and fine if they are harvested as the pollen begins to shed, but they are weaker than those obtained from later harvesting. Hemp made its mark because of the strength of the fiber. The cells vary from about 0.5 to 1 inch long, and, like flax, they are thick-walled tubes, although the lumen has blunt ends. The fibers may be up to 6 ft long and are roughly cylindrical with cracks, swellings, and other irregularities.

Ramie

Ramie comes from plants with the botanical name Boehmeria niva or B. tenacisseme. Fibers are removed by decortication, which is a process whereby the fibers are removed from soaked stalks by scraping or beating. Gums are then removed by soaking in caustic soda followed by neutralization in an acid bath. The fiber is then washed and oiled. The thick-walled cells often reach 18 inches long. Normally the fiber is rather stiff but mercerized ramie has some qualities that allow it to approach the performance of cotton.

The Leaves Fibers

Sisal

Sisal, from the leaves of a tropical plant, is often called sisal hemp. This is a hard fiber larger and stiffer than the bast fibers, flax, hemp, jute, and ramie. Sisal grows on large plantations in Java, Haiti, Kenya in East Africa, West Africa, and Central America. Principal uses are for cordage, ropes, and binder twine.

Animal fibers

The animal fibers that are most used in consumers' goods are wool, which is the protective covering of the sheep, and silk, cultivated or wild, which is the product of the silkworm and is obtained from its cocoon. Less important fibers include hair fibers from camels, rabbits, goats, cats, horses, and cattle. They differ microscopically from wool and, as a rule, are stiffer and more wiry than wool and do not felt well. Cashmere, a goat fiber, vicuna and alpaca, and camel's hair, however, are quite soft and may be classified as wool.

Cat hair and cow hair can be used as textile fibers, but they are used mostly for fur felts. Cow hair, although harsh and coarse, can be made into blankets.
• **Hair**
  
  • **Wool**

Wool is normally defined as the fleece of sheep. Wool is a protein called keratin, which has a main polypeptide chain with amino acid side chains. It is an outgrowth of the epidermis (skin) of the sheep and the surface of the fiber has minute overlapping scales extending lengthwise and pointing to the end remote from the root or cuticle. The root is embedded in the epidermis. Wool grows in tufts, in or near the follicles in the skin of the animal; however, the useful, outermost portions of the fibers on the animal are no longer growing. Growth occurs by multiplication of the soft cells of the papilla, which exist at the base of the follicle. The papilla is a vascular arrangement of connective tissue extending into and nourishing the root of a hair. The useful part of the fiber is displaced from the cuticle as new cells are added and the fiber gets longer.

![Figure 1.2: Portion of wool fiber showing scales](image)

• **Filament**
  
  • **Silk**

Silk is extruded by the silkworm into a cocoon and the silk has to be reeled from that cocoon before it can be used. Silkworms are of the Lepidoptera family, and of the Bombyx species, which feed only on mulberry leaves. Cultivated species are often B. mori, but there are also other species such as B. textor and B. sinensis. Indian Tasar silkworms are Antherea proylei and A. mylitta, which feed on leaves other than mulberry. A. assamensis (Mugar) silkworms and others are also used for fiber harvesting.

1.2.1.1. **Man-made Fibers**

These are the fibers that are not found in nature. They are all produced by humans from regenerated cellulose and petroleum derivatives. A general description of broad bases for classification of manufactured fibers should be helpful.

➤ **Fibers Derived from a Cellulosic Base**

Some fibers, such as rayon and acetate, have a base of natural plant cellulose, the same as cotton. Other fibers are based on protein found in milk, soybeans, or corn meal. Others are based on natural rubber from the rubber tree.
Fibers Derived Synthetically from a Noncellulosic Base

- Nylon, Polyester, Acrylic, Modacrylic

The fibers in this classification may be called general-purpose fibers since they are widely used for many kinds of clothing and for many industrial purposes. The fiber-forming substances are chemical compounds created largely from petroleum and natural gas. These compounds are also used for plastic materials. Other noncellulosic man-made synthetic fibers may be called special-purpose fibers. They are glass, metallic, azlon, rubber.

1.2.2. Systems Of Yarn Manufacture

Although there are important differences, the process stages and the machines used at each stage in processing wool and cotton have similar underlying principles. Taking into consideration the necessity to cater for a continuous process, these are:

- cleaning, blending, and completely disentangling the fibers;
- assembly of the opened fibers into a continuous length;
- reducing the number of fibers in the cross-section to form a strand of the required linear density or count, twisting of the strand to form a yarn, and winding the yarn onto a package.

In modern yarn manufacture, these stages may be said to translate to the following stages:

- preparation for carding;
- carding;
- preparation for spinning; and
- Spinning.

Carding is a process that completely disentangles the fibers, ideally separating them to the single-fiber level. It is at this stage that the web of fibers is formed into a continuous sliver.

Figure 1.3 shows a schematic of the cotton card.
Figure 1.3: The cotton card

A typical woolen card as shown in Figure 1.4 consists of two sections, the scribbler and the carder, each consisting of a number of cylinders.

Figure 1.4: The woolen card

Man-made fibers are produced in continuous lengths by an extrusion process. Before these extruded fibers can enter the standard yarn-production process, they need to be chopped or stretch-broken into short lengths of fiber. The average length can be chosen depending on the system of yarn manufacture used for processing the particular man-made fiber. Man-made fibers usually enter the processing chain either at the preparation-for-carding stage or at the preparation-for-spinning stage. In some systems of yarn manufacture, when processing cotton and wool, there is an additional stage of combing, after carding, where a proportion of the shortest fibers and any remaining impurities are removed. Combing produces a higher-quality and more lustrous yarn.
Although the processing steps in converting fiber to yarn generally follow these stages, different methods and machine designs are required to handle the different fiber types. Furthermore, it is also possible to manipulate fibers in different ways to produce yarns with completely different characteristics. Different systems of yarn manufacture have therefore evolved. The primary systems of yarn manufacture are described below.

1.2.2.1. Cotton System

This is the most widely used system for fibers with a mean fiber length of 15-50 mm and can process cotton, man-made staple fiber, and their blends. Yarns can be either carded or combed. (See Figure 1.5) Combed yarns are produced when the fibers are subjected to the combing operation, which is an option with this system.

![Figure 1.5: The cotton system](image)
1.2.2.2. Woolen System

This is a versatile system for fibers with a mean fiber length of 25-80 mm, producing bulky, whiskery yarns from wool, waste fibers, reprocessed fibers, fibers of various colours, man-made fibers, and their blends. In this system, the carded web is converted to a number of slubbings rather than a single sliver. The slubbings are directly converted to yarn, and the fibers are therefore not aligned. This system may be used to produce hand-knitting yarns, carpet yarns, and yarns for the manufacture of apparel items such as certain types of women's dresswear and men's jackets. The weave pattern of fabrics made from such yarns is generally not as well defined as that in fabrics made from worsted-system yarns because of the arrangement of fibers in the yarn, the fullness of the yarn, and the effect of subsequent finishing treatments.

The Worsted System

The worsted system, for fibers with a mean fiber length of 40-200 mm, consists of the two specialist operations of topmaking, where combed slivers are produced, and spinning, where the sliver is converted to a yarn. Mills may be topmakers, spinners, or vertical organisations, which carry out both the operations. Combing is an essential stage in the worsted system. The system produces lean yarns with comparatively well-defined twist from well-ordered fibers of wool, man-made staple fibers, and their blends. Yarns produced by this system are used in the manufacture of high-quality apparel fabrics, such as suitings.
1.2.2.3. Man-Made Systems

Man-made fibers are produced from polymers. Man-made fibers are manufactured by spinning the polymer. There are three major types of spinning processes: melt, dry and wet spinning.

- **Melt spinning**

  In melt spinning, the polymer is melted by heating. The molten polymer is pumped through the tiny holes of a spinnerette; thus the fiber is formed. The fiber is then cooled and solidified. (See Figure 1.9)
Figure 1.9: Simple fibre extrusion

- **Dry spinning**

  In dry spinning, polymer is dissolved in a solvent. After extrusion through a spinnerette, the solvent is evaporated and the fiber is solidified. (See Figure 1.10)

- **Wet spinning**

  In wet spinning, the polymer is dissolved in a solvent similar to dry spinning. After extrusion, the solvent is removed in a liquid coagulating medium. (See Figure 1.11)
Figure 1.10: Dry spinning

Figure 1.11: Wet Spinning
1.2.3. Yarn Types and Usage Places

The primary classification of yarns is as filament or staple.

- **Filament Yarns:**

  Filament yarns are made from long, continuous strands of fiber. *Monofilament yarns,* those made from a single filament, find limited use in nylon hosiery (where an exceptionally sheer fabric is wanted), in some open-work decorative fabrics, and in fabric webbing (used in some lightweight beach or casual furniture) as well as in a variety of industrial uses.

  More commonly, many filaments are joined to form *multifilament yarns.* Multifilament yarns can be made more cohesive by twisting them together loosely or more tightly. The amount of twist together with the characteristics of the fibers (luster, hand, cross-sectional shape, etc.) will determine the appearance and feel of the yarn. For example, a loosely twisted smooth filament yarn made from a bright fiber would be characterized by marked luster, resistance to pilling, and a smooth surface.

  Sometimes filament yarns are put through an additional process called *texturing.* Texturing modifies the feel and bulk of filament yarns.

- **Staple Yarns**

  Staple, or *spun,* yarns are made from staple length fibers. Being short, staple fibers must be held together by some means in order to be formed into a long, continuous yarn. Although the multiple processes required to make staple yarn add significantly to the cost of the yarn, the aesthetic qualities such as comfort, warmth, softness, and appearance make these yarns highly desirable in many products. Natural fibers, except for silk, are all staple fibers. Silk and manufactured fibers can be cut or broken into staple fibers, so that it is possible to spin any natural or manufactured fiber into a staple yarn.

  In addition to identifying yarns as being made from either filament or staple fibers, yarns are also classified based on a number of other characteristics. Authorities often differ when they define yarn types. The following are the most common classifications.

- **Yarns Classified By Number Of Parts**

  Yarns that have been classified by the number of parts they possess are divided into *single,* *ply,* and *cord yarns.* A *single yarn* is made from a group of filament or staple fibers twisted together. If a single yarn is untwisted, it will separate into fibers. A single yarn might be identified as either a single yarn of staple fibers or a single yarn of filament fibers.
Ply yarns are made by twisting together two or more single yarns. If ply yarns are untwisted, they will divide into two or more single yarns, which, in turn, can be untwisted into fibers. Each single yarn twisted into a ply yarn is called a ply.

Cord yarns are made by twisting together two or more ply yarns. Cord yarns can be identified by untwisting the yarn to form two or more ply yarns. Cord yarns are used in making ropes, sewing thread, and cordage and are woven as decorative yarns into some heavyweight novelty fabrics.

- **Yarns Classified By Similarity Of Parts**

Simple yarns are those yarns with uniform size and regular surface. They have varying degrees of twist, ranging from loose to moderate, tight or hard twist. Single, ply and cord yarns can all be simple yarns if their components are uniform in size and have a regular surface. When one strand of fibers is twisted together evenly, it is classified as a simple single yarn. Two simple, single yarns twisted together create a simple ply yarn.

Yarns made to create interesting decorative effects in the fabrics into which they are woven are known as novelty yarns. (See Figure 1.12) Some authors also call these yarns complex yarns, although complex yarns usually have more than one part. Novelty yarns can be single, ply, or cord, staple or filament. Novelty yarns are used in knitted sweaters and dresses, contemporary drapery and upholstery fabrics, and the decoration of men’s and women’s suiting fabrics.

In the industry novelty yarns tend to be referred to as fancy yarns. Terminology identifying these yarns is confusing. The following list of terms and their definitions represents an attempt to define these terms as they appear to be accepted by most authorities.

- **Boucle yarns** are ply yarns. An effect yarn (so-called because it is used to create decorative effects) forms irregular loops around a base yarn or yarns. Another yarn binds or ties the effect yarn to the base. Ratine yarns are similar to boucle in construction. The loops in ratine yarns are spaced evenly along the base yarn. Snarl yarns are another type of loop yarn in which two or more single yarns under different tension are twisted together. The varying tension allows the effect yarn to form alternating unclosed loops on either side of the base yarn.

- **Flake, flock, or seed yarns** are made of loosely twisted yarns that are held in place either by a base yarn as it twists or by a third or binder yarn. These yarns are relatively weak and are used in the filling to achieve decorative surface effects.

- **Nub yarns** are ply yarns in which an effect yarn is twisted around a base yarn a number of times in a small area to cause an enlarged bump or 'nub.' Sometimes a binder yarn is used to hold the nubs in place. The spacing of the nubs may be
at regular or irregular intervals. Nubs are often different colors than the base yarn. The terms *knot, spot, or knop* are also applied to this type of yarn.

- **Slub yarns may** be either ply or single yarns of staple fibers. The slub effect is created by varying the twist in the yarn, allowing areas of looser twist to be created. This produces a long, thick, soft area in the fabric called a *slub*. Slub yarns are irregular in diameter. The surface of fabrics woven with slub yarns shows these irregularities. Yarns made in this way have areas of varying twist, causing weaker areas in the yarn. In many fabrics slub yarns are placed in the filling or crosswise direction where fabrics receive less strain. Slubs are the same color as the rest of the yarn and cannot be pulled out of the fabric without damaging the structure of the fabric. Filament yarns can be spun with varying degrees of twist. These yarns also create a slubbed appearance in fabrics. Such filament yarns are known as *thick-and-thin yarns*.

- **Spiral, or corkscrew, yarns** are made of two plies, one soft and heavy, the other fine. The heavy yarn winds around the fine yarn.

- **Chenille yarns** are made by a totally different process and require several steps in their preparation. First, leno-weave fabric is woven. This fabric is cut into strips, and these strips, which have a soft pile on all sides, are used as yarns.

![Figure 1.12: Some types of novelty yarns](image-url)
APPLICATION ACTIVITY

Use technical English about the production of yarn.

<table>
<thead>
<tr>
<th>Steps of process</th>
<th>Suggestions</th>
</tr>
</thead>
</table>
| Translate the text given below | ➢ Please read all of the text.  
➢ If you do not know words in text, research the meaning during translation  
➢ Use English dictionary for the meaning of words from English to Turkish  
➢ You can find detailed information about the technical words in the text. |

Yarn consists of several strands of material twisted together. Each strand is, in turn, made of fibers, all shorter than the piece of yarn that they form. These short fibers are spun into longer filaments to make the yarn. Long continuous strands may only require additional twisting to make them into yarns. Sometimes they are put through an additional process called texturing.

The characteristics of spun yarn depend, in part, on the amount of twist given to the fibers during spinning. A fairly high degree of twist produces strong yarn; a low twist produces softer, more lustrous yarn; and a very tight twist produces crepe yarn. Yarns are also classified by their number of parts. A single yarn is made from a group of filament or staple fibers twisted together. Ply yarns are made by twisting two or more single yarns. Cord yarns are made by twisting together two or more ply yarns.
CHECKLIST

If you have behaviors listed below, evaluate yourself putting (X) in “Yes” box for your earned skills within the scope of this activity otherwise put (X) in “No” box.

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Have you had the knowledge of technical English about the terms of yarn production?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Have you had the knowledge of technical English about the methods of man-made systems?</td>
<td></td>
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<tr>
<td>3. Have you had the knowledge of technical English about the systems of yarn manufacture?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Have you had the knowledge of technical English about the yarn types and usage places?</td>
<td></td>
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</tr>
</tbody>
</table>

EVALUATION

Please review your "No" answers in the form at the end of the evaluation. If you do not find yourself enough, repeat learning activity. If you give all your answers "Yes" to all questions, pass to the "Measuring and Evaluation".
MEASURING AND EVALUATION

Answer the following questions and measure your knowledge.

1. Which one is a novelty yarn?
   A) Simple
   B) Cord
   C) Chenille
   D) Ply

2. “A …….is a strand of natural or man-made fibers or filaments that have been twisted or grouped together for use of weaving, knitting, or other methods of constructing textile fabric.” What is this definition for?
   A) Fibre
   B) Yarn
   C) Fabric
   D) Ply

3. “In ……… spinning, polymer is dissolved in a solvent. After extrusion through a spinnerette, the solvent is evaporated and the fiber is solidified.” Which is right for this definition?
   A) Melt
   B) Dry
   C) Wet
   D) Silk

4. “A…………. is a hair-like unit of raw material of which cloths are made Which one is a vegetable fibers?
   A) Fibre
   B) Yarn
   C) Fabric
   D) Ply

5. Which one is an animal fibers?
   A) Cotton
   B) Wool
   C) Polyamid
   D) Kapok
6. “........ is a process that completely disentangles the fibers, ideally separating them to the single-fiber level.” Fill in the blank with correct one.
A) Carding  
B) Combing  
C) Roving  
D) Spinning

7. “....... yarns are made by twisting together two or more single yarns.”?
A) Cord  
B) Boucle  
C) Spiral  
D) Ply

8. “....... yarns are made from long, continuous strands of fiber”?
A) Staple  
B) Boucle  
C) Filament  
D) Linen

EVALUATION

Please compare the answers with the answer key. If you have wrong answers, you need to review the Learning Activity. If you give right answers to all questions, pass to the next learning activity.
LEARNING ACTIVITY-2

**AIM**

If suitable conditions provide, you will be able to define the basic concepts about weaving and industrial weaving.

**SEARCH**

- Search some English materials about weaving from different sources.
- Bring the materials to the class.
- Discuss about the materials.

2. BASIC CONCEPT FOR WEAVING AND INDUSTRIAL WEAVING

2.1. Weaving Preparatory Operations

Yarn is the basic building block in weaving. Therefore, after yarn manufacturing, the next successive step would be to weave the yarn into a fabric. However, in practice, the condition of yarn produced on the spinning machine is not always good enough to be used directly for fabric formation. Package size, yarn surface characteristics, and other factors make it necessary for both filling yarn and warp yarn to be further processed for efficient fabric formation. These preparatory processes are called weaving preparation.

Warp and filling yarns are subjected to different conditions and requirements during weaving. Therefore, the preparation of warp and filling yarns is different. Warp yarn is subjected to higher stresses which require extra preparation. The filling yarns are not subjected to the same type of stresses as the warp yarns and thus are easily prepared for the weaving process. Depending on the spinning method, the filling yarns may not be prepared at all, but rather taken straight off the spinning process and transported to the weaving process. This is the case with open-end (rotor), air-jet and friction spinning systems which provide a large single-end package suitable for insertion during weaving. The processes used to prepare yarns for weaving depend on yarn type as well.

Winding is the major preparation process for filling yarn. Warp preparation includes winding, warping, slashing and drawing-in or tying-in. Figure 2.1 shows the major preparation processes for filling and warp yarns.
2.1.1. Winding

Winding is basically transferring a yarn from one type of package to another. (See Figure 2.2-Schematic of winding process). This simple definition may make the winding sound like a trivial process; however, it is an important and necessary process that performs the following functions especially for ring spun yarns.

- Winding produces a yarn package that is suitable for further processing. Ring spinning produces small packages of yarn (called spinner's packages or bobbins) which would be depleted relatively quick during filling insertion or warping. Therefore, the amount of yarn on several small packages is combined by splicing or knotting onto a single package (See Figure 2.3). Knotting has been replaced by splicing in modern winding machines.

- The winding process provides an opportunity to clear yarn defects. Thin and thick places, slubs, nep or loose fibers on the yarn are cleared during winding and, thus, the overall quality of the yarn is improved. Staple yarns require this clearing operation most because they may have these kinds of faults more often.

The increasing use of newer spinning technologies resulted in a situation where the old concept of yarn clearing and package quality now has become a part of the spinning process rather than part of a separate winding process.
2.1.2. Warp Preparation

The preparation of warp yarn is more demanding and complicated than that of the filling yarn. Each spot in a warp yarn must undergo several thousand cycles of various stresses applied by the weaving machine. Weaving stresses include dynamic
extension/contraction, rotation twist/untwist), and clinging of hairs. Additionally, there are metal-to-yarn and yarn-to-yarn flexing and metal-to-yarn and yarn-to-yarn abrasion stresses. Modern weaving machines have placed increased demands on warp preparation due to faster weaving speeds and the use of insertion devices other than the shuttle. Warp yarn must have uniform properties with sufficient strength to withstand stress and frictional abrasion during weaving. The number of knots should be kept to a minimum. The knots should be standard type and size such that they fit through the heddle eyes and reed dents. Size agent must be applied uniformly on the surface of the yarn. The yarns on the warp sheet must be parallel to each other with equal tension.

Warp preparation involves winding, warping, slashing and drawing-in or tying-in. The purpose of warp winding is to form a package of good quality yarn that is large enough to be used in the creel of a warping machine. Winding of yarn for warping is usually done at relatively high tension.

2.1.3 Warping

In general terms, warping is transferring many yarns from a creel of single-end packages forming a parallel sheet of yarns wound onto a beam or a section beam (Figure 2.4.). Today's warping machines can process all kinds of materials including coarse and fine filament and staple yarns, monofilaments, textured and smooth yarns, silk and other synthetic yarns such as glass. Usually a static eliminator device is recommended for yarns that can generate static electricity.

The warp beam that is installed on a weaving machine is called a weaver's beam. A weaver's beam can contain several thousand ends and for different reasons it is rarely produced in one operation. There are several types of warping processes depending on the purpose.

![Figure 2.4: Shematic of Warping process(V-creel).](image)
2.1.3.1. Direct Warping

In direct warping, the yarns are withdrawn from the single-end yarn packages on the creel and directly wound on a beam (Figure 2.5.).

![Direct warping machine](image)

**Figure 2.5: Direct warping**

Direct warping is used in two ways:

Direct warping can be used to directly produce the weaver's beam in a single operation. This is especially suitable for strong yarns that do not require sizing such as continuous filaments or monofilaments and when the number of warp ends on the warp beam is relatively small. This is also called direct beaming.

Direct warping is used to make smaller, intermediate beams called warper's beams. These smaller beams are combined later at the slashing stage to produce the weaver's beam. This process is called beaming. Therefore, for example, if the weaver's beam contains 9000 warp ends, then there would be—say—9 warper's beams of 1000 ends each. If this weaver's beam were to be made at one stage, the creel would have to 9000 yarn packages, which is hardly possible to manage and accommodate (Note: The warper's beams may also be called—confusingly enough—section beams. Therefore, this method of producing weaver's beam may also be called section beam warping). Usually 3 to 4 ends per cm (8 to 10 ends per inch) are recommended on section beams for slashing purposes. Beam hardness is recommended to be

50-60 (Shore 0-2 durometer); hardness should be achieved with tension, not from packing roll pressure.
Direct warpers are used to warp all conventional staple fibers, regenerated fibers and filaments. In direct warping, a flange beam is used. Since all the yarns are wound at the same time, the flanges provide sufficient yarn stability on the beam. The typical beam flange diameters are 800, 1000, 1250 and 1400 mm with working widths of 1400 to 2800 mm. Machine specific options include tape applicator, static eliminator, windscreen, comb blowing and dust extraction devices, yarn storage and inspection units, oiler, tension roller unit, beam removal unit and control platform. Figure 2.6 shows an expanding zigzag comb which is used to control the width of the beam and keep the yarns parallel and straight.

![Expanding zigzag comb](image)

**Figure 2.6: Expanding zigzag comb**

### 2.1.3.2. Cone (Section) Warping

In cone warping, a section beam is produced first as shown in Figure 2.7. Other names used for section warping are pattern warping, band warping or drum warping. The section beam is tapered at one end. Warp yarn is wound on the beam in sections, starting with the tapered end of the beam (Figure 2.8). Each section has multiple ends that are traversed together slowly during winding along the length of the section to form the angle. Due to the geometry of the yarn sections, the last section on the beam will have a tapered end that will make the whole yarn on the beam stable. It is important that each layer on the beam contain the same number of yarns. The same length of yarn is wound on each section which is measured by a measuring roller. The warping speed can be adjusted in the range of 20 to 800 m/min; however, residual elongation will be reduced at high speeds.
The circular cross section of the cone eliminates differences in yarn lengths in the first and subsequent sections. (Figure 2.8).

To obtain a uniform winding hardness from inside to outside, the winding tension needs to be held constant throughout the warp length, which can be done by varying the braking force. This method also reduces the tension variations during starting and stopping operations.

Lease bands are used in section warping. After a few turns at the beginning, a lease band is inserted in the axial direction of the beam (Figure 2.9). In unwinding, the lease bands are useful to identify the number of yarn layers.

After all the sections on the beam are wound completely, then the yarn on the beam is wound onto a regular beam with flanges, before slashing. This process is called beaming. Sometimes a section beam is also used in the slashing stage.
With today's computerized sectional warping systems, once the basic style information is entered, the computer automatically calculates the following [1]:

- number of sections on the beam and width of each section
- carrier lateral movement speed and automatic positioning of each section start point
- automatic stops for leasing
- calculation of the correct feed speed irrespective of the material and warp density
- The computer can also monitor the following:
  - automatic stops for predetermined length
  - operating speed regulation of +/- 0.5% between warping and beaming
  - beaming traverse motion
  - memory of yarn breakage during warping for beaming

2.1.4 Warping Machines

A typical warping machine has three major components: *creel, headstock and control devices.*

- **Creel**
  - There are various types of creels. The most common creel types are:
    - parallel standard creel with fixed package frame (single end creel)
    - parallel creel with package trucks
    - parallel creel with swiveling package frame sections (for cotton, viscose, polyester/cotton, wool colored)
• parallel creel with reserve packages (magazine creel, for synthetic filaments)
• parallel creel with unrolling draw-off for polypropylene, monofilaments
• V-creel with reversible frames
• V-creel with reversible frames and automatic knotter (for cotton, viscose, polyester/cotton)
• V-creel with traveling packages

Parallel creels are used for sectional warping and direct warping; V-creels are used for direct warping.

➢ Headstock

The yarn speed should be kept as constant as possible during warping. In cone (section) warping, a constant speed drive is generally sufficient in providing approximately uniform yarn speed on the surface of the beam. In direct warping, the change due to yarn build up on the beam is significant. Therefore, in direct warping, mechanisms that are similar to the ones used in winding are utilized to attain uniform yarn speed; surface friction drive and variable speed drive are commonly used.

➢ Control Devices

Similar to winding, warp yarns are threaded through tension devices, stop motions, leasing rods and the reed. Uniform tension is necessary so that all the warp ends behave the same way. The tension on the warp yarns is kept relatively low. Every ends requires a tension controller which is usually located close to the package.

2.1.5 Slashing (Sizing)

Although the quality and characteristics of the warp yarns coming out of the winding and warping processes are quite good, they are still not good enough for the weaving process for most of the yarns. The weaving process requires the warp yarn to be strong, smooth and elastic or extensible to a certain degree. To achieve these properties on the warp yarns, a protective coating of a polymeric film forming agent (size) is applied to the warp yarns prior to weaving; this process is called slashing or sizing. Sizing is not a value added process in woven fabric manufacturing. This is because, after the fabric is woven, the size materials will be removed from the fabric during the finishing operation, which is called desizing.

The main purposes of slashing are as follows:
➢ to increase the strength of the yarns
➢ to reduce the yarn hairiness that would cause problems in weaving process
➢ to increase the abrasion resistance of the yarns against other yarns and various weavings machine elements
to reduce fluff and fly during the weaving process for high speed weaving machines.

The ultimate goal of sizing is to eliminate or reduce warp breaks during weaving.

It should be noted that only warp yarns need to be sized. This is because, as mentioned earlier, warp yarns are subject to harsher treatments than filling yarns during the weaving process on the weaving machine. Therefore, the filling yarns will be free of size and no special finishing considerations are necessary for these yarns in the fabric.

2.1.6. Drawing-In

After slashing, the sized warp beam is prepared to be placed on the weaving machine. High fashion fabrics generally have high density which increases the demand on the quality of the shed opening. As a result, warp leasing is becoming more popular. Figure 2.10 shows a warp leasing machine. Different lease combinations can be selected with the automated leasing machines.

![Warp leasing machine](image)

Figure 2.10: Warp leasing machine

Drawing-in is the entering of yarns from a new warp into the weaving elements of a weaving machine, namely drop wires, heddles and reed, when starting up a new fabric style (Figure 2.11). Tying-in the new warp ends to the depleted warp is done when a new pattern is not required.
Figure 2.11: Schematic of drawing-in

A drop wire is a narrow metal sheet that is hung in the air by the tensioned warp yarn. If the warp yarn is broken, then the drop wire drops and touches a metal bar that extends along the width of the machine. This contact between the drop wire and metal bar closes an electrical circuit and shuts down the machine immediately (Figure 2.12). There is a drop wire for each warp yarn.

Figure 2.12: Electrical diagram of warp stop motion

After drop wire, the warp yarn goes through the heddle eye (there is only one warp yarn per heddle eye). This is done according to a plan called drawing-in-draft. Then, the yarn is threaded through the reed spaces. A reed space is the opening between two dents (metal) in a reed. In general, one, two or three warp yarns are passed through one reed space. The reed plan specifies the number of yarns per reed space. The number of yarns depends on the diameter of the yarns and the dent opening; each yarn should be able to move freely up and down in the reed space independent of the other yarn(s).
In the manual mode of drawing-in, one person sorts the warp yarn and the other draws it through from the other side. The sorting step can be automated by a reaching machine (Figure 2.13).

Today, the drawing-in and tying-in processes are fully automated. Drawing-in is done using robot-like machines. A special type of heddle is needed for automated drawing-in. Figure 2.14 shows an automated drawing-in machine. The warp ends, taken from the warp sheet, are fed individually to the drawing-in element; heddles are separated from the stack and brought to the drawing-in position; a plastic knife opens a gap in the reed and a hook draws-in the warp end through the heddle and reed in one step (Figure 2.15).

Automatic drawing-in increases speed, flexibility and quality in weaving preparation compared to manual drawing-in. A drawing rate of 50,000 warp ends per 8 hours (200 ends per minute) is possible.
Figure 2.15: Automatic drawing of warp end through drop wire, heddle eye and reed.

2.1.7. Tying-in

After the depletion of a warp beam on the weaving machine, if there will be no change in design, then the drawing-in process needs not be repeated. The ends of the old warp beam (now a fabric beam) are cut and the ends of the new warp beam are tied to the corresponding ends of the old beam which is called tying-in process. Then, the warp ends are pulled through the heddle eyes and reed until the knots are cleared.
A small portable robot is used on or off the weaving machine for tying-in. Typical knotting speed of a knotter is from 60 to 600 knots per minute.

Figure 2.16: Warp tying machine

2.2. Weaving Machines

The carrier used for transporting the filling yarn may differ from one kind of loom to another. The different devices used form the basis for classifying different types of looms. Within the industry many people refer to newer equipment as weaving machines rather than looms. Weaving machines vary from older, shuttle looms to modern shuttleless machines with sophisticated electronic controls. Classification of weaving machines can be done as follows:
Shuttle Looms

In shuttle weaving, the filling is inserted by a shuttle that traverses back and forth across the loom width. Figure 2.18 shows a shuttle with a quill (pirn) in it. Shuttles can be made of wood, plastic or a combination of both. Figure 2.19 shows various shuttles and Figure 2.20 shows different quill designs. Filling yarn is wound on the quill. As the shuttle moves across the loom, the filling yarn is unwound from the pirn and laid in the shed. The shuttle moves continuously back and forth across the loom. On each side of the loom, there is a picking stick that propels the shuttle by hitting it and causes it to fly across the loom inside the open shed. Picking sticks are usually made of special woods that can absorb energy without fatigue.
Figure 2.19: Various shuttles

Figure 2.20: Various quills
Shuttleless Looms

Shuttleless weaving machines were invented to increase the speed of weaving and reduce the literally deafening noise. The modern loom with a shuttle, although much faster in operation than the earliest automatic looms, is not susceptible to further increases in speed because of the variety of operations that the machine must perform. Time is required for stopping the shuttle and accelerating it in the other direction and the weight of yarn on the quill that must be carried across the shed limits the speed. For this reason, future loom developments are likely to be in the area of shuttleless weaving.

Shuttleless machines may be classified as to the method used in inserting the filling yarns. Four basic types have been developed:

- Machines with grippers or projectiles (throw across)
- Machines with mechanically operated gripper arms or rapiers (reach across)
- Machines employing water or air jets to carry the filling (spit or blow across)
- Machines that form multiple sheds (multiphase)

In hand weaving and automatic shuttle weaving, the filling yarn is continuous and runs back and forth across the fabric, but in most shuttleless weaving, the filling yarn extends only from selvage to selvage, as it is cut off before it passes across the shed. In all shuttleless weaving, the yarn for the filling is unwound from large, stationary packages of yarn that are sometimes set on one side and at other times set on both sides of the loom. Since weaving speed depends on fabric width, there is every incentive to build wider machines for more efficient filling insertion.

Projectile or gripper looms

Projectile weaving machines use a projectile equipped with a gripper to insert the filling yarn across the machine. The projectile can move more quickly than a conventional shuttle because of its decreased size; it can travel farther more easily, thereby making possible the weaving of wider fabrics, and it does not require the step of filling the shuttle; it pulls the yarn directly from a prepared yarn package. (See Figure 2.21)
Two types of projectile looms are used. In one, the projectile travels only in one direction. It is returned to the starting point by a conveyor belt. To maintain the weaving speed, each machine must have several projectiles, although only one is in use or any one time.

In the other type of projectile machine, a single projectile inserts one filling yarn alternately from the right- and left-hand sides of the loom. The projectile serves the same function as a conventional shuttle, but instead of holding a quill, it carries the yarn behind it. Packages of yarn must, therefore, be placed on both sides of the machine.

The projectile machine not only weaves fabric more quickly than does the shuttle loom, but it runs with less noise, making it possible for manufacturers to comply more easily with government regulations that restrict noise levels.

There is also a saving in power costs for wide-width fabrics. Narrow fabrics are not economically woven on this loom since too much time is spent in periods of acceleration of the projectile. Wide fabric widths are quite productive, as the power consumed is less than that for a conventional shuttle loom of the same size. Sheets are woven side by side on some of these machines to take advantage of these savings.

Rapier Looms

In this type of weaving, a flexible or rigid solid element, called rapier, is used to insert the filling yarn across the shed. The rapier head picks up the filling yarn and carries it through the shed. After reaching the destination, the rapier head returns empty to pick up the next filling yarn, which completes a cycle. A rapier performs a reciprocating motion.

Rapier weaving machines can be two types:
- **Single rapier machines:** A single, rigid rapier is used in these machines. The rigid rapier is a metal or composite bar usually with a circular cross section. The rapier enters the shed from one side, picks up the tip of the filling yarn on the other side and passes it across the weaving machine while retracting (Figure 2.22). Therefore, a single rapier carries the yarn in one way only and half of the rapier movement is wasted. Also there is no yarn transfer since there is only one rapier. The single rapier’s length is equal to the width of the weaving machine; this requires relatively high mass and rigidity of the rapier to ensure straight movement of the rapier head. For these reasons, single rapier machines are not popular. However, since there is no yarn transfer from rapier to rapier, they are suitable for filling yarns that are difficult to control.

![Figure 2.22: Shematic of single rapier insertion system](image)

- **Double rapier machines:** Two rapiers are used in these machines. One rapier, called giver, takes the filling yarn from the yarn accumulator on one side of the weaving machine, brings it to the center of the machine and transfers it to the second rapier which is called the taker. The taker retracts and brings the filling yarn to the other side. Similar to the single rapier machines, only half of the rapier movements is used for filling insertion. (See Figure 2.23).
Air-jet weaving is a type of weaving in which the filling yarn is inserted into the warp shed with compressed air. Figure 2.24 shows a schematic of air-jet weaving utilizing a multiple nozzle system and profiled reed which is the most common configuration in the market. Yarn is drawn from a filling supply package by the filling feeder and each pick is measured for the filling insertion by means of a stopper. Upon release of the filling yarn by the stopper, the filling is fed into the reed tunnel via tandem and main nozzles. The tandem and main nozzle combination provides the initial acceleration, where the relay nozzles provide the high air velocity across the weave shed. Profiled reed provides guidance for the air and separates the filling yarn from the warp. A cutter is used to cut the yarn when the insertion is completed.

The advantages of air-jet weaving machines are:
- high productivity
- low initial outlay
- high filling insertion rates
- simple operation and reduced hazard because of few moving parts
- reduced space requirements
- low noise and vibration levels
- low spare parts requirement
- reliability and minimum maintenance
A water-jet weaving machine inserts the filling yarn by highly pressurized water. The tractive force is provided by the relative velocity between the filling yarn and the water jet. If there is no velocity difference between the water and yarn, then there would be no tension on the yarn which would result in curling and snarling of the yarn. The tractive force can be affected by the viscosity of the water and the roughness and length of the filling yarn; higher viscosities cause higher tractive forces. The viscosity of water depends on the temperature.

Water-jet weaving machines have the same basic functions of any other type of weaving machines. The principle of filling insertion with a water-jet is similar to the filling insertion with an air-jet: they both use a fluid to carry the yarn. However there are some differences that affect the performance and acceptance of water-jet weaving machines. For example, the yarn must be wettable in order to develop enough tractive force.

The flow of water has three phases: 1) acceleration inside the pump prior to injection into the nozzle, 2) jet outlet from the nozzle, 3) flow inside the shed. The water flow inside the shed has a conical shape with three regions: compact, split and atomized. Compact and split portions are better for yarn insertion. Due to water weight the jet axis forms a parabola which necessitate; adjusting the axis of the nozzle upward by some angle. The flow of water then follows the motion of angular projection.

Unlike the air-jet weaving machines, the pump and picking system is fixed firmly to the machine frame to ensure that the beat-up mechanism moves the reed only. Due to the viscosity of water and its surface tension, a water-jet is more coherent than an air-jet. As a result, the water-jet does not break up that easily and has a longer propulsive zone. There are no varying lateral forces in a water-jet to cause the filling yarn to contort. Besides, since the wet moving element is more massive, there is less chance for the filling yarn to entangle with the warp The braking of the filling yarn is provided by the reed.
Multi-phase looms

A multiphase weaving machine is one in which several phases of the working cycle take place at any instant such that several filling yarns can be inserted simultaneously. In these machines, more than one shed is formed at a time; therefore, they are also called multi-shed weaving machines. This concept is drastically different than single phase machines in which each of the five functions takes place subsequently. Therefore, it is appropriate to consider the multiphase weaving machines as the third generation of weaving machines.

Within the last decade, Sulzer Textil has developed a new multiphase weaving machine called M8300 Multi-Linear Shed Weaving Machine. M8300 is a multiphase air-jet weaving machine in which 4 picks are inserted simultaneously. It has a filling insertion rate of over 5000 m/min compared to 2000 m/min of single phase air-jet weaving machines. At ITMA'99 in Paris, Sulzer Textil exhibited a show speed of 3230 ppm, which corresponds to 6088 m/min of filling insertion rate. Currently, the commercial speed is around 2800 ppm.

The M8300 produces standard fabrics that amount to 65% of all fabrics produced worldwide. The M8300 technology eliminates the insertion faults and utilizes the basic requirements for uniform fabric appearance. Figure 11.1 shows the filling insertion of a multi-phase weaving machine.

![Diagram](image)

Figure 2.25: The filling insertion elements
2.3. Weaving Weaves

2.3.1. Plain Weaves and Derivatives

The plain weave is the simplest of the weaves and the most common. It consists of interlacing warp and filling yarns in a pattern of over one and under one. Imagine a small hand loom with the warp yarns held firmly in place. The filling yarn moves over the first warp yarn, under the second, over the third, under the fourth, and so on. In the next row, the filling yarn goes under the first warp yarn, over the second, under the third, and so on. In the third row, the filling moves over the first warp, under the second, and so on, just as it did in the first row. (See Figure 2.26)

![Diagram of the plain weave](image)

Figure 2.26: (a) Diagram of the plain weave; (b) close-up photograph of a plain-weave fabric

The weave can be made with any type of yarn. Made with tightly twisted, single yarns that are placed close together both in the warp and filling and with the same number of yarns in both directions, the resulting fabric will be a durable, simple, serviceable fabric. If, however, the warp were to be made from a single yarn and the filling from a colorful boucle yarn, a quite different, much more decorative fabric would result. Both are the product of the same, basic, plain weave.

Plain-weave fabrics are constructed from many fibers and in weights ranging from light to heavy. Weaves may be balanced or unbalanced. Decorative effects can be achieved by using novelty yarns or yarns of different colors. Together with many of these novelty fabrics, a number of standard fabric types are made in the plain weave.
Rib variation

- Warp rib

Warp rib formula has 1/1 interlacing in the filling direction and an interlacing pattern different than 1/1 in the warp direction. This results in a design that has ribs or texture ridges across the fabric in the warp direction which are caused by grouping of filling yarns. Figure 2.27 shows a 2/2 warp rib structure which is the simplest of all warp rib designs.

![Figure 2.27: (2-2) Warp rib design](image)

The repeat units of all warp ribs have two warp yarns. The first warp follows the formula and the second warp does the opposite. Therefore, any warp rib design requires a minimum of two harnesses. The number of filling yarns in the repeat unit is the sum of the digits in the warp rib formula.

Warp rib formula are classified as regular (balanced) or irregular (unbalanced). The numerator and denominator of a regular or balanced warp rib formula is the same number, e.g. 2/2, 3/3, etc. In irregular or unbalanced formula, the digits are different numbers, e.g., 2/3, 4/2, 2/3-3/2, etc. Figure 2.28 shows irregular warp rib designs. If only a portion of the formula has the same number as numerator and denominator, the design is still considered to be an irregular rib.
Figure 2.28: Irregular warp rib design

- Filling rib

Filling rib formula has 1/1 interlacing in the warp direction and an interlacing pattern different than 1/1 in the filling direction. This results in a design that has ribs or texture ridges across the fabric in the filling direction. These ribs are caused by grouping of warp yarns. Figure 2.29 shows a 2/2 filling rib structure which is the simplest of all filling rib designs.

Figure 2.29: 2/2 filling rib design

Analogous to the warp ribs, the repeat units of all filling ribs have two filling yarns. The first filling follows the formula and the second filling does the opposite. Therefore, any filling rib design requires a minimum of two harnesses. The number of warp yarns in the repeat unit is the sum of the digits in the filling rib formula. The regular (balanced) or
irregular (unbalanced) formulae apply to filling ribs as well. Figure 2.30 shows examples of irregular filling ribs.

![Figure 2.30: Irregular filling rib designs](image)

- **Basket variation**

  The basket weave, a variation of the plain weave, uses two or more warp and/or two or more filling yarns side by side as one yarn. (See Figure 2.31) The resultant cloth is fairly loose in weave.

![Figure 2.31: (a) The basket weave variation of the plain weave;(b)monks cloth](image)
2.3.2. Twill weaves and derivatives

Twill fabrics are readily identified by the diagonal lines that the weave creates on the surface of the fabric. Because there are fewer interlacings, the yarns in twill fabrics can be spaced closely together, packed tightly, and held firmly in place. Therefore, twill fabrics are usually strong and durable; they are also supple and drape well. Most twill weave fabrics are made in bottom weight. The compact structure of twill fabrics enables them to shed soil readily, although when soiled they may be difficult to get clean. Depending on their construction, twill fabrics generally show good resistant to abrasion. Twill fabrics are often used for tailored garments, particularly those made of worsted wool yarns.

The simplest twill weave is created by the warp yarn crossing over two filling yarns, then under one, over two, under one, and so on. In the next row, the sequence begins one yarn down. (See Figure 2.32) The area in which one yarn crosses over several yarns in the opposite direction is called a *float*.

The lines created by this pattern are called wales. When the cloth is held in the position in which it was woven, the wales (diagonal lines) will be seen to run either from the lower left corner to the upper right corner or from the lower right to the upper left. If the diagonal runs from the lower left to the upper right, the twill is known as a *right-hand twill*. (See Figure 2.32) When the twill runs from the lower right to the upper left, the twill is known as a *left-hand twill*. (See Figure 2.33)

![Figure 2.32: Right handed warp faced twill(The simplest twill)](image)
There are a number of types of twill weaves. All use the same principle of crossing more than one yarn at a regular, even progression. Descriptions of twills may be made in terms of the pattern of warp yarns crossing filling yarns. The description of twill weaves is notated as 2/1, 2/2, 3/2, and so on. The first digit refers to the number of filling yarns crossed over by the warp and the second digit to the number of filling yarns the warp passes under before returning to cross the filling again. When the crossing is over and under the same number of yarns, the fabric is called an even or even-sided twill. When warps pass over a larger or smaller number of filling yarn than they pass under, the fabric is called an uneven twill.(See Figure 2.34)
2.3.3. Satin weaves and derivatives

Satin-weave fabrics are made by allowing yarns to float over a number of yarns from the opposite direction. Interfacings are made at intervals such as over four, under one using five harnesses); over seven, under one (eight harnesses); or over eleven, under one (twelve harnesses). Floats in satin fabrics may cross from four to twelve yarns before interlacing with another yarn. No pronounced diagonal line is formed on the surface of the fabric because the points of intersection are spaced in such a way that no regular progression is formed from one yarn to that lying next to it.

When warp yarns form the floats on the face of the fabric, the fabric is a warp-faced satin. (See Figure 2.35) When filling yarns float on the face, the fabric is filling-faced satin. (See Figure 2.36)

Satin-weave fabrics made from filament yarns are called satins; those from spun yarns are sateen. Most warp-faced weaves have filament yarns because filament yarns do not require a tight twist to serve as warp yarns, whereas cotton, being a staple fiber, must be given a fairly high degree of twist if it is to serve as a strong warp yarn. Therefore, sateen fabrics are usually filling faced, although some warp sateens are made.

Satin-weave fabrics are highly decorative. They are usually made from filament yarns with high luster to produce a shiny, lustrous surface and tend to have high fabric counts. They are smooth and slippery in texture and tend to shed dirt easily. The long floats on the surface are, of course, subject to abrasion and snagging. The longer the float the greater is the likelihood of snags and pulls. Satins are often used as lining fabrics for coats and suits because they slide easily over other fabrics. The durability of satin-weave fabrics is related to the density of the weave, with closely woven, high-count fabrics having good durability. Satins made from stronger fibers are, of course, more durable than those made from weaker fibers.
2.4. Weaving Textile Products and Uses

- **Lightweight Plain-Weave Fabrics:** Lightweight plain-weave fabrics may be light in weight because they have either a low fabric count or are constructed of fine yarn and are usually sheer.
  - The following low-fabric-count balanced plain weaves have somewhat specialized uses.
  - *Cheesecloth* is open weave soft fabric originally used in producing cheese, serving as a wrapper or strainer for curds.
  - *Crinoline* and *buckram* are heavily sized to serve as stiffening fabrics.
  - *Gauze*, with a higher count than cheesecloth, is used in theatrical costumes and medical dressings, as well as for blouses and dresses.

The following are high-count balanced plain weaves with fine yarns.
- *Chiffon* is made from fine, highly twisted filament yarns. Because of the tightly twisted crepe yarns, chiffon has excellent drape, and although it is delicate in appearance, it is relatively durable. Sheer evening dresses, blouses, lingerie, and other dressy apparel are constructed from the fabric.
- *Ninon*, a sheer plain weave of filament yarns, is often used in sheer curtains and draperies.
- *Organdy* is a sheer cotton fabric that is given a temporarily or permanently stiffened finish.
- *Organza* is a stiff sheer fabric made of filament yarns.
- *Voile*, a soft fabric with somewhat lower fabric count and higher twist yarns, has a distinctive two-ply warp and good drapability.

- **Medium-Weight Plain-Weave Fabrics:** Medium-weight balanced plain weaves usually have fairly high fabric counts, contain medium-weight yarns (12 to 29 tex), and are opaque. Distinguishing characteristics may be design, color, finish, or fabric count.
  - *Calico* is a closely woven fabric with a small printed design.
  - *Chambray* fabrics have colored warp yarns and white filling yarns that produce a heather appearance. Some contemporary chambrays may have warp and filling yarns of different colors.
  - *Chintz* is a fabric printed with large designs that is often given a polished or glazed finish. Solid color glazed fabrics are called polished cotton.
  - *Gingham* is a woven check or plaid design made with yarns of different colors.
  - *Muslin*, generally woven from cotton or cotton blends, is made in both heavily sized, bleached qualities and in better grades for sheets and pillow cases. Muslin sheets are not combed and have a lower count (128 to 140 total yarns per inch) than do percale sheets.
• **Percale**, a closely woven, plain weave of cotton or blended fibers, is made from yarns of moderate twist. Percale yard goods are generally carded, but percale sheets are finer and more luxurious in feel and are made of combed yarns. Percale sheets have a count of 180 to 200 yarns (warp plus filling) per inch.

➤ **Heavyweight Plain-Weave Fabrics:** The following are common heavyweight plain-weave fabrics.

• **Butcher linen** is a plain, stiff, white fabric made from heavy yarn.
• **Crash** is made from thick and thin yarns, giving the fabric a nubby look.
• **Homespun** is a furnishing fabric made with irregular yarns to resemble hand-spun and hand-woven fabrics.
• **Osnaburg** is made of low-quality cotton for industrial use and in interior fabrics for curtains and upholstered furniture.

➤ **Rib Fabrics**

The following are some standard rib-weave fabrics.

• **Bengaline** and **ottoman** heavyweight fabrics with large ribs, are used mostly in upholstery and furnishings.
• **Broadenloth** is a medium-weight unbalanced plain weave with fine ribs. The rib weave makes it crisper than medium-weight balanced weaves. It is often made from cotton or cotton blends.
• **Faille** has a prominent rib and is made with fine filament yarns in the warp and heavy spun yarns in the filling. It is usually heavy weight, although lighter-weight tissue failles are also produced.
• **Grosgrain** has very prominent ribs and is usually woven in narrow ribbon widths.
• **Poplin**, a bottom-weight rib weave, is usually made from cotton or cotton blends.
• **Shantung** has a nubby, irregular rib in the filling. Formerly made almost exclusively of silk, shantung is now made from a variety of manufactured fibers as well.
• **Taffeta** is a medium-weight weave made from filament yarns that is often used for evening wear.
• **Bedford cord** is a sturdy fabric constructed with a pronounced lengthwise cord.
• **Dimity**, a sheer cotton fabric, is often made with a lengthwise cord effect. Some dimity fabrics use larger yarns in both the warp and filling direction to achieve a checked, or **barred**, effect.
Basket Fabrics

The following are among the more common basket-weave fabrics.

- **Monk's cloth** is a coarse cloth of large yarns. Monk's cloth uses four or more yarns as one in the weave. Its major uses are in household textiles such as curtains, spreads, and the like.
- **Hopsacking** is made of many different fibers. This fabric simulates the fabrics used in bags for gathering hops. It has a 2-2 or 3-3 basket weave and is commonly used in upholstery.
- **Modified basket weaves** may use double yarns in one direction but not in the other. Oxford cloth, which is made in this way, is a soft fabric, often made of cotton or cotton blends that is used for shirts. Frequently, it is made with narrow colored stripes in the warp, or a colored warp.
- **Duck and canvas** are heavy, tightly woven, and very stiff plain-weave fabrics made of even yarn for industrial use. They usually have an uneven weave pattern. Because of the tight weave, these fabrics are often used for outdoor purposes.

Twill Fabrics

The following are among the more common twill weave fabrics.

- **Serge** is a popular basic twill fabric made from any number of different fibers. When serge is made from wool, it is often woven from worsted yarns. Serge will take a crease well, but wool serge tends to become shiny with wear. It tailors well.
- **Flannel**, if made of wool, is usually a twill weave with a napped finish.
- **Plaids or tartan** patterns are yarn-dyed even-sided twills.
- In a **herringbone** twill the direction of the twill reverses itself to form a broken diagonal that appears like a series of herringbone patterns create a decorative effect. (See Figure 2.37) Herringbone twills are common in suitting fabrics.
Figure 2.37: Herringbone twill fabric

- *Denim* is a durable heavyweight twill with colored warp yarns and white filling yarns. Since it is a warp-faced twill, the colored warp yarns predominate on the face and the white filling yarns on the back.
- *Drill* is another heavyweight fabric, usually of a solid color.
- *Jean* is a lighter-weight twill, usually with colored warp yarns and white filling yarns.
- *Gabardine* is durable and closely woven. It is made into a variety of weight from many different fibers such as wool, rayon, cotton, and manufactured fibers.

➢ **Satin Fabrics**

The following are some names given to satin fabrics.

- *Antique satin*, a satin made to imitate silk satin of an earlier period, often uses slubbed filling yarns for decorative effect.
- *Peau de soie* is a soft, closely woven satin with a flat, mellow luster.
- *Slipper* satin is a strong, compact satin, heavy in weight. It is often used for evening shoes.

Novelty effects in fabrics are in large part a result of selection of novelty yarns for incorporation into fabrics made in one of the basic weaves.

- *Crepe* fabrics may be defined as fabrics characterized by a crinkled, pebbly surface. (See Figure 2.38) Originally, crepe fabrics were made from crepe yarns, that is, yarns with an exceptionally high degree of twist, up to sixty-five turns per inch. Most standard crepe fabrics were made in the plain weave, some with rib effects, and some in satin weave, as in crepe-backed satin.

Figure 2.38: Crepe fabric
• **Seersucker**, another plain-weave fabric, is created by holding some warp yarns at tight tension, some at slack tension. Those at slack tension puff up to form a sort of "blister effect." Seersucker surface effects are permanent. Often the slack and tight yarns are each made from a different colored yarn, to provide a decorative striped effect.

The following are some of the fabrics made on the *dobby loom*:

- **Bird's eye**, a cloth made with small diamond-shaped figures, has a weave that is said to resemble the eye of a bird. Bird's eye is also called diaper cloth.
- **Pique** is a medium- to heavyweight fabric, often of cotton, with a pronounced lengthwise cord, often combined with other small figures or patterns such as honeycomb or waffle effects.
- **White-on-white** has a white dobby figure woven on a white background and is often used for men's shirtng.

The following are some of the best-known *jacquard patterns*:

- **Brocade** features an embossed or embroidered appearance. Elaborate patterns, often of flowers and figures, stand out from the background. Pattern and ground are usually different weaves. Brocades are made from a wide range of fibers and with a wide range of price and quality. Fabrics are use for upholstery, draperies, and evening and formal clothing.
- **Brocatelle** is similar to brocade, but with figures or patterns standing in high relief. Brocatelle is used mostly for upholstery fabrics and draperies.
- **Damask** is a flatter fabric than brocade and often has a fine weave. Damask figures often use a satin weave to reflect light from the pattern, whereas the background is made in a plain or twill construction. Linen damasks have long been used for luxurious tablecloths. Damasks are reversible. Cotton and linen damasks are made either with four-yarn float or a seven-yarn float in the satin weave. The longer floats are more lustrous, but the shorter floats are more durable, as they are less likely to snag or be subject to abrasion. (See Figure 2.39)
- **Tapestry-like** fabrics have an appearance that simulates hand-woven tapestries. Used extensively in fabrics for interiors, these jacquard-woven fabrics have highly patterned designs on the face. Although the back is also figured, the colors within the design differ. For example, a leaf that appears on the face as green will be some other color on the back. (See Figure 2.40)
Figure 2.39: Damask fabric

Figure 2.40: Tapestry-type fabric woven on a jacquard loom (a) face; (b) back
Use technical English about the weaving.

<table>
<thead>
<tr>
<th>Steps of process</th>
<th>Suggestions</th>
</tr>
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| Translate the text given below | ➢ Please read all of the text.  
➢ If you do not know words in text, research the meaning during translation  
➢ Use English dictionary for the meaning of words from English to Turkish  
➢ You can find detailed information about the technical words in the text. |

In weaving, lengthwise yarns are called warp; crosswise yarns are called weft, or filling. Most woven fabrics are made with their outer edges finished in a manner that avoids raveling; these are called selvages. They run lengthwise, parallel to the warp yarns. The three basic weaves are plain, twill, and satin. Fancy weaves—such as pile, Jacquard, dobby, and leno—require more complicated looms or special loom attachments for their construction.

The manner in which the yarns are interlaced determines the type of weave. The yarn count and number of warp and filling yarns to the square inch determine the closeness or looseness of a weave. Woven fabrics may also be varied by the proportion of warp yarns to filling yarns. Some effects are achieved by the selection of yarns or of combinations of yarns.

CHECKLIST

If you have behaviors listed below, evaluate yourself putting (X) in “Yes” box for your earned skills within the scope of this activity otherwise put (X) in “No” box.

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>1. Have you had the knowledge of technical English about the yarn preparation steps for weaving?</td>
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<tr>
<td>2. Have you had the knowledge of technical English about the types of warping?</td>
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<tr>
<td>3. Have you had the knowledge of technical English about the classification of weaving machines?</td>
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EVALUATION

Please review your "No" answers in the form at the end of the evaluation. If you do not find yourself enough, repeat learning activity. If you give all your answers "Yes" to all questions, pass to the "Measuring and Evaluation".
Answer the following questions and measure your knowledge.

1. “………. is basically transferring a yarn from one type of package to another” Fill in the blanks with correct answer?
   A) Warping
   B) Drawing-in
   C) Tying
   D) Winding

2. “In ……….warping, the yarns are withdrawn from the single-end yarn packages on the creel and directly wound on a beam.” Fill in the blanks with correct answer.
   A) Direct
   B) Indirect
   C) Drawing
   D) Slashing

3. Which one is a typical warping machine component?
   A) Shuttle
   B) Rapier
   C) Creel
   D) Bobbin

4. “………. is the entering of yarns from a new warp into the weaving elements of a weaving machine, namely drop wires, heddles and reed, when starting up a new fabric style.” Which words make the sentence meaningful?
   A) Warping
   B) Drawing-in
   C) Tying
   D) Winding

5. “The ………. weave, uses two or more warp and/or two or more filling yarns side by side as one yarn.” Fill in the blank with the correct word.
   A) Twill
   B) Rib
   C) Basket
   D) Herringbone
6. “…….. is made from fine, highly twisted filament yarns” Which words make the sentence meaningful?
A) Poplin
B) Chiffon
C) Damask
D) Brocade

7. “…….., a bottom-weight rib weave, is usually made from cotton or cotton blends.” Fill in the blanks with correct answer.
A) Chiffon
B) Poplin
C) Denim
D) Flannel

8. “…….. fabrics may be defined as fabrics characterized by a crinkled, pebbly surface.” Which words make the sentence meaningful?
A) Drill
B) Gabardine
C) Crep
D) Brocatelle

EVALUATION

Please compare the answers with the answer key. If you have wrong answers, you need to review the Learning Activity. If you give right answers to all questions, pass to the next learning activity
LEARNING ACTIVITY-3

AIM

If suitable conditions provide, you will be able to define the concepts about knitting and industrial knitting.

SEARCH

➢ Search some English materials about Knitting from different sources.
➢ Bring the materials to the class.
➢ Discuss about the materials.

3. BASIC CONCEPT FOR KNITTING AND INDUSTRIAL KNITTING

“Knitting is the process of making cloth with a single yarn or set of yarns moving in only one direction. Instead of two sets of yarns crossing each other as in weaving, the single knitting yarn is looped through itself to make a chain of stitches. These chains or rows are connected side by side to produce the knit cloth” (American Fabrics and Fashions Magazine 1980, 370). The interlocking of these loops in knitting can be done by either vertical or horizontal movement. When the yarns are introduced in a crosswise direction, at right angles to the direction of growth of the fabric, and run or interlock across the fabric, the knit is known as a weft knit. (Some sources may refer to these knits as filling knits, but the term weft knit is used in the knitting industry.) When the yarns run lengthwise or up and down, the knit is known as a warp knit.

In knitting terminology, the rows of stitches that run in columns along the lengthwise direction of the fabric are known as wales. This corresponds to the warp direction of woven fabrics. Crosswise rows of stitches or loops are called courses. The direction of the courses corresponds to the filling of woven goods. (See Figure 3.1.)
Both warp and weft knits are made by machine. Knitting machines may be either flat or circular. The flat-type knitting machine has needles arranged in one or two straight lines and held on a flat needle-bed. The cloth is made by forming stitches on these needles. The resulting fabric is flat. Machines with flatbeds are used to make both warp and weft knits. (See Figure 3.2.)

The circular knitting machine has needles arranged in a circle on a rotating cylinder. (See Figure 3.3.) The resulting fabric is formed into a tube. Circular knitting machines produce weft knits almost exclusively.
A generic term, "Weft Knitting" is used in industry to describe both "Flat" and "Circular" methods of production.

3.1. Circular knitting

The term circular covers all those weft knitting machines whose needle beds are arranged in circular cylinders and/or dials, including latch, bearded and very occasionally compound needle machinery, producing a wide range of fabric structures, garments, hosiery and other articles in a variety of diameters and machine gauges.

Although more restricted in patterning capabilities than flat machines, they may offer advantages in productivity and fineness of gauge.

3.1.1. Materials

- **The Needle**

The hooked metal needle is the principal element of machine knitting. During the yarn feeding the hook is opened to release the retained old loop and to receive the new loop which is then enclosed in the hook. The new loop is then drawn by the hook through the old loop which slides on the outside of the bridge of the closed hook.
Bearded needle:

There are five main parts of the bearded needle. (Fig. 3.4)

- The stem around which the needle loop is formed.
- The head where the stem is turned into a hook to draw the new loop through the old loop.
- The beard which is the curved downwards continuation of the hook that is used to separate the trapped new loop inside from the old loop as it slides off the needle beard.
- The eye or groove cut in the stem to receive the pointed tip of the beard when it is pressed, thus enclosing the new loop.
- The shank which may be bent for individual location in the machine or cast with others in a metal 'lead'.

Latch needle:

The latch needle has nine main features:

- The hook which draws and retains the new loop.
- The slot or saw-cut which receives the latch-blade (not illustrated).
The cheeks or slot walls which are either punched or riveted to fulcrum the latch-blade (not illustrated).

The rivet which may be plain or threaded. This has been dispensed with on most plate metal needles by pinching in the slot walls to retain the latch blade.

The latch-blade which locates the latch in the needle.

The latch spoon which is an extension of the blade and bridges the gap between the hook and the stem covering the hook when closed as shown in broken lines.

The stem which carries the loop in the clearing or rest position.

The butt which enables the needle to be reciprocated when contacted by cam profiles on either side of it forming a track. Double-ended purl type needles have a hook at each end, whilst one hook knits, the inactive hook is controlled as a butt by a cam reciprocated element called a slider.

The tail which is an extension below the butt giving additional support to the needle and keeping the needle in its trick.

Figure 3.5: Latch needle

➢ The sinker

The sinker is the second primary knitting element. It is a thin metal plate with an individual or collective action approximately at right angles from the hook side between adjoining needles. (See Figure 3.6). It may perform one or more of the following functions
dependent upon the machine's knitting action and consequent sinker shape and movement: loop formation, holding-down, knocking-over.

➤ **The jack**

The Jack is a secondary weft knitting element which may be used to provide flexibility of latch needle selection and movement. It is placed below and in the same trick as the needle and has its own operating butt and cam system. The needle may thus be controlled directly by its butt and cam system or indirectly by the movement of the jack.

![Image of the sinker](image)

**Figure 3.6: The sinker**

➤ **Cam**

Cams are the devices which convert the rotary machine drive into a suitable reciprocating action for the needles or other elements. The cams are carefully profiled to produce precisely-timed movement and dwell periods and are of two types, engineering cams and knitting cams.

**3.1.2. Production stages**

Figure 3.7 illustrates some of the features of a modern circular fabric producing machine which ensure that high quality fabric is knitted at speed with the minimum of supervision.
(1) The top and
(2) bottom stop motions are spring-loaded yarn supports that pivot downwards when the yarn end breaks or its tension is increased. The action releases the surplus yarn to the feeder thus preventing a press-off and simultaneously completes a circuit which stops the machine and illuminates an indicator warning light.

Figure 3.7: High Speed Four-Track Single-Jersey Machine

(3) Various spring-loaded detector points are carefully positioned around cylinder according to their particular function. A pointer will be tripped to stop
the machine by a fault or malfunctioning element such as a yarn slub, fabric lump, needle head, latch spoon, etc.

- (4A) The tape positive feed provides three different speeds (course lengths) and is driven and can be adjusted from the drive arrangement (4B.)
- (5) The cylinder needle cam system for each feed is contained in a single replaceable section and contains an exterior adjustment for the stitch cam slide.
- (6) The automatic lubrication system.
- (7) Start, Stop and Inching buttons.
- (8) The cam-driven fabric winding down mechanism which revolves with the fabric tube.
- (9) The revolution counters for each of the three shifts and a pre-set counter for stopping the machine on completion of a specific fabric length (in courses).
- (10) Side creel (optional)
- (11) Lint Blower (useful when knitting with cotton spun yarns)

3.1.3. Products and uses

- Plain

Plain is produced by the needles knitting as a single set, drawing the loops away from the technical back and towards to technical face side of the fabrics. (See Figure 3.8)

![Figure 3.8: Plain](image)

Plain is the base structure of ladies hosiery, fully fashioned knitwear and single Jersey fabrics.

- Rib

Rib requires two sets of needles operating in between each other so that wales of face stitches and wales of reverse stitches are knitted on each side of the fabric. (See Figure 3.9 and Figure 3.10)
Rib structures are elastic, form-fitting and retain warmth better than plain structures. Because of ribs characteristics they are particularly suitable for the extremeties of articles such as socks, the cuffs of sleeves, rib borders for garments, and stolling and strapping for cardigans.

- **Interlock**

Interlock was originally derived from the rib but requires a special arrangement of needles knitting back-to-back in an alternate sequence of two sets so that the two courses of loops show wales of face loops on each side of the fabric exactly in line with each other thus hiding the appearance of the reverse loops. (See Figure 3.11)

- **Purl**

Purl is the only structure have certain wales containing both face and reverse meshed loops. It is particularly suitable for baby wear, where width and length stretch is required, and also for adult knitwear. (See Figure 3.12)
3.2. Flat Knitting

Flat knitting is a method for producing knitted fabrics in which the work is turned periodically, i.e., the fabric is knitted from alternating sides. The two sides (or "faces") of the fabric are usually designated as the right side (the side that faces outwards, towards the viewer and away from the wearer's body) and the wrong side (the side that faces inwards, away from the viewer and towards the wearer's body).

Flat knitting is usually contrasted with circular knitting, in which the fabric is always knitted from the same side. Flat knitting can complicate knitting somewhat compared to circular knitting, since the same stitch (as seen from the right side) is produced by two different movements when knitted from the right and wrong sides. Thus, a knit stitch (as seen from the right side) may be produced by a knit stitch on the right side, or by a purl stitch on the wrong side. This may cause the gauge of the knitting to vary in alternating rows of stockinette fabrics; however, this effect is usually not noticeable, and may be eliminated with practice (the usual way) or by using needles of two different sizes (an unusual way).

In flat knitting, the fabric is usually turned after every row. However, in some versions of double knitting with two yarns and double-pointed knitting needles, the fabric may turned after every second row.

A "Flat" or V-Bed knitting machine consists of 2 flat needle beds arranged in an upside-down "V" formation. These needle beds can be up to 2.5 metres wide. A carriage, also known as a Cambox or Head, moves backwards and forwards across these needle beds, working the needles to selectively, knit, tuck or transfer stitches. A flat knitting machine is very flexible, allowing complex stitch designs, shaped knitting and precise width adjustment. It is, however relatively slow when compared to a circular machine.
3.2.1. Materials

➢ The Knock-over Bits

The trick walls are replaced at the needle bed verges by fixed, thinner polished and specially shaped knock-over bit edges. In rib gating, a knock-over bit in one bed will be aligned opposite to a needle trick in the other bed. During knitting, the edges of the knock-over bits restrain the sinker loops as they pass between needles and thus assist in the knocking-over of the old loops and in the formation of the new loops. Flat machines do not normally employ holding-down sinkers as the take-down tension and the loops on the needles in the other bed help to hold the old loops down on the needles stems.

➢ The Cover Plate

This is a thin metal blade located in a slot across the top of the needle bed tricks which prevents the stems of the needles from pivoting upwards out of the tricks as a result of the fabric take-down tension drawing the needle hooks downwards, whilst allowing the needles to slide freely in "heir tricks. The plate can be withdrawn sideways out of the needle bed to allow needles to be removed.

➢ The Security Spring

Supporting the tail of each needle is a security spring which fits over the lower edge of the needle bed. When the spring is pushed fully into position it locates into a groove on the undersurface of the needle bed and the butt of the needle which it supports is aligned with the knitting cam-track on the undersurface of the traversing cam-carriage. When a needle is not required to be in action, its security spring is not located in the groove, so that the needle is nearer to the lower edge of the needle bed and its butt is by-passed by the cam-carriage as it traverses across the trick.

On machines employing jacquard selection the positioning of the security spring is replaced either by the thrust of a jacquard steel onto the tails of the elements or by the raising or depressing of the knitting butts into the tricks, in order to position the needle butts for each carriage traverse.

➢ The Latch Brushes

Latch brushes are attached to the cam-plates of both needle beds to ensure that the needle latches are fully opened. The supports of the brushes are adjustable to ensure precise setting of the bristles relative to the needles.
The Carriage Guide Rails

The cam-carriage either slides or runs on ball-bearings or wheels along guide rails, one of which is fixed over the lower end of each needle bed. It is propelled either by hand or from a motor-driven continuous roller chain.

The Yarn Carriers

Each yarn carrier is attached to a block which slides along a bar, which, like the carriage guide rails, passes across the full width of the machine. The carrier bar may be of the double prism type so that yarn carriers may be attached to slide along both the front and the back surfaces.

The yarn carriers are picked up or left behind by the carriage as required, by means of driving bolts or pistons which are attached to and are controlled from, either manually or automatically, the carriage bow. There is a bolt for each carrier bar track, which when lowered, entrains with a groove in the shoulder of a yarn carrier guide block. Stop plates having inclined edges are positioned on the carrier bars at the knitting selvedges. On contact with a stop plate, the base of the bolt rises and is lifted out and disconnected from the groove of the carrier block so that the carriage continues its traverse without that carrier.
Figure 3.13: cross-section of a simple V-bed flat machine
3.2.2. Production stages

Figure 3.14 illustrates the knitting action of a hand flat machine and Figure 3.15 shows the underside of the cam-carriage and the cams forming the tracks which guide the needle butts through the knitting action.

A set of cams — raising cam (S) (clearing cam), guard cam and two stitch cams necessary in order to knit a course of loops on one bed of needles in either direction of carriage traverse — is termed a lock.

The symmetrical camming arrangement is typical of many V-bed machines as it enables a similar action to be achieved in both directions of carriage traverse in each needle bed. The needle butts will enter the system from the right during a left to right carriage traverse and from the left during a right to left traverse so that two raising cams (on most machines) and two stitch cams are required for each knitting system. Only one cam of each type carries out its function during a traverse, the other acts as a guard cam by forming part of the cam-track for the butts. In the traverse in the opposite direction, the roles of the two cams are reversed.

The numbers 1 to 4 correspond to the numbers of the knitting action illustrations assuming a carriage traverse from left to right. Similar positions may be plotted for the return traverse using the cams given an (L) designation to provide the positive movements.

1. The rest position
   The tops of the heads of the needles are level with the edge of the knock-over bits. The butts of the needles assume a straight line until contacting the raising cams R (R) because the leading stitch cams S (L) and A.S (L) are lifted to an inactive position. The lifting action is an alternating action, which always lowers the trailing stitch cams and raises the leading stitch cams in each system as the traverse commences. This action prevents needles from being unnecessarily lowered and a strain being placed on the old loops prior to the commencement of the knitting action.

2. Clearing
   The needle butts are lifted as they contact the leading edge of cams R (R) which raise the needles to tucking in the hook height with the undersurface of cams S (L) acting as guard cams. The needles are lifted to full clearing height as their butts pass over the top of cardigan cams C (R) and C(L).

3. Yarn feeding
   The yarn is fed as the needles descend under the control of guard cam (G) and the required loop length is drawn by each needle as it descends the stitch cam S (R).
4. Knocking-over

To produce synchronized knocking-over of both needle beds simultaneously, the stitch cam S (R) in the front system is set lower than the auxiliary stitch cam A.S (R) so that the latter is thus rendered ineffective. If, however, delayed timing of the knock-over is employed, knock-over in the front bed will occur after knock-over in the back bed. In this case stitch cam S (R) is not set as low as A.S (R), so that the depth setting of the latter cam produces the knock-over action. Delayed timing is only normally used on gauges finer than 8 npi and cannot be used for broad ribs.

Figure 3.14: Knitting action of a hand flat machine
Figure 3.15: underside of the cam carriage
Stitch cam settings
The stitch cams are located in slots by studs and they may be raised or lowered to a different setting position by moving the stud along the slot. Unless the rate of yarn feed is controlled, the setting of the stitch cam at knock-over will determine the stitch length because it controls the distance the head of the needle descends below the knock-over bit edge from the rest position. The alternating stitch cam settings are indicated by pointers on a calibrated scale on the outside of the cam-plate. On hand flats the adjustment of the settings is obtained by hand controls whilst on automatic flats as many as five different stitch cam settings can be achieved during a garment sequence once the initial adjustments have been made.

3.2.3. Products and uses

- **Rib Knits:**
  Rib knits have greater elasticity in the width than in the length. They are stable and do not curl stretch out shape as do the jersey knits. For this reason, they are often used to make cuffs and necklines on the weft knitted garments. (See sample of some ribs in Figure 3.16)

![Figure 3.16: Rib Sample](image)

- **Interlock Knits:**
  The resulting fabric, like double knit fabrics, is thicker than single knit fabric, and more stable in the widthwise direction. Interlock fabrics have been traditionally used for underwear.
Purl knits:

Purl knit fabrics have high crosswise and lengthwise stretch. They are often made into a variety of decorative sweaters. Interesting textures can be achieved by the use of fluffy, soft yarns. (See Figure 3.17)

![Figure 3.17: Purl knit sweater](image)

3.3. Warp knitting

In warp knitting, each yarn is looped around one needle at a time. The guide bar that carries the yarns moves sideways as well as forward and back so that the yarns are carried both lengthwise and, to a limited extent, diagonally. This diagonal motion is needed to ensure that the yarns interlace not only with the loop directly below in the same wale but also with loops to the side in adjacent wales. If the yarn interlaced only vertically, there would be no point at which each individual chain of stitches was attached to its neighboring chain.

This construction provides resistance to laddering (running), since each stitch is most directly connected not only with the stitch beneath but also with a stitch placed diagonally and lower. In forming the stitch, diagonal underlay moves the yarn from loop to loop.

3.3.1. Materials

- The Warp Beams

To ensure uniform conditions of warp feed and tension, the ends are supplied from flanged beams attached to shafts which turn to unwind the warp sheet in parallel formation. For convenience of handling, a number of beams may be attached to a beam shaft to achieve the full width of warp sheet, for example, a warp sheet 84 inches (213 cm) wide might be supplied from a full width beam, two beams each 42 inches (106 cm) wide, or four beams each 21 inches (53 cm) wide.
The Guide Bar

Each guide bar is normally supplied with a warp sheet from its own beam shaft to suit its requirements of threading and rate of warp feed for its particular lapping movement. Occasionally, two partly-threaded guide bars may be supplied from the same full-threaded beam provided they make lapping movements of the same extent to each other whilst moving in opposite directions. The minimum number of guide bars and warp sheets for commercially acceptable structures is usually two.

The Guides

Warp guides are thin metal plates drilled with a hole in their lower end through which a warp end may be threaded if required, they are held together at their upper end in a metal lead and are spaced in it to the same gauge as the machine. The leads in turn are attached to a guide bar so that the guides hang down from it with each one occupying a position at rest midway between two adjacent needles, in this position the warp thread cannot be received by the needles and it will merely produce a straight vertical float. The needles only receive the warp thread in their hooks if the guide bar overlaps across their hooks, or across the side remote from their hooks when the guide bar underlaps. All guides in a conventional guide bar produce an identical lapping movement at the same time and therefore have identical requirements of warp, tension and rate of feed, although the threads may differ in colour or composition from each other.

3.3.2. Production stages

Several types of warp knits are made on a number of different warp knitting machines.

Tricot

Tricot machines account for the largest quantity of warp knits. Tricot fabric is knit flat. On the face side the wales create the appearance of a fine, lengthwise line. On the back side crosswise ribs appear in a horizontal position.

In the manufacture of tricot, guide bars move the yarns from side to side. The tricot machines may have from one to four guide bars. The greater the number of bars, the greater the distance the yarn moves between stitches. In moving from one placement to the next, underlay yarns are carried across the back of the fabric. (See Figure 3.18) This extra yarn creates heavier-weight fabrics.
Tricot fabrics are identified as one-bar, two-bar, three-bar, or four-bar, depending on the number of guide bars used in their manufacture. One-bar, or single-bar, tricot is relatively unstable and is seldom used for garments. It is, however, used as backing for some bonded fabrics. It will run, because the loops interlace close together. Two-bar tricot is stable and fairly light in weight and is used extensively in lingerie, blouses, and the like. Three- and four-bar tricots are used for dresses and men’s wear and are heavier than two-bar tricot. (See Figures 3.19 a and b.)

In addition to the basic tricot fabric, a number of variations can be made. A tricot satin is produced by allowing yarns to float further across the back surface of the fabric before they interlace. Other textured tricots known as brushed tricots are made with raised, napped surfaces or with small loops. The fabric as knitted is smooth on both sides. The surface effects are achieved during finishing when the fabric is passed through a special machine.
equipped with wire rollers that either pull loops to the surface of the fabric or break some of the filaments to give a "brushed," soft, napped surface. Brushed and looped tricot fabrics are made with long underlaps that form the pile or loops.

Three- and four-bar tricot constructions permit the carrying of hidden yarns through the fabric. Monofilaments that stabilize the fabric or spandex filaments for stretch may be concealed in the complex structure of the tricot fabric.

- **Simplex**

  Simplex knitting machines create warp knits similar to tricot but with a denser, thicker texture—a sort of double knit tricot.

- **Raschel**

  Raschel knitting machines are flat beds with two to forty-eight guide bars. A mechanism called a fall plate controls the placement of the laid-in yarns. In the normal knit stitch formation, the needle moves up and down, looping yarns on and off the needle to form a continuous chain. In Raschel machines the fall plate is lowered to prevent the laid-in yarn behind it from forming a normal loop. Instead, the yarn is carried along in the fabric in a horizontal or diagonal direction, according to the pattern desired. In some fabrics this technique is used to simulate the effect of embroidery; in others, it gives a woven appearance. (See Figure 3.20.)

![Figure 3.20: (a)Close-up views of two open constructured Raschel knit fabrics.](image)

- **Crochet Knits**

  An especially versatile variation of the Raschel knitting machine is used to make fabrics that simulate hand-crocheted fabrics. Although the mechanism of the machine varies...
slightly from that of an ordinary Raschel knitting machine, the principle of forming lengthwise loops held together by laid-in yarns is the same in both machines.

### 3.3.3. Products and uses

- **Tricot Knits**

  Tricot fabrics can be made with a variety of open effects to create interesting lacelike patterns, as well.

- **Simplex Knits**

  Simplex knits are used in products requiring heavier fabrics, such as women's gloves, handbags, and simulated suede-textured apparel fabrics.

- **Raschel Knits**

  Raschel knits can range from finely knitted laces to heavy-duty fabrics. Elaborately patterned surface effects can also be achieved with the Raschel machine. The fabrics have lengthwise rows of loops held together by laid-in yarns and may, to the eye, have the appearance of woven goods or lace.

  Among the most popular types of Raschel fabrics are power net of elastomer yarns for foundation garments and swimsuits, thermal cloth for cold-weather underwear, lace, and tailored menswear fabrics. Pile warp knits for fake fur fabrics are made by incorporating an extra yarn in the structure that is then brushed. In power nets for foundation garments, the laid-in yarns are spandex core yarns.

- **Crochet Knits**

  The resulting textiles range from narrow trimmings, including those with fancy fringes, to wider fabrics (25 to 75 inches) used for apparel or household textiles.

### 3.4. Hosiery knitting

For centuries the production of hosiery was the main concern of the knitting industry, emphasized by the fact that the prototype machines for warp, circular, flat and full fashioned knitting were all originally conceived for this purpose. Nowadays, however, hosiery production is almost exclusively centered on the use of small-diameter circular machines.
3.4.1. Materials

- **Timing Chain**

  The timing chain consists of square ring metal links, hooked one onto the next for easy rearrangement, which pass as an endless loop over a sprocket Wheel which turns freely on the cam shaft and is racked by means of clawker.

- **The Cum Drums**

  These are large-diameter drums which are attached to and revolve with the control shaft. One or more may be employed on a machine.

![Figure 3.21: Double cylinder half-hose machine](image-url)
3.4.2. Production stages

The term 'hosiery' specifically refers to knitted coverings for the feet and legs but it may generically be applied to all types of knitted goods and fabric. Most hosiery articles are knitted with integral tubular legs and feet on small diameter circular machines. These machines have a master control which automatically times and initiates the mechanical operations and changes of stitch length necessary to produce the garment length knitting cycle although later making-up and finishing operations may still be required.

3.4.3. Products and uses

Hosiery is usually available for a range of foot sizes and in the case of staple fibre spun yarns such as cotton or worsted, different foot lengths are obtained by knitting them with differing total numbers of courses. However, hosiery knitted from continuous filament stretch nylon yarn may have an extension of 50 per cent so that a standard foot length is capable of accommodating itself to a range of foot sizes.

The following types of hosiery articles are particularly common: Hose which have a leg length extending above the knees; three-quarter hose, which are of knee length (which is approximately twice the foot length; Men's half-hose which are usually in two leg length ranges of between 7 and 9 inches or between 11 and 15 inches (18—23 and 28—38 cm); Tights, which have a body section which, although having an elasticated waist band is composed of the same knitted structure as the leg sections and designed to be worn over briefs or panties; and panty-hose, which are designed to replace briefs and be worn as an integral underwear and legwear garment.

3.5. Flat Knitted Ready-Made

3.5.1. Materials

Most weft knitted fabric in continuous lengths is knitted on large diameter multi-feeder latch needle machines and is slit into open width during finishing. The emphasis on productive efficiency and quality control in the manufacture, finishing and conversion of fabric into articles of apparel or other end-usage tends to encourage the establishment of larger units with longer production runs involving more capital intensive techniques than is necessarily the case in production of articles from garment lengths. Improvements in the quality control of knitted fabric and in the techniques of finishing and converting it have led to increased outlets for its products.

In handling operations during manufacture, the lengths of fabric must be maintained in as relaxed and tension-free a state as possible in order to reduce the problems caused by dimensional distortion and shrinkage. Apart from scouring, bleaching, dyeing and printing, the finishing process offers a wide range of techniques for modifying the properties of the
knitted structure including heat setting, stentering, decating, raising, topping, pleating and laminating.

3.5.2. Production stages

In the cutting room the lengths of fabric are layed-up many ply thicknesses deep onto long cutting tables using a traversing carriage to transport and lay the fabric. Cutting out techniques vary widely from marked lays whose outlines are followed by hand-guided cutting knives to press cutters whose blades are the outline of the garment part or cutting blades guided by a computerized programme.

In making-up, the lockstitch seam is not as useful as it is for woven fabrics because it lacks extensibility. For jersey wear the double-kicked chain stitch is useful whilst in the making-up of knitwear the three-thread overlock is popular because as well as being extensible it securely binds the cut edges of the fabric after neatly trimming them. For comfort in underwear and lingerie a flat-butt ed seam secured by a flat seam such as the five-thread flatlock is generally preferred.

3.5.3. Products and uses

Every kind of products, which made flat knitting fabric, for wearing. For example; sweaters, t-shirts, underwears, sports-wear, evening dress for ladies.
APPLICATION ACTIVITY

Use technical English about the knitting.

<table>
<thead>
<tr>
<th>Steps of process</th>
<th>Suggestions</th>
</tr>
</thead>
</table>
| Translate the text given below | ➢ Please read all of the text.  
➢ If you do not know words in text, research the meaning during translation  
➢ Use English dictionary for the meaning of words from English to Turkish  
➢ You can find detailed information about the technical words in the text. |

Circular knitting or knitting in the round is a form of knitting that creates a seamless tube. When knitting circularly, the knitting is cast on and the circle of stitches is joined. Knitting is worked in rounds (the equivalent of rows in flat knitting) in a spiral. Originally, circular knitting was done using a set of four or five double-pointed needles. Later, circular needles were invented, which can also be used to knit in the round: the circular needle looks like two short knitting needles connected by a cable between them. Longer circular needles can be used to produce narrow tubes of knitting for socks, mittens, and other items using the Magic Loop technique. Machines also produce circular knitting; double bed machines can be set up to knit on the front bed in one direction then the back bed on the return, creating a knitted tube. Specialized knitting machines for sock-knitting use individual latch-hook needles to make each stitch in a round frame.
CHECKLIST

If you have behaviors listed below, evaluate yourself putting (X) in “Yes” box for your earned skills within the scope of this activity otherwise put (X) in “No” box.

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Have you had the knowledge of technical English about the terms of circular knitting?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Have you had the knowledge of technical English about the machines of circular knitting?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Have you had the knowledge of technical English about usage places of circular knitting?</td>
<td></td>
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</tr>
</tbody>
</table>

EVALUATION

Please review your "No" answers in the form at the end of the evaluation. If you do not find yourself enough, repeat learning activity. If you give all your answers "Yes" to all questions, pass to the "Measuring and Evaluation".
Answer the following questions and measure your knowledge.

1. ( ) “......... is the process of making cloth with a single yarn or set of yarns moving in only one direction.” Which one is suitable for this definition?
   A) Weaving
   B) Knitting
   C) Warping
   D) Dyeing

2. ( ) “The ........ knitting machine has needles arranged in one or two straight lines and held on a flat needle-bed.” Fill in the blanks with the correct answer.
   A) Warp
   B) Circular
   C) Hosiery
   D) Flat

3. ( ) “......... requires two sets of needles operating in between each other so that wales of face stitches and wales of reverse stitches are knitted on each side of the fabric.”
   A) Interlock
   B) Plain
   C) Purl
   D) Rib

4. ( ) “.........is produced by the needles knitting as a single set, drawing the loops away from the technical back and towards technical face side of the fabrics.”?
   A) Plain
   B) Interlock
   C) Purl
   D) Rib

5. ( ) “.........knit fabrics have high crosswise and lengthwise stretch.” Fill in the blanks with the correct answer.
   A) Plain
   B) Interlock
   C) Purl
   D) Rib
6. ( ) Which one is a material of warp knitting machine?
   A) Warp beams
   B) Guides
   C) Sinker
   D) Guides Bar

7. ( ) “......... knitting machines are flat beds with two to forty-eight guide bars.” Fill in the blanks with suitable one.
   A) Hosiery
   B) Simplex
   C) Tricot
   D) Raschel

8. ( ) “.......knits have greater elasticity in the width than in the length.”?
   A) Plain
   B) Rib
   C) Purl
   D) Interlock

EVALUATION

Please compare the answers with the answer key. If you have wrong answers, you need to review the Learning Activity. If you give right answers to all questions, pass to the next learning activity.
LEARNING ACTIVITY - 4

AIM

If suitable conditions provide, you will be able to define the basic concepts of dyeing, printing and finishing technologies.

SEARCH

➢ Search some English materials about dyeing, printing and finishing from different sources.
➢ Bring the materials to the class.
➢ Discuss about the materials.

4. BASIC CONCEPTS FOR DYEING, PRINTING AND FINISHING TECHNOLOGIES

4.1. Preparatory finishing

Before basic and functional finishes are applied to fabrics, certain preparatory steps must usually be taken. These include inspection of the goods while still in the greige, bleaching, scouring, degumming (of silk), immunizing, and occasionally mercerization (of cotton). Inspection takes place at the mill; the other processes take place at the finishing plant or at the mill.

4.1.1. Production stages

➢ Singeing

To produce a smooth surface finish on fabrics made from staple fibers, the fabrics are passed over a heated copper plate or above a gas flame. The fiber ends burn off. The fabric is moved rapidly, and only the fiber ends are destroyed. Immediately after passing the flame, the fabric enters a water bath that puts out any remaining sparks.

The burning characteristics of fibers must be taken into account when this process is applied, as heat-sensitive fibers melt, forming tiny balls on the surface of the fabric. These
balls interfere with dye absorption, so that, as a general rule, hear-sensitive fibers would be singed after dyeing or printing. The tendency of some manufactured fibers to pill may be decreased by singeing.

Filament yarns do not require singeing, as there are no short fiber ends to project onto the surface of the fabric. Fabrics that are to be napped are not singed.

- **Bleaching**

  The object of this preparatory operation, of course, is to whiten the cloth, which may come from the loom grayish brown in color. Inexpensive cottons are often merely washed and pressed after coming from the looms and are sold as unbleached goods. The natural tan color of flax makes bleaching one of the most important processes in finishing linen. Wild silks are usually bleached before they are dyed. If a silk cloth is to be a light color or pure white, it must be bleached. Wool is frequently bleached in the yarn, but it may be bleached after weaving or scouring.

- **Scouring**

  When scouring is done as a finish, it is called piece scouring. The purpose of the process is to remove any sizing, dirt, oils, or other substances that may have adhered to the fibers in the processing of the yarns or in the construction of the cloth. To avoid the formation of an insoluble soap film on the fabric, soft water is used for scouring.

- **Degumming**

  Before a silk fabric can be dyed or other finishes applied, it must be degummed, unless the yarns were degummed before weaving. Boiling silk fabrics in a mild soap solution followed by rinsing and drying will accomplish this purpose. As a result, the fabric will have a beautiful sheen and a soft hand.

- **Mercerization of Cotton**

  Although this process can be done in the skein of yarn, frequently mercerization is done after weaving. Any type of cotton, polyester/cotton, and polyester/rayon blend can be mercerized, but best results are obtained on long-staple cottons. (Newer rayon and cotton blends are now also being mercerized.) The process consists of holding the fabric in tension while treating it with a strong solution of sodium hydroxide at a uniform temperature of 70° to 80° F. Mercerization can be done before or after bleaching and occasionally after dyeing. In the last two instances, mercerization may be considered a basic finish.

  The purposes of mercerization are threefold: (1) to increase the fabric’s luster, (2) to improve its strength, (3) to give it greater affinity for dye.
4.2. Dyeing

Fabrics in colors such as blue, yellow, red, green, and their combinations are made by impregnation of the cloth with certain color substances called dyestuffs. The fastness of these colors depends on the chemistry of the dyestuff, the affinity of the dyestuff for the fabric, and the method of dyeing the cloth. A fast dyestuff is minimally affected by sunlight, perspiration, washing, or friction.

4.2.1. Dye stuffs

Dyes are divided into a number of classifications. Within each of these classifications there exist a range of colors, and each of these colors may vary somewhat in its fastness to different conditions. The names given to the dye classes generally relate to the method of application and, to a lesser extent, the chemical composition of the dye class.

In the following discussion of dye classes, the classes are grouped according to the fiber types for which they are most widely (though not exclusively) used.

- Azoic Dyes:

  Azoic dyes (also called naphthol dyes) are used primarily on cotton fibers, but they can also be applied to acetates, olefins, polyesters, and nylon. The reaction that produces dyeing takes place when two components, a diazonium salt and a naphthol compound, join together to form a highly colored, insoluble compound on the fabric. These dyes are also known as ice dyes because the reaction takes place at lowered temperatures. They have good colorfastness to laundering, bleaching, alkalis, and light. They do tend to crock somewhat, however. Colors are mainly in the red range.

- Direct Dyes:

  Direct dyes, historically referred to as substantive dyes, are water soluble dyes used primarily for cotton and rayon, although some polyamide and protein fibers are also dyed with these compounds. These dyes have the advantage of being applied direct in a hot
aqueous dye solution in the presence of common salts required to stabilize the rate of dyeing, making the process relatively inexpensive. They also possess the disadvantage of poor fastness to laundering because they are primarily physical bound to the fibers and are soluble in laundering solutions. After treatment with cationic compounds (positively charged) can improve wet fastness.

- **Vat Dyes:**

  Vat dyes are insoluble in water. By chemical reduction they are converted to a soluble form. The dye is applied to the fibers, and then the dye, now within the fiber, reoxidized to the insoluble form. This creates a color that is fast to both light and washing.

  Because vat dyes must be applied in an alkaline solution, they are not suitable for use with protein fibers. Primarily used with cottons and rayons, vat dyes can also act as disperse dyes on polyester. These dyes provide a wide range of colors except for red and oranges. Denim is a popular fabric in which the warps yarns are traditionally dye with the vat dye indigo.

- **Sulfur Dyes:**

  Sulfur dyes produce mostly inexpensive dark colors, such as black, brown, or navy and are applied in an alkaline solution to cottons and rayons. Fabrics dyed with sulfur dyes must be carefully processed or a buildup of excess chemicals on the fibers will eventually weaken the fibers. Like vat dyes, sulfur dyes are applied to textile materials in a soluble form and then oxidized to an insoluble form within the fiber. Colorfastness of sulfur dyes is good to washing and fair to light. Black and yellow sulfur dyes may accelerate light degradation of cellulosic fibers.

- **Reactive Dyes:**

  In this class of dyes, the dyestuff reacts chemically with the fiber to form covalent bonds. Reactive dyes are applied most commonly to the cellulosic fibers, cotton, rayon, and linen. They are easy to apply and can produce a wide range of bright colors. Reactive dyes have good wash fastness because the chemical bonds between dye and fiber are strong.

  Wool can also be colored with reactive dyes, although wools that have been chlorinated, bleached, or shrink-proofed tend to have poor wet fastness. Reactive dyes are however, a good choice for washable wools and silks because of their colorfastness to laundering.
Dyes Used Primarily for Protein Fibers

- Acid Dyes:

Acid dyes have one to four negatively charged functional groups. Applied in acid solution, they react chemically with the basic groups in the fiber structure to form ionic bonds. Because wool has both acid and basic groups in its structure, acid dyes can be used successfully on wools. These dyes are also utilized for dyeing nylon and, to a lesser extent, for acrylics, some modified polyesters, polypropylene, and spandex. They have little affinity for cellulosic fibers. Colorfastness of acid dyes varies a good deal, depending on the color and the fiber to which the dye has been applied.

Metal complex dyes, or premetallized dyes, are usually classified with acid dyes. These are dyes that have been reacted with a metal mordant, such as chromium or cobalt, before application to the fiber. The resulting dyes are very stable, with excellent light and wash fastness, but the resulting colors are not as bright as those of unmetallized acid dyes. Major applications are for protein fibers and nylon.

- Chrome, or Mordant Dyes:

Used on the same general group of fibers as acid dyes, chrome dyes (also called mordant dyes) are applied with a metallic salt that reacts with the dye molecule to form a relatively insoluble dyestuff with improved wet- and light fastness. As the name of the dye indicates, chromium salts are most often used for the process. Especially effective for dyeing wool and silk, these dyes have excellent colorfastness, but residual metals may be harmful, especially to silk fabrics. Chrome dyes usually produce duller colors.

Dyes Used Primarily for Manufactured Fibers

- Basic or Cationic Dyes:

Basic dyes contain positively charged amino groups that are attracted to negative groups in fibers; for this reason, they are also known as cationic dyes. Wool and silk have negative acid groups and acrylic fibers usually have sulfonic acid groups added to the polymer for dyeing with basic dyes. Modified nylon and polyester fibers can also be dyed with basic dyes.

The colors that these dyes produce are exceptionally bright. Silk is often dyed with basic dyes because of their bright colors, but the fastness to laundering is poor. Recent developments of basic dyes for synthetics produce excellent colorfastness.
Disperse Dyes:

Developed for coloring acetates, disperse dyes are now used to color many other manufactured fibers. The dye is sparingly soluble in water. Particles of dye disperse in the water without dissolving but, rather, dissolve in the fibers.

Disperse dyes can be applied to a wide variety of fibers, including acetate, acrylic, aramid, modacrylic, nylon, olefin, polyester, and triacetate, and are really the only practical means of coloring acetate and polyester fibers.

Colors produced with disperse dyes cover a wide range and generally have good fastness. Blues, however, tend to be discolored by nitrous oxide gases in the atmosphere and may gradually fade to a pinkish color. Greens may fade to brown. This fume fading is apparent primarily in disperse-dyed acetate. The main source of fumes in homes is gas-fired stoves and heaters.

4.2.2. Production stages

Color may be added to fabric at any one of four steps in its processing. Color can be added to manufactured fibers before the fiber is extruded, or dyes can be applied to fibers, to yarns, or to constructed fabrics or finished products.

Mass Coloration

Mass coloration is the addition of color to manufactured fibers before they are extruded. These fibers have been variously known as spun-dyed, solution-dyed or dope-dyed fibers. Pigment is dispersed throughout the liquid fiber solution. When the fiber is extruded, it carries the coloring material as an integral part of the fiber.

This "locked-in" color is extremely fast to laundering (that is, it will not diminish); however, such colors can be sensitive to light and bleaching or may fade. The range of colors in which solution dyeing is done is rather limited for economic reasons. The fiber manufacturer must produce substantial quantities of fiber to justify the expense of adding an extra step during the manufacturing process. Furthermore fiber production takes place well in advance of the time when fabrics reach the market. Fashion color trends may change fairly rapidly, so that, by the time a mass colored fabric reaches the market, the color may be out of fashion and not salable, for this reason, spun-dyed fabrics are generally produced in basic colors.

Mass coloration is used on acetate to prevent gas fading. Gas fumes in the air may turn some blue or green dyes used for acetate to pink or brown.
Dyeing Fibers

When color is added at the fiber stage, this process is known as fiber dyeing or stock dyeing. It is a batch process in which loose (usually staple) fibers are immersed in a dye-bath, dyeing takes place, and the fibers are dried. Exhaustion is quicker in fiber dyeing because the dye liquor has better access to fiber surfaces. Levelness may be a problem but its effect can be minimized by blending fibers later during yarn processing.

Stock-dyed fibers are most often used in tweed or heather effect materials in which delicate shadings of color are produced by combining fibers of varying colors. Fiber-dyed fabrics can be identified by untwisting the yarns to see whether the yarn is made up of a variety of different colored fibers. In solid-colored yarns untwisted stock-dyed fibers will be uniform in color, with no darker or lighter areas.

Fibers for worsted wool fabrics are sometimes made into a sliver before they are dyed. This variation of fiber dyeing is known as top dyeing. By dyeing the fibers after they have been combed, the manufacturer avoids the wasteful step of coloring the short fibers that would be removed in the combing process. The dyed tops can be drawn or gilled to produce heather effects in the yarns.

Yarn Dyeing

If color has not been added either to the polymer or the fiber, it can be applied to the yarns before they are made into fabrics. Yarns may be dyed in skeins, in packages, or on beams. Special dyeing equipment is required for each of these batch processes.

In skein dyeing, large skeins of yarn are loosely wound on sticks and placed in a vat for dyeing. In package dyeing, the yarn is wound onto a number of perforated tubes or springs. The dye is circulated through the tubes to ensure that the yarns have maximum contact with the dye. (See Figure 4.1) Beam dyeing is a variation of package dyeing, which uses a larger cylinder onto which a set of warp yarns is wound.

Many types of fabrics utilize yarn of differing colors to achieve a particular design. Stripes in which contrasting sections of color alternate in the length or crosswise direction, chambrays in which one color is used in one direction and another color is used in the other direction, complex dobby or jacquard weaves, and plaids may all require yarns to which color has already been added.

Yarn-dyed fabrics may be identified by unraveling several warp and several filling yarns from the pattern area to see whether they differ in color. Not only will each yarn be a different color, but the yarns will have no darker or lighter areas where they have crossed other yarns.
Usually yarns are dyed to one solid color, but in a variant of the technique called space dyeing, yarns may be dyed in such a way that color-and-white or multicolored effects are formed along the length of the yarn.

![Diagram of dyeing process](image)

**Figure 4.1: Package dyeing of yarns**

**➢ Piece Dyeing**

Fabrics that are to be a solid color are usually piece dyed. In piece dyeing, the finished fabric is passed through a dye bath where the fibers in the fabric absorb the dye. A number of different methods are used for piece dyeing, each of which differs slightly in the way in which the fabric is handled.

Fabrics may be dyed in either continuous or batch processes. In continuous dyeing, the cloth continually passes through the dyebath. This is the cheaper process and where possible, is used for dyeing large yardages. Batch dyeing is used for shorter fabric lengths. Some fabrics are dyed in open, flat widths. Knitted fabrics and those woven materials that are not subject to creasing are handled in "rope" form, which is bunched together and handled as a narrower strand. They are usually attached at the ends to form a continuous loop. Some dyeing methods are especially suitable for certain types of fabrics and unsuitable for others. Many different kinds of machines be used for piece dyeing.

**➢ Batch Processes**

Beck and jet dyeing are batch processes for fabric in rope form. Beck dyeing, also called box or winch dyeing, is frequently used for dyeing wool fabrics and knits, as it places relatively little tension on the fabric during dyeing. The loop of fabric is pulled in and out of the dye bath by a winch, and large sections are allowed to accumulate in the bottom of the
beck to increase the residence time in the bath. (See Figure 4.2.) Up to twelve ropes of fabric can be dyed side by side at the same time. Devices in the machine keep the ropes separate.

*Jet dyeing* is a newer method that uses propulsion of the dye liquor through the fabric to improve dye penetration. Dyeing takes place in a closed system that carries a fast-moving stream of pressurized dye liquor. A fluid jet of dye penetrates and dyes the fabric. After it passes through this jet, the fabric is floated through an enclosed tube in which the fluid moves faster than the fabric. This prevents the fabric from touching the walls, keeping it constantly immersed in the dyebath. Turbulence is created by locating elbows in the tube. The turbulence aids in diffusing dyes and dyebath auxiliaries. Since no pressure is put on the fabric, even delicate fabrics can be dyed by this process. Jet dyeing has the advantage of being economical in operation and at the same time allowing a high degree of quality control.

Batch processes that dye fabric in flat widths are *jig* and *beam* dyeing. Jig dyeing is a process that places greater tension on the fabric than the beck and jet machines. Fabrics are stretched across two rollers that are placed above a stationary dye bath. The fabric is passed through the dye bath and wound on one roller. The motion is then reversed until the desired exhaustion or depth of shade is achieved. The tension created by placing the fabric on the rollers means that this process must be reserved for fabrics with a fairly close weave that will not lose their shape under tension.

*Beam dyeing*, which is used for lightweight, fairly open-weave fabrics, utilizes the same principle as beam dyeing of yarns. The fabric is wrapped around a perforated beam and immersed in the dye bath. Tightly woven fabrics would not allow sufficient dye penetration; hence, this method must be applied to loosely woven cloth. It has the added advantage of not putting tension or pressure on the goods as they are processed.

![Diagram](image-url)

**Figure 4.2:** Side view diagram of a typical dye beck showing movement of fabric through the dye bath
Figure 4.3: Jet dyeing machine

1. Fabric guide roll
2. Loading and unloading port
3. Header tank
4. “U” tube
5. Suction control
6. Suction control
7. Suction control
8. Delivery control
9. Main Pump
10. Filter
11. Heat exchanger
12. Service tank

Picture 4.1: Jet dyeing machine
Continuous Processes

Continuous dyeing, used in producing large quantities of piece-dyed goods that can withstand tension and pressure, generally follows some variation of the pad-dry-cure sequence. The last steps can be a steam setting process rather than drying and curing. Fabrics pass through a dyebath, then through pads or rollers that squeeze out the excess dye, and finally into a steam or heated chamber in which the dye is set. An example is the Thermosol process, developed by DuPont for application of disperse dyes to synthetics. Predrying with infrared heaters can be done before the fabric enters the heating chamber.

The process, while efficient, is not without its disadvantages. Leveling can be a problem because the dye absorption may not be uniform and dye migration to the surface may occur during drying. In addition, as dye is picked up, the bath become depleted and fresh dye liquor must be added.

Variations of this continuous process are vacuum impregnation and foam application. The vacuum method was introduced to improve the dyeing of heavyweight fabrics. Trapped air, caught in denser fabrics such as corduroy and heavyweight ducks makes dyeing them difficult. In this system, a perforated stainless steel cylinder imposes a vacuum as the dye liquor is applied to the other side of the fabric. The result is more thorough dye penetration. The vacuum system has been particularly useful in dyeing pile fabrics as it allows equal dye penetration of both the pile and the ground fabric.

In foam dyeing the dye solution is spread over the fabric as foam that then collapses carrying the dye into the fiber. Level application has been difficult to achieve and this method is little used.

Figure 4.4: Diagram of jig dyeing method. Rollers reverse and fabric is passed through the dyebath multiple times.
4.2.3. Fastness

A fabric that retains its color during care and use is said to be colorfast. Fastness is an important concern of consumers. Small aggregates of dye molecules distributed evenly throughout the fiber make for a more satisfactory result than do surface applications of color.

Fabrics may be more or less colorfast to a variety of different substances or conditions. The importance of colorfastness depends on the use of the fabric.

Even dyes that belong to the same class can have differing degrees of colorfastness to the same condition, so that the consumer has no real guarantee of color permanence unless a label specifies that a particular fabric is colorfast. Dye performance labeling is not required by any form of legislation or regulation. Some manufacturers do, however, include colorfastness information on labels. Such labels will generally describe the conditions under which the fabric is colorfast, such as "colorfast to laundering, but not to chlorine bleaching" or "colorfast to sunlight."

4.2.3.1. Types of fastness and uses

- **Fastness to sunlight**
  
  Colorfastness to sunlight may be important in evaluating the usefulness of fabrics for curtains, draperies, carpets, and outdoor clothing. Light fastness is usually a function of the dye structure rather than its retention within the fibers. The molecular structure that provides the color can be interrupted by light, particularly ultraviolet light. Additives or finishes are available to stabilize dyes from this type of action.

- **Fastness to perspiration**
  
  Perspiration may cause some color change and/or color transfer, and some colors are may be lost or diminished by heat.

- **Fastness to fumes and ozone**
  
  When garments exposed to the nitrogen oxide gases present in the atmosphere, color change often occurs. The change is gradual, showing up first in the most exposed part of the fabric and under the arms, where moisture accelerates the change.

- **Fastness to laundering**
  
  Colorfastness to laundering is, of course, important in those garments and household textiles that must undergo frequent laundering. Some colors are not fast to laundering but are fast to dry cleaning, or vice versa.
Fastness to dry cleaning

When a garment getting dirty and must be dry clean we have to be careful. Because the solvents which uses as a dry cleaning agent could harmful for the garments color.

Fastness to pressing

While the some garments are pressing, especially if it has a dark color, the color would be change.

Fastness to crocking

Some dyes tend to crock, or rub off on fabrics or other materials with which they come in contact. Others will bleed into water during laundering and may be picked up by lighter-colored fabrics. Chlorine bleaches will remove color from most dyed fabrics, but some dyes are more sensitive than others to the action of chlorine bleaches.

4.3. Printing

Fabrics with colored figures stamped on them are known as printed cloths. The design in this case is not woven into the cloth but is printed on after the cloth has been woven. If the background of the fabric is to be white, the cloth is usually bleached before it is printed.

The printing of fabrics represents an important part of the textile industry. It is interesting to note that printed goods are often bought on impulse by the consumer because a particular pattern, design, or color combination in a dress, sport shirt, or sheet appeals to him or her. To retain this market, the print industry and those involved in the textile business face a major problem of meeting competition and maintaining price levels in the face of increasing raw material and labor costs. To alleviate this problem, chemists have developed new methods.

4.3.1. Production stages

First, the artists submit their textile designs to manufacturers. Out of an assortment of designs submitted, great numbers are rejected. The few accepted ones are then printed on samples of fabrics.

Dyestuffs used for printing are the same as those used for piece-dyeing or yarn-dyeing, except that dyestuffs may be thickened with starch, gum, or resin to prevent a color from bleeding or running outside the outline before it is dry. When they are dried, printed cloths are passed over hot rollers and then steamed so that the colors are set. Any excess dye is removed by a washing after the steaming. Colors carefully printed can be fast to both light and washing. It has been found that mercerization of the gray goods before printing results in a brighter, stronger colored print.
4.3.2. Printing Types and Uses

There are many different ways of printing fabrics. The chief ones are as follows:

- **Direct or roller printing:** The principle direct printing is creation of a colored design by applying a dye or a pigment directly onto a textile substrate (yarn or fabric). (See Picture 4.2 and Picture 4.3 and Picture 4.4)
  - *Block printing:* appears to be oldest direct printing technique.
  - *Mordant printing:* Inventive printers found another means of combining printing and dyeing to add color patterns directly to fabric.
  - *Blotch printing:* Both a colored background and design motifs are printed onto the fabric.
  - *Overprinting:* is application of a design on a fabric that has already been pieced dyed.

![Picture 4.2: A part of a roller printing machine](image-url)
Discharge printing or dyeing

When the design is to contain not more than two colors, the method called discharge is often used. The whole cloth is dyed a solid color first; then the design on the roller is covered with a chemical, which, when it is applied to the cloth, discharges (removes) the color from it in those portions that correspond to the design on the roller. The background is left colored and the design is white. The same depth of color appears on both sides, because the colored portion was piece-dyed first. (See Picture 4.5)
Solid, dark ground colors that are equally saturated on the front and back of the goods are characteristic features of discharge prints.

- **Resist printing or dyeing**

  In this method, the design is printed first with a chemical paste so constituted that when the cloth is dyed the parts covered by the paste resist the dye and retain their original color. (See Picture 4.6) Batik work is an excellent example of one type of resist dyeing. (See Picture 4.7) The portions of the fabric that are to resist the dye are covered with paraffin. The whole cloth is then dyed and, when dried, the paraffin is removed. At times the paraffin cracks during the dyeing, so that little runs of color appear in the resisted portions. Often the resisted portions are painted by hand in different colors.
Sometimes certain yarns are chemically treated to resist dye before they are woven. When the cloth is piece-dyed, the yarns so treated do not take the dye. Accordingly, stripes and checks appear in piece-dyed goods.

Another type of resist dyeing is called tie-dyeing, used in fabrics for scarves and other accessories. Pieces of string are tied around bunches of cloth where the dye is to be resisted. The fabric is left tied in many little bunches while immersed in the dyestuffs. When the fabric is dry, the strings are removed, and very interesting sunburst designs appear. Parts of the fabric may be tied in different proportions and dipped in more than one color. It is possible to produce a varicolored design in this way. Still more complicated designs can be made by stitching the design areas rather than by tying.

Another type of resist dyeing is stencil printing, which is done by hand. Paper or metal is cut in the desired pattern and is placed over the fabric where the pattern is to be resisted. The parts that are covered do not take the dye.

Hand block printing

Before the method of direct roller printing was discovered, fabrics were printed by hand. The method is very similar to rubber stamping. A wooden block with a portion of the design carved on it is inked with dyestuff and stamped on the cloth by hand. The number of blocks used corresponds to the number of colors in the design. Great skill is required to stamp each portion of the design accurately so that all designs will be clear in outline and proportionate without a change in depth of color. Hand blocking gives a greater variety of designs and a color effect, for the regular repetition of a pattern that is necessary in the roller method is not necessary in hand blocking.
Linen is used quite extensively for hand blocking because it has the proper texture and quality. As hand-blocked fabrics are generally expensive, it does not pay to do such handwork on a poor grade of cloth. Real India prints are produced by hand block printing.

One way of detecting hand blocking is to look along the selvage for the regularity of the repetition of the design. In roller printing, the design must be repeated at regular intervals. Not so with hand blocking. Another way of detecting hand blocking is to look at the edges of the designs. Almost invariably one color runs into another in at least a few places. Also, the quality of workmanship may be determined by the clearness of each color, the sharpness of outline, and the regularity of the design.

- **Duplex printing**

  When a fabric is intended to be reversible, it is printed on one side, turned over, and then printed again on the other side so that the outlines of the designs on each side coincide. There is a special machine called a duplex printing machine that prints both sides of a fabric simultaneously. This method, if done well, gives the impression that the design is woven in.

- **Flock printing**

  The application of short, dyed cotton, rayon, or wool fibers to fabric or to paper is called flock printing. There are two methods of application: (a) The flock fibers are pressed into the resin substance, which has already been printed on the fabric, (b) The flock is applied to the resin-printed fabric by electrolysis. The second method produces a velvety surface.

- **Painted design**

  Hand painting is most effective on silks. The design is outlined on the fabric with wax and is filled in later by hand brushwork. Usually the wax is mixed with dye so that the outline appears a different color and so stands out from the background. The dyes may be thickened, as is done for roller or block printing, or real oil paint may be used for the design. Most hand painted fabrics are expensive because of the great amount of artistic labor involved.

- **Screen printing**

  When a design called for delicate shading, the process originally employed to produce the pattern was similar to that used for reproducing photographs in newspapers. Today a photochemical process reproduces the design exactly as it was painted. Elaborately shaded effects can be printed exactly like the original and reproduced many times. The fabric is first stretched on a padded table. A printing screen, made of silk, nylon, or metal stretched on a frame, is placed over the fabric. (See Picture 4.8) The parts of the pattern on the screen that are not to take the print are covered with enamel or certain paints to resist the printing paste.
The printing paste is poured on the screen and pushed through the pattern portion with a wooden or rubber paddle called a squeegee. When one section of a pattern has been finished, the frame is moved to the next section, and so on until the entire length has been completed.

![Picture 4.8: Flat bed screen print table](image)

For screen printing, a continuous operation has now been mechanized, so that several yards can be printed every minute. The fabric moves along a table, and the automatic application of the screens is electrically controlled. An automatic squeegee operates electronically. Mechanized printing reduces costs appreciably for large batches. Whenever high-quality fashion prints on exclusive dress goods or intricate patterns and big repeats are requisites, screen printing is an important process.

Fabrics with large designs in limited quantities are frequently screen printed by hand. Rayon jerseys, crepes, and other dress fabrics, luncheon cloths, bedspreads, draperies, and shower curtains are often screen printed.

Rotary screen printing

Rotary screen printing is a combination of screen and roller printing. A perforated cylindrical screen produces the design rather than a flat screen. The color, in paste form, is fed into the inside of the screen and is forced through the "pores" in the screen into the fabric. New technological developments make it possible to produce fine line engravings. Intermittent patterns are being printed with extreme accuracy on sheetings and other household textiles. To handle repeat orders, changeover time has been reduced greatly as
have faults in the prints that make it necessary to sell imperfect goods as "seconds" at much reduced prices. The newer machines have computer-guided electronic controls for each roller screen.

- **Pigment printing**

Instead of applying dyestuffs that impregnate the fabric, color is produced by finely ground insoluble particles of color that remain on the surface and are not absorbed into the material.

![Picture 4.9: Pigment printing](image)

The pigment is dispersed in an emulsion of water and oil and a resin binder is stirred in that, with the application of heat, binds the pigment to the cloth. The pigment is usually applied by means of screen printing. Pigment printing is sometimes called pigment dyeing because the entire fabric is colored solid and not in patterns and a variety of colors.

- **Photographic printing**

A design is photographed and the negative is covered with a screen plate to break up the solid areas of the design. A light is then projected through the screen plate onto another film to make a contact print. This film is placed on a copper roller treated with sensitizing solution. A powerful arc light focused on the film affects the sensitized roller by baking the coating where the light passes through. The roller is then washed to take away the solution from sections that the light did not reach. These portions of the roller are etched away to form the pattern. The roller is then treated to remove the baked coating, and printing is done from the roller. This method provides fine designs for dress goods.
- **Airbrushing**

Another method of producing shaded effects on fabrics employs a mechanized airbrush to blow color into the fabric. The hand guides the brush. This method is most effective on silk brocades and fabrics that are made in Jacquard or dobby designs.

- **Heat-transfer printing**

In this technique the fabric is printed in nonpolluting color on large rolls of paper. The fabric in the greige and the printed paper are carried around a heated cylinder on a Nomex blanket. The heat transfers the design to the cloth. Heat, speed of rotation, and blanket tension are adjusted to the requirements of the cloth to ensure that virtually all the dye in the pattern is exhausted. The paper is then discarded as trash. Almost any design can be printed by this process.

Costs of production are kept down by storing fabric in the greige until needed to fill orders. Only the printed paper needs to be stored until required, at a much lower cost than storing fabric.

This method is suitable for printing on fabrics of thermoplastic fibers, such as polyester, that melt at high temperature.

- **Polychromatic printing or jet printing**

This is a process of applying (squirting) dye on a continuous width of fabric. The movement of the various jets controls the design. Patterns in stripes of many colors are possible with this technique. Jeans, shirts, scarves, and bathroom mats can be printed in this way. This process is sometimes called polychromatic printing because the fabric shows a variety of colors.

### 4.4 Finishing

After fabric preparation and coloring, finishes can be applied to modify the appearance, hand, and/or texture of the textile. These finishes may change the surface appearance or texture, add a design feature, or alter the body and hand of the fabric.

#### 4.4.1. Mechanical finishes

- **Calendering**

Calendering is a broad, general term that refers to a mechanically produced finish achieved by passing fabrics between a series of two or more rollers. The object of calendaring is to smooth the fabric and/or create interesting surface effect.

Simple calendaring (make very smooth surface)
Glazing (highly glazed surface)
Cireing (a high surface polish)
Embossing (pressing a pattern onto fabrics) (See Figure 4.5)
Schereinering (produces fabrics with soft luster and hand)
Moire (watered or clouded surface) (See Figure 4.6)

Figure 4.5: Embossing

Figure 4.6: Moire effect

➢ **Beetling**

Linen and cottons that are intended to look like linens are beetled, a process in which the fabric is pounded (in a machine equipped with hammers that strike over the surface of the fabric) flattening the yarns and making them smoother and more lustrous.

➢ **Raising**

The process for staple fiber constructions consists of pulling out a layer of fibers from the structure of a fabric to form a pile. This results in a lofty handle, and may also subdue the weave or pattern of the cloth in addition to blending the various colors.
Napping and sueding

Napped and sueded fabrics are fabrics in which fiber ends are brushed up onto the surface of the fabric.
- Brushing (to remove loose fiber from the surface)
- Shearing (removes unwanted fibers projecting onto surface of the fabric)

4.4.2. Chemical finishes

Design finishes

A number of primarily chemical finishing processes have been developed to create design on fabrics. Applying these finishes similar to printing.

Burn-out designs

Chemicals that dissolve some fibers can produce alterations in fabric appearance. One can create open areas in fabrics by imprinting a cellulosic fabric with a sulfuric acid paste that dissolves the printed area. Such fabrics are likely to fray around the edges of the dissolved area and are not especially durable.

In blended fabrics, this technique can be used to create interesting effects. Two different fibers are used. When the dissolving material is imprinted on the fabric, one of the fibers is dissolved, leaving the other unharmed. Areas with no chemical imprinted on them remain intact and create the design. By contrasting the texture, luster, or color of the "burned out" fiber with that of the second fiber, attractive decorative effects can be achieved. (See Picture 4.10)
Acid Designs

Treating cotton fabric with acid causes it to become more transparent as some of the surface fibers are dissolved away, creating fabrics with a "frosted" design. Fabric areas are coated with acid-resistant materials. When the finish is applied, these areas remain opaque, while the acid-treated areas become transparent.

Plisse Designs

A puckered effect called plisse is achieved in fabrics by imprinting them with chemicals that cause the fabric to shrink. When these chemicals are printed in a design, some areas of the fabric shrink while others do not. This causes untreated areas to pucker or puff up between the treated areas. (See Figure 4.7) Cottons and rayon react in this way when treated with sodium hydroxide, an alkali, as do nylon printers with phenol, an acid. Although plisse is a fairly durable finish, such fabrics should not be ironed because the pressing of the plisse flattens the surface. Thermoplastic fiber; can also be embossed to simulate plisse.
Finishes that affect hand or texture

➢ **Softening**

Some fabric may feel harsh after production or heat setting of manufactured fabrics, durable press finishes, and some treatments given to acrylic fabrics may produce an unpleasant hand. Applying fabric softeners during finishing can overcome these negative qualities. The chemical compounds used penetrate intersections between yarns and fibers to allow a certain amount of slippage, thereby creating suppler, smoother, and more pleasant-feeling fabric.

➢ **Stiffening**

A special acid treatment known as parchmentizing is used to give some cottons a permanently stiff character. Permanently finished organdy, for example, is made by this process.

### 4.4.3. Special purpose finishes

Finishes that are applied to fabrics to make them better suited for specific uses come under this category. In general, these finishes are newer than the basic finishes, many of them having been perfected during World War II and later.
**Abrasion Resistance**

Abrasion resistance is a matter of the degree to which a fabric can withstand the friction of rubbing or chafing. The newer man-made fibers, such as nylon, acrylic, and polyester, have good abrasion resistance; the natural fibers lack this property. To overcome this drawback, fibers with high potential abrasion resistance can be blended with fibers of low abrasion resistance (not a finish).

The chief objection to the use of resins lies in the fact that these finishes may increase wet soiling of the fabrics.

**Absorbent Finishes**

For such articles as towels, bed linens, diapers, and underwear, the absorption of moisture is important. A treatment with ammonium compounds causes cottons, linens, and rayons to absorb water more readily.

A chemical finish has been found that corrects the hardness and lack of water absorbency of nylon. The use of this finish has improved the appearance, comfort, and salability of finished nylon hosiery and piece goods.

**Antibacterial Finishes**

When perspiration is produced, it is immediately contaminated with various types of bacteria on the skin. Bacterial decomposition begins. It is this bacterial action that causes the odor of perspiration and has a deteriorating effect on the fabric. It may also change the color of the fabric or transfer the color to a lighter fabric.

Antiperspirants, applied under the arms, are commonly used to check perspiration, but they sometimes irritate the skin. To prevent the odor of perspiration, bacterial decomposition must be prevented. Frequent washing helps. Germicides can be applied on the skin or on the fabrics. If the latter is the case, the germicide has to be carefully chosen. It must be colorless, so as not to stain the fabric, and odorless; it should not affect the dyes or finishes of the fabric, should not irritate the skin, and should not be removed by the first few washings. A few compounds have been found to possess these qualities. Fabrics treated with these germicides- fungicides have been found to have semi-permanent finishes (do not wash out in as many as forty washings) and to pass the sterility test of the U.S. Pharmacopeia. Fabrics treated with these compounds also sufficiently protect the wearer against the fungus that causes athlete's foot. This fabric treatment will prove effective for as many as twenty-five launderings.

Antibacterial finishes prevent bacteria-caused odors in textiles and/or reduction of the changes of bacterial infections resulting from contact with contaminated textiles. Sanitized is a trademarked finish that protects fabrics from deterioration and odor-causing effects of bacteria, mildew, and mold.
➢ **Antislip Finishes**

Seam fraying and yarns shifting (slipping) in the fabrics are common annoyances to the consumer. Finishing agents such as resins—hard, waxy substances remaining after distillation of volatile turpentine—have been used, but they are not generally durable to washing. Other chemical treatments reduce surface slickness but are not durable. Urea and melamine formaldehyde resins are the most durable of the finishing agents used to reduce yarn slippage.

➢ **Antistatic Finishes**

A chemical treatment applied to noncellulosic man-made fibers to eliminate static electricity is a boon to the customer. An annoyance to the wearer is a nylon slip that clings to the body or to an outer garment, or a crackling lining as a coat is taken off, or acrylic slacks that cling to the legs on a cold, windy day. Static charge or static electricity is controlled in natural fibers and in rayon by the introduction of humidity in the air and by employing some weaving lubricants in the processing of the fibers. The newer man-made fibers, such as nylon, polyester, and acrylics, are more difficult to process. Humidity is not the sole answer. Some type of coating must be used to carry away electrostatic charges built up on the fiber. For knit goods, Badische has developed an antistatic process that will last for the life of the garment. Consumers can partially control the static by the use of softeners such as Sta Puf, Downy, and Negastat in the wash water. Permanent antistatic agents have been developed by the finishing industry.

➢ **Inflammability Finishes**

The problem of flammability in textile fabrics came to the fore when some toddlers dressed in cowboy suits were fatally burned when they came too near a campfire. In another case, a woman wearing a sequin-trimmed gown accidentally came into contact with the lighted cigarette of a passerby and suddenly the woman's gown became a flaming torch.

Textile products can be made flame resistant by using fibers that are inherently flame resistant or by application of a flame-resistant finish. Modacrylic fibers offer adequate flame resistance at a moderate cost and have some use in carpets, curtains, and children's sleepwear.

Many other synthetic fibers shrink from ignition flames, providing some protection. Untreated polyester and nylon, for example, will pass the test for children's sleepwear based on this characteristic.

For fibres that are not flame resistant, a flame retardant treatment can be applied. Durable finishes for cotton and cotton blends fabrics contain phosphorus which reacts chemically with the fibers and inhibits the production of compounds that fuel the flame.
Commercial flame retardant finishes are Pyrovatex, Proban, and PhyronO, the latter produced by Ciba Chemicals.

- **Mildew and Rot Repellent Finishes**

  Mildew is a parasitic fungus that grows rapidly in warm humid weather. Fabrics of cotton, linen, rayon, and wool are particularly vulnerable to this fungus. Microorganisms present in the air and soil can grow on wet fibers. Consequently, if clothing is not completely dry before it is put away, it can mildew. If clothing is improperly rinsed, soap or oils adhere to the fibers and provide a field for the growth of mildew.

  Prevention of mildew is possible by treating the fabrics with nontoxic, odorless germicides. Certain metallic salts have this effect. For cotton, one method is to modify the cotton fiber so that its surface is cellulose acetate, which is resistant to mildew. A resin impregnation of the cotton fiber, which prevents contact of the microorganism with the fiber, can also be used.

  Permanent rotproofing of cotton is possible through a treatment with a condensation resin. A new technique overcomes the drawback of loss of strength of the cotton fiber that resulted from conventional methods of applying condensation resins. If a suitable organic mercury compound is added to the rotproofing finish, it is possible to protect cotton against surface mildew growth.

- **Moth Repellent Finishes**

  To mothproof a fabric in the finishing process, colorless chemicals similar to dyestuffs are added to the dye bath. This treatment makes the fabric permanently moth-repellent. Although this method is effective, the high cost of the chemicals required may make its use prohibitive. Another way is to atomize the finished fabric with the mothproofing chemical, which is colorless, odorless, and harmless to humans. The compound used in processing the fabric either poisons the moth or kills it upon contact.

  Wool or silk fabrics may be made moth-repellent. Cotton, linen, and the man-made fibers do not attract moths.

- **Waterproof Finishes**

  A fabric that is waterproof allows no water to penetrate from the surface to the underside. Coatings made from rubber or synthetic plastic materials can create fabrics that are completely waterproof; however, these fabrics tend to be warm and uncomfortable because they create a barrier that traps air and perspiration close to the body. For umbrellas, galoshes, and raincoats, the fabrics should be waterproof.
4.5. Test Laboratory

Textile testing is used to determine whether products meet established standards. These testing methods have been proven to be both valid and reliable.

To ensure accuracy and reliability, textile testing must be carried out under carefully controlled conditions. Atmospheric conditions (particularly the amount of moisture present that might be picked up by fibers) affect the performance of textiles. For this reason, testing is done with temperature and humidity being maintained at standard levels: 70°F (21°C) and 65 percent relative humidity. Testing equipment must conform to specifications established in the test methods and fabric specimens must be of uniform size. Test measurements are repeated a number of times because of variability in results from one specimen to another. Results are averaged. Those overall measurements more accurately characterize the materials being tested than does the measurement of a single sample that might possess some atypical quality.

4.5.1. Laboratory devices

The following photographs are most useful laboratory devices.

![Automatic Strength Tester device](Picture 4.11: Automatic Strength Tester device)
Picture 4.12: CSI abrader for testing surface abrasion

Picture 4.13: Pilling tester
Picture 4.14: Pure bending tester

Picture 4.15: Color matching

Picture 4.16: Crockmeter
4.5.2. Chemical tests

- **Commercial test for fastness to perspiration for fabrics;**
  
  Light color silks, especially those used for evening wear, should be fast to perspiration.

  Test process: Separate spicemans are wetted out in alkaline and acid perspiration solutions. Fabrics are inserted in a perspiration tester, are subjected to a fixed mechanical pressure, and are allowed to dry slowly in an oven 100+ 2°F for at least six hours.
Bleeding, migration of color, or changes of dyed material are evaluated.

- **Commercial test for fastness to fumes and ozone for fabrics;**

  Test process: A specimen of the fabric to be tested and a control fabric are placed in an exposure chamber with a lighted gas burner. In this way, they are exposed simultaneously to oxides of nitrogen from burned gas fumes until the control fabric shows a change in color that corresponds to a standard of fading established. The change in the color of the fabric undergoing to the test at the above point is measured by a “Standart Grey Scale” established for assessing the change in color.

- **Commercial test for fastness to dry cleaning;**

  Test process: Samples of material are treated in a Launder with a solvent and tested specimen compared with the Gray Scale for color change.

- **Commercial test for fastness to sunlight;**

  Commercial testing agencies frequently use standard tests for lightfastness. A specially designed powerful carbon arc lamp has the same effect as strong sunlight. Samples to be tested revolve around this lamp for a definite period of exposure.

  - *Sunlight method.* Specimens are exposed against standards, on sunny days only, between the hours of 9 a.m. and 3 p.m.
  - *Daylight method.* Specimens are allowed to remain in a test cabinet for 24 hours a day. Specimens are also exposed to low-intensity radiation (before 9 a.m. and after 3 P.M.) and on cloudy days, during which time the specimen temperature may be low and the moisture content high. Since these tests may produce varying results, laboratories test a specimen under a variety of conditions simulating the performance of the fabric in a machine called a Weather-Ometer.
  - *Fade-Ometer method:* Colorfastness is rated in terms of number of "standard fading hours required to produce just appreciable fading" (change of color of any kind, when compared with unexposed samples).
  - *Xenon Weather-Ometer:* For most fabrics not sensitive to low-intensity radiation and atmospheric contaminates, this xenon arc lamp method produces results comparable to the natural sunlight methods described previously.
4.5.3. Physical tests

- Commercial test for fastness to crocking;

Fabrics used for street and business dresses must withstand a great deal of friction; that is, the color should not rub off, or crock, even though the fabric is not intended to be washable.

- Dry crocking. A test specimen is fastened to the base of the Crockmeter. A standard crock cloth is attached to the rubbing finger of the machine. The finger is lowered onto the test specimen, and by turning the crank the finger is caused to slide back and forth twenty times.

- Wet crocking. Fabric squares are wetted in distilled water and are then placed between two filter papers (like a sandwich). The "sandwich" is passed through a wringer. The transfer of color (both wet and dry) is evaluated by comparing with a chart for measuring transference of color or with the Geometric Staining Scale.

- Commercial test for fastness to laundering;

In a 45-minute accelerated test, specimens are placed in stainless steel tubes or glass jars that revolve at a standard speed in a water bath that is thermostatically controlled. Metal balls are added to each tube to simulate washing action.

Tested specimens are evaluated for alteration in color by comparing them with the International Geometric Scale. Color staining is evaluated by comparison with the AATCC chart for measuring transference of color or the Geometric Staining Scale.

4.5.4. Analytic tests

These are the tests for identifying some blends fabric.

4.5.5. Special purpose tests

- Testing Factors Related To Durability

- Mechanical properties

Fabric strength evaluations are made in terms of breaking strength, tearing strength, or bursting strength. A variety of machines is used to measure strength, and fabric samples are prepared for testing according to ASTM test method procedures.

Breaking strength, the force required to break a woven fabric when it is pulled under tension, is measured on a tensile testing machine. (See Picture 4.11) The strength is reported
in pounds or newtons of force required to break the fabric. Half the specimens are prepared with warp yarns running in the direction of stress, and the other half have the stress in the filling direction.

At the same time that breaking strength is being tested on a tensile testing machine, the degree of elongation that the fabric undergoes before breaking may be determined and reported as a percentage of the original length. Fabrics may also be tested for recovery from elongation. They are stretched to certain percent of their original length and then permitted to recover for a specified time.

Tearing strength of a fabric, expressed in pounds or grams, is the pressure required to continue a tear or rip already begun in a woven fabric. Strength can be measured on a tensile tester by cutting a slit in a fabric specimen and mounting the two parts, or "tongues" in the clamps of the machine. Other instruments provide alternate methods for holding the two split ends of the sample before tearing.

- Abrasion resistance

Abrasion resistance can be determined on several different types of abrasion-testing machines. The results of tests run on different machines cannot be compared, as each machine tests with a different motion and each holds the fabrics in different positions. Some instruments determine only flat abrasion, while others can measure resistance to edge and flex abrasion. The CSI surface abrader pictured in Picture 4.12 is one of the latter type.

Pilling is a result of abrasion but can also affect the appearance of a fabric. It is often important to determine a fabric's tendency to pill when evaluating its serviceability. The Zweigle Pilling Tester can be used for this purpose. Specimens are tumbled in cork-lined cylinders and then the number of pills in a specified fabric area can be counted. Alternatively, pilled fabric specimens can be subjectively rated against photographs representing different pilling levels.

Abrasion is one of those factors most likely to be affected by each individual's unique use of textiles. For example, the linings of overcoats are subject to abrasion from garments worn beneath them. A person who favors soft, smooth-textured clothing would subject the lining of a coat to considerably less abrasion than one who prefers coarse-textured, rough-surfaced textiles.

- Testing Factor Related To Appearance And Hand

- Dimensional Stability

Shrinkage or growth of fabric during wear and care can render an apparel or household textile item both unappealing and unusable. Consequently a required level of dimensional stability is often specified when selecting fabrics for textile products. It is
traditionally determined by placing marks on the fabric, subjecting it to laundering, dry cleaning, or other conditions, and then remeasuring the marked area. The shrinkage or growth is reported as a percentage of the original dimensions. Changes in the lengthwise and crosswise directions are reported separately. The effectiveness of a shrink-resistant finish can be determined by comparing the shrinkage of finished and unfinished fabrics. Not only may fabrics shrink, but they may also twist or skew during laundering. Knits and twill weaves are especially susceptible because there are twist stresses built up during the processing of these fabrics. A test method was developed by AATCC for determining skewness change in fabrics. The diagonal lines of a marked square are measured, and the percent change in their length calculated.

- **Wrinkle Recovery**

  Wrinkle recovery of fabrics is measured by creasing small fabric samples for a specific time, allowing them to recover, and calculating the angle that the two creased ends form.

  Fabrics with good recovery will result in measured angles that are high, around 150 degrees. Untreated cotton fabrics usually have recovery angles less than 100 degrees.

  Retention of a smooth fabric appearance after laundering can be determined by comparison with standard plastic replicas representing different levels of wrinkling. Fabrics are laundered and visually compared to the replicas. Ratings for smoothness appearance (SA) range from 1 (poor) to 5 (very good). Standard test methods also exist for determining the appearance of creases in durable press items after laundering and the appearance of finished garments and other textile products.
Pilling is an unpleasant phenomenon associated with spun yarn fabrics especially when they contain synthetics. Synthetic fibers are more readily brought to the surface of fabric due to their smooth surface and circular cross section and due to their higher tensile strength and abrasion resistance, the pills formed take a long time to be abraded by wear. With knit fabric, two more problems occur, viz., "picking" where the abrasion individual fibers work themselves out of yarn loops onto the surface when garment catches a pointed or rough object. These two effects are more predominant in the weave, is more open and yarn is bulkier.

The finish has to cement the fibers within the yarn so that their dragging becomes more difficult, without affecting the handle adversely. Special polymer formers of acrylate type or latex type are useful but should form a film of good cohesion, should hydrophilic and should not form a tacky surface. Padding in polymer dispersion or emulsion followed by drying at moderate temperature gives the desired effect.
CHECKLIST

If you have behaviors listed below, evaluate yourself putting (X) in “Yes” box for your earned skills within the scope of this activity otherwise put (X) in “No” box.

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<th>Evaluation Criteria</th>
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<td>1. Have you had the knowledge of technical English about the terms of pilling?</td>
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<td>4. Have you had knowledge of technical English about the process of finishing?</td>
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EVALUATION

Please review your "No" answers in the form at the end of the evaluation. If you do not find yourself enough, repeat learning activity. If you give all your answers "Yes" to all questions, pass to the "Measuring and Evaluation".
Answer the following questions and measure your knowledge.

1. Which one is the dye most often used on *cellulosic* fibers?
   A) Azoic
   B) Cationic
   C) Acid
   D) Basic

2. Which one is the dye most often used on *protein* fibers?
   A) Azoic
   B) Cationic
   C) Acid
   D) Basic

3. “Fastness to ………. may be important in evaluating the usefulness of fabrics for curtains, draperies, carpets, and outdoor clothing..”
   Fill in the blanks with the correct answer.
   A) Fume
   B) Sunlight
   C) Crocking
   D) Perspiration

4. Which one is not a method of coloring a textile fabric?
   A) Printing
   B) Dyeing
   C) Weaving
   D) Finishing

5. “When the design is to contain not more than two colors, the method called……..”
   Fill in the blanks with the correct answer.
   A) Screen
   B) Pigment
   C) Flock
   D) Discharge
6. “The application of short, dyed cotton, rayon, or wool fibers to fabric or to paper is called ……….”?  
   A) Screen  
   B) Pigment  
   C) Flock  
   D) Discharge

7. “……..dyeing is batch process for fabric in rope form.” Which dyeing method is?  
   A) Piece  
   B) Yarn  
   C) Open  
   D) Jet

8. “The object of this preparatory operation, of course, is to whiten the cloth, which may come from the loom grayish brown in color.” Which one?  
   A) Bleaching  
   B) Carbonizing  
   C) Scouring  
   D) Mercerization

**EVALUATION**

Please compare the answers with the answer key. If you have wrong answers, you need to review the Learning Activity. If you give right answers to all questions, pass to the module evaluation.
Answer the following questions and measure your knowledge.

1. …………… draws out the roving (very slackly twisted sliver) and puts in the required amount of twist.
   A) Drawing
   B) Carding
   C) Mixing
   D) Spinning

2. Which operation does not necessary to use in cotton system?
   A) Scouring
   B) Carding
   C) Spinning
   D) Combing

3. “A ……… is a narrow metal sheet that is hung in the air by the tensioned warp yarn.”
   Fill in the blank with the correct word.
   A) Rapier
   B) Heddle
   C) Reed
   D) Drop wire

4. “The ……… weave is the simplest of the weaves and the most common.” Fill in the blank with the correct word
   A) Plain
   B) Twill
   C) Satin
   D) Rib

5. “The ……… knitting machine has needles arranged in a circle on a rotating cylinder.”
   Fill in the blanks with the correct answer.
   A) Warp
   B) Circular
   C) Hosiery
   D) Flat
6. “……… is a thin metal plate with an individual or collective action approximately at right angles from the hook side between adjoining needles.”
   A) Plate
   B) Cam
   C) Sinker
   D) Needle

7. Which one is a special purpose finishes?
   A) Waterproofing
   B) Softening
   C) Raising
   D) Calendering

8. Which one is physical test for a textile cloth?
   A) Sunlight
   B) Crocking
   C) Fume
   D) Perspiration

EVALUATION

Please compare the answers with the answer key. If you have wrong answers, you need to review the Learning Activity. If you give right answers to all questions, please contact your teacher and pass to the next module.
### LEARNING ACTIVITY -1 ANSWER KEY

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### MODULE EVALUATION ANSWER KEY

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