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UNIT
1
PRODUCTION OF TEXTILE/FABRIC

STRUCTURE

1.1 LEARNING OBJECTIVES

After completion of this unit, you should be able to:

- Define different types of yarns
- Describe the methods of producing textiles for different types of yarns
- Define the Bi-component yarns
- Explain Bi-constitute yarns
- Discuss about chemical treated natural fiber yarns
- Learn about the bulk yarns and lube bulk yarns.

1.2 INTRODUCTION

We all know that food, clothing and shelter are the three basic necessities of life. We eat food to survive and protect ourselves from diseases we need a

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house to live in. Why do we wear clothes? We wear clothes for protection against climate, for modesty and beauty, and also to show our status. The material that we use for clothing is called fabric. Suppose, we go to a shop to buy fabric for our dress, we will see a variety of fabrics there.

Have you ever wondered as to what these fabrics are made of? Why are some clothes warm, some rough and others soft? Why do some fabrics go bad after washing while others remain the same? How do you get variety in fabrics?

This unit first gives you brief information on the methods of fabric formation. The unit also gives information about the meaning and different types of fibers. It also tells you about how to use the burning test to identify various fibers. The unit also highlights the characteristics of fibers. The unit also defines yarn and its different types.

1.3 FABRIC PRODUCTION

1.3.1 Meaning of Fabric

The term 'fabric' doesn't need any explanation because you all know what it means. Fiber (American English) or Fibre (International English) are hair-like materials (*they look like threads*) that form the building blocks from which yarn and fabric are made.

So we can describe fabric as:

Fabric is a material that can be used to make clothing or household articles. Sometimes we see the seat of a chair or a couch weaved with nylon or cotton thread. These are made with tape - when two sets of tapes are interlaced with each other at right angles. Similarly a fabric is also made by interlacing two sets of yarns at right angles. This whole process of interlacing two sets of yarns at right angles to make a fabric is called weaving.

Weaving is the process in which the weaver interlaces two sets of yarns at right angles to each other to form a fabric. Weaving is done on *looms*. Hand operated looms are called handlooms and power operated ones are called power looms.

Weaving is also done by fitting one set of yarns on the loom which forms the length of the fabric. These are called the **warps**. The other set of yarns interlaced at right angles with the warps, are called **wefts**. The yarns can be interlaced in many different ways. These different ways of interlacing of yarns is called weaving. There are many types of weaves used to make different kinds of fabrics like cambric, popline, matt, satin, velvet, towels, denims, etc.

Blending is the process of making thread from more than one kind of fibres. You all must have heard of fabrics with names like *terecot* and *cotswool*. These are the names of mixed fabrics. *Cotswool* is a mixture of cotton and wool, and terewool of wool and terene. At the yarn stage itself, two types of fibres are mixed, pulled out and twisted together to form the yarn.

So the question comes how the fabric is prepared? Take a cloth and pull out a thread. Untwist to loosen this thread. You will see that it is made up of smaller threads or hair like strands. Pull out one of these. This single hair like strand is called a fibre.

A **fibre** actually is a hair like strand from which all types of fabrics are made. Then question arises how many types of fibres are there?

1.3.2 Classification of Fibres

It is usually seen that the fibres of a thread may be made of wool or cotton. You may pull fibres from a ball of cotton. On pulling you see that these fibres are very *short*. These are called *staple fibres*. If you pull fibres from a nylon fabric, you will find that these are long fibres. Such fibres are called *filament fibres* or simply filaments. Hence, you can classify fibres into two groups.

- *Short* fibres –also called - *Staple* fibre
- *Long* fibres –also called - *Filament* fibre

The classification of fibres can also be done on the basis of their origin. For example,

1. **Natural Fibres:** The fibres which are obtained from natural sources are called natural fibres, for example, fibres from plants and animals.

   Some more examples of fibres from natural sources are cotton, Jute, silk, wool, etc.

   The natural fibres are further divided into two categories:

   - **Vegetable Fibres:** As is understood from the name *vegetable fibres* are obtained from different plants. Some are well known and useful to man. For example, cotton, jute and coir. Cotton is obtained from seed of the plant, jute is obtained from the stem of a plant and coir is the outer covering of coconut.
   - **Animal Fibres:** The *animal fibres* are obtained from different animal sources. For example, we get wool from sheep and goat. We get wool from their hair. Wool can also be obtained from the hair of rabbits and camels. Another animal fibre you all are familiar with is silk. It is the secretion of an insect called the silk worm.

2. **Man-made Fibres:** Unlike the natural fibres these type of fibres are obtained from chemical substance. These are called *manmade fibres*. They are rayon, polyester, nylon, acrylic (cashmilon) etc.

   So this may be called the second way to classify fibres? For example:

   - *Natural* fibres –are obtained from- Plants and animals
   - *Man-made* fibres –are obtained from - Chemical substances

The classification of fibres can be better understood from the chart given below:

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FIBRE

On basis of length: Staple (short), Filament (long)

On basis of origin: Natural (Vegetables, animals), Man-made

Staple (short)	Filament (long)	Natural — Vegetables	Natural — animals	Man-made
e.g.	e.g.	e.g.	e.g.	e.g.
Cotton	Silk,	Cotton Jute	Wool Silk	Rayon
Jute	Nylon,	e.g. Cotton, Jute,	e.g. Wool, Silk	Polyester Acrylic. Nylon.
Wool,	Rayon, Polyester			Polyester, Acrylic

Figure 1.1: Classification of Fibre

Synthetic is another name for manmade fabrics. When you go to the market to buy fabrics, you must have heard from the shopkeeper that it is a synthetic material. Don't get disturbed. The first man-made fibre is known as rayon and was produced in the latter part of 19th century. Man-made fibres are generally filament fibres. Other examples are nylon, polyester, and acrylic.

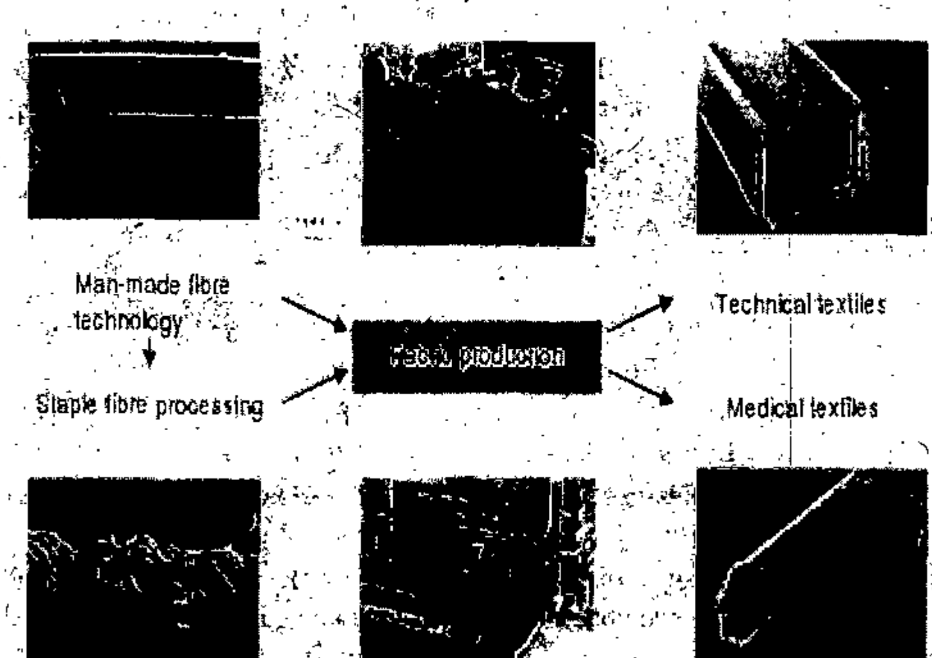

Figure 1.2: Fibre Production

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Table 1.1: Machinery Used in Textile Fabric Production

Weaving	Knitting	Braiding
■ Air-jet ■ Rapier ■ Narrow fabric	■ Warp knitting ■ Stitch-bonding ■ Ultrasonic-tube-welding machine ■ Double-need bar Raschel	■ Radial braiding ■ 3D-Rotary braiding

1.3.3 Identification of Fibres

Burning Test: This test is helpful in identifying the quality of fibres used in the production of a fabric. Once fibres are identified it will help the buyer to choose as per requirement, and not be cheated by salesmen.

The method used in the burning test is:-

- First, take out a yarn from the fabric.
- Second, burn one end of the yarn either with a match stick or burning *candle*.

Third, check the following:

1. How the fibre catches fire?
2. Notice the type of flame and its colour.
3. Notice the smell after burning the fibre.
4. Check the ash left behind after burning the fibre.

All the above points will help you to identify the quality of fibres used in the manufacturing of a piece of fabric.

Table 1.2: Identification of Fibres

Fibre	Inflame	Type of Flame	Smell	ASH
Cotton and Rayon	Catches fire eqasily	Continues to burn with a bright	Smell of burning yellow flame	Light feathery ash paper
Silk and Wool	Does not catch fire	Burnes with a yellow flame. easily	Smell of burning hair Does not continue to burn	Black crushable bead
Nylon, Polyter Acrylic	Does not catch fire easily, melts	Shrinks away from flame. Burns with sputtering away	No definite smell	Hard, uncrushable bead

1.4 PRODUCING TEXTILES FOR FIBRE YARNS

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Textile production is a major industry. It is based in the conversion of three types of fibre into yarn, then fabric, then textiles. These are then fabricated into clothes or other artifacts. Cotton remains the most important natural fibre, so is treated in depth. There are many variable processes available at the spinning and fabric-forming stages coupled with the complexities of the finishing and colouring processes to the production of wide ranges of products. There remains a large industry that uses hand techniques to achieve the same results.

In order to determine a fabric's appearance, how it would wear and its care, it is important to understand the characteristics of the fibers from which the fabric is made.

1.4.1 Different Types of Yarns

Yarn is a long continuous length of interlocked fibres, suitable for use in the production of textiles, sewing, crocheting, knitting, weaving, embroidery and rope making. Thread is a type of yarn intended for sewing by hand or machine.

Do you remember pulling a thread from a cloth and opening it? Yes, you found hair like fibres. That thread which was made of fibres is called yarn. Yarns are made up of a number of fibres twisted together. Fibres are thin and small and cannot be made into a fabric directly. So they are first converted into yarns which are longer, thicker and stronger. We use these yarns to make fabrics.

A yarn is a continuous strand made up of a number of fibres which are twisted together. The process of making yarns from fibres is called *spinning.* Here the fibres are not only twisted but also pulled out or drawn.

You can try spinning and making a yarn yourself. Take some cotton and start pulling out a few fibres. While pulling also twist. You will see that a yarn is formed. The spinning process helps to hold the fibres together and makes the yarns strong, smooth and fine. Even the filament fibres are twisted together to form a stronger, finer and smoother yarn. Spinning can be done by using a takli (spindle), a charkha or a spinning machine. Modern manufactured sewing threads may be finished with wax or other lubricants to withstand the stresses involved in sewing. Embroidery threads are yarns specifically designed for hand or machine embroidery.

1.4.2 Structure

Spun yarn is made by twisting or otherwise bonding staple fibres together to make a cohesive thread. Twisting fibres into yarn in the process called spinning can be dated back to the Upper Paleolithic,and yarn spinning was one of the very first processes to be industrialized. Spun yarns may contain a single type of fibre, or be a blend of various types. Combining synthetic fibres (which can have high strength, lustre, and fire retardant qualities) with natural fibres (which have good water absorbency and skin comforting qualities) is very common. The most widely used blends are cotton-polyester and wool-acrylic fibre blends. Blends of different natural fibres are common too, especially with more expensive fibres such as alpaca, angora and cashmere.

Yarns are made up of a number of plies, each ply being a single spun yarn. These single plies of yarn are twisted together (plied) in the opposite direction to make a thicker yarn. Depending on the direction of this final twist, the yarn will be known as *s-twist* or *z-twist*. For a single ply, the direction of the final twist is the same as its original twist.

Filament yarn consists of filament fibres (very long continuous fibres) either twisted together or only grouped together. Thicker monofilaments are typically used for industrial purposes rather than fabric production or decoration. Silk is a natural filament, and synthetic filament yarns are used to produce silk-like effects.

Texturized yarns are made by a process of air texturizing (sometimes referred to as *taslanizing*), which combines multiple filament yarns into a yarn with some of the characteristics of spun yarns.

1.4.3 Measurement

Yarn quantities are usually measured by weight in ounces or grams. In the United States, Canada and Europe, balls of yarn for handcrafts are sold by weight. Common sizes include 25g, 50g, and 100g skeins. Some companies also primarily measure in ounces with common sizes being three-ounce, four-ounce, six-ounce, and eight-ounce skeins. These measurements are taken at a standard temperature and humidity, because yarn can absorb moisture from the air. The actual length of the yarn contained in a ball or skein can vary due to the inherent heaviness of the fibre and the thickness of the strand; for instance, a 50 g skein of lace weight mohair may contain several hundred metres, while a 50g skein of bulky wool may contain only 60 metres.

There are several thicknesses of yarn, also referred to as weight. This is not to be confused with the measurement and/or weight listed above. The Craft Yarn Council of America is making an effort to promote a standardized industry system for measuring this, numbering the weights from 1 (finest) to 6 (heaviest).[4] Some of the names for the various weights of yarn from finest to thickest are called lace, fingering, sport, double-knit (or DK), worsted, aran (or heavy worsted), bulky, and super-bulky. This naming convention is more descriptive than precise; fibre artists disagree about where on the continuum each lies, and the precise relationships between the sizes.

A more precise measurement of yarn weight, often used by weavers, is Wraps Per Inch (WPI). The yarn is wrapped snugly around a ruler and the number of wraps that fit in an inch are counted.

Labels on yarn for handicrafts often include information on gauge, known in the UK as tension, which is a measurement of how many stitches and rows are produced per inch or per cm on a specified size of knitting needle or crochet hook. The proposed standardization uses a four-by-four inch/ten-

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by-ten cm knitted or crocheted square, with the resultant number of stitches across and rows high made by the suggested tools on the label to determine the gauge.

In Europe textile engineers often use the unit tex, which is the weight in grams of a kilometre of yarn, or decitex, which is a finer measurement corresponding to the weight in grams of 10 km of yarn. Many other units have been used over time by different industries.

1.4.4 Color

Yarn may be used undyed, or may be colored with natural or artificial dyes. Most yarns have a single uniform hue, but there is also a wide selection of variegated yarns:

- **Heathered or tweed:** yarn with flecks of different colored fiber
- **Ombre:** variegated yarn with light and dark shades of a single hue
- **Multi-colored:** variegated yarn with two or more distinct hues (a "parrot colorway" might have green, yellow and red)
- **Self-striping:** yarn dyed with lengths of color that will automatically create Stripes in a knitted or crocheted object
- **Marled:** yarn made from strands of different-colored yarn twisted together, sometimes in closely-related hue .

1.4.5 Fibre Blends

A blend is an intimate mixture of fibers of different composition, length, diameter or color spun together into one yarns. Blended yarns are produced *by blending or mixing single or ply yarns with different fibre species.*

Why we need to blending

1. To produce fabrics with a better combination of performance characteristics. Durability is important in end uses., nylon or polyester blended with cotton wool provide strength and abrasion resistance, while the wool or cotton look can be maintained.
2. To improve spinning, weaving, and finishing efficiency and to improve uniformity.
3. To obtain better texture, hand or fabric appearance, because fibre blending with different shrinkage properties fibres can produce bulky, lofty fabrics or fur-like fabrics with guard hairs.
4. To minimize fibre cost. Since expensive fibre blending with cheaper fiber, fibre cost is reduced.
5. To obtain cross-dyed effects or create new colour effects such as heather. It is cause the fibres with unlike dye affinity are blended to gather and then piece dyed.

Blending methods

1. Blending of different staple fibres in raw stock by stacking method or doubling method.

2. *Mixing continuous filament yarns, as may be done by air jet texturing* in the production of Tasland type yarn.
3. Construction of a multi-ply yarn from different single yarn.
4. *Core-spinning of staple fibres round a core yarn which may be a* continuous filament yarn.
5. Mixing of different yarns during knitting or weaving.
6. *Mixing of different monomer units into molecules of a copolymer.*

1.4.6 Different Types of Fibre Yarns

There are basically two groups of fibers:

- Natural fibers, consisting of animal and plant fibers
- Man-made or manufactured/synthetic fibers

Animal Fibres Angora

There are two types of Angora:

- Mohair (made from the Angora Goat)
- Angora Rabbit Hair (made from the Angora Rabbit)

Typically when we talk about *Angora*, we refer to Angora Rabbit Hair, while the fibers from the Angora Goat are more commonly known as *Mohair*.

There are 4 different angora rabbit breeds, namely, English, French, Satin and Giant. Angora wool harvested from these rabbits are lightweight, silky, fine, and very soft. It is 7 times warmer than wool, and is ideal for baby clothes, winter underwear, sweaters and mittens. As only a small amount of wool can be harvested from these adorable creatures, angora is often combined with other fibers to minimize the high cost of this luxurious fiber.

1.4.7 Camel Family (Alpaca/Llama/Camel/Vicuna)

Yarns made from the fibers of these animals are very soft, lustrous, lightweight and warm.Alpaca is often used for the manufacture of warm, luxurious apparel.

The down hairs of the Llama will produce a soft yarn also suitable for the manufacture of apparel.Camel hair is from the extremely soft and fine fur from the undercoat of the camel. Camel's hair can be used alone but is most often combined with fine wool for overcoating, topcoating, sportswear and sports hosiery.Vicuna is the world's most valuable fiber. Vicuna is small and wild and belongs to the Camel family. It yields the finest animal fiber in the world. This *fiber is rare and very expensive.*

1.4.8 Cashmere

Cashmere, also known as the fiber of kings, is produced from the fine, soft undercoat of hair of the Kashmir goat. Sixty percent of the world's supply of cashmere is produced in China, Mongolia and Tibet, and the remainder from Turkey, Afghanistan, Iraq, Iran, Kashmere, Australia and New Zealand. *Cashmere yarn is extremely soft,* lightweight, yet very warm. It is very luxurious and possesses excellent drape. As each Kashmir goat is capable of producing an average of only 4-6 ounces of underdown per year, Cashmere is hence very expensive.

1.4.9 Mohair

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Made from the hairs of the Angora goat, mohair is durable, warm, extremely lightweight, and lustrous with a soft hand. It is the most resilient natural textile fiber, and is often combined with other fibers in the production of apparel and home fashion items.The finest grade of mohair is Kid Mohair, obtained from the first shearing of a young angora goat. Kid Mohair possesses the unique feature of natural wicking properties that takes perspiration away from the skin, preventing bacterial build up and odor.

1.4.10 Wool

Wool is a natural fiber made from the fleece of sheep. Talk about wool and it conjures up a picture of cozy warmth. However, wool is not uniform among all sheep. Sheep live in a wide variety of climates and conditions, and develop their wool to suit the conditions under which they live or are bred.

Today there are different grades of wool for different uses. There are coarse wools for carpets, soft fine wools for undergarments, highly crimped wools for bulky woolen yarns, wools with very long fibers for strong fine worsted yarns - a wide range from which the textile manufacturers can choose for a specific product. The most valuable of wools is Merino wool. Merino wool is a very long staple, extremely fine wool from the Merino sheep. Merino wool, particularly when twisted into a worsted yarn, is smooth to the skin. The fine fibres are soft, and the long staple gives fewer ends, reducing any irritation from loose ends.Wool is popular in the manufacture of clothing and home furnishings as it is warm, resists wrinkle, is lightweight and durable, absorbs moisture, is flame resistant, and has a natural stretch and elasticity.

1.4.11 Silk

Silk is a natural protein fibre containing about 70-75% of actual fibre fibroin secreted from two salivary glands in the head of the silkworm larva, and about 25-30% sericin, a gum which cements the two filaments together.

Silk of the finest quality is obtained from the unwound filament of the silkworm cocoon. To obtain lower grades of silk, broken or waste filaments and damaged cocoons are retained, treated to remove the sericin, and combed. This is then processed into yarn, marketed as spun silk, which is inferior in character to the reeled product and much cheaper. Low grade silk is made from damaged cocoons that were spoiled by emerging moths used for breeding stock. Filaments from the coarse outer portion of the cocoon, which is removed by brushing before reeling, and the inner portion of the cocoon, which remains after reeling the raw silk, are mixed with silk from damaged cocoons to make low grade silk. Silk has a high natural lustre and sheen of a white or cream color. It has a reputation as a luxurious and sensuous fabric, retains its shape, drapes well, caresses the figure, and shimmers with a luster all its own. Silk is naturally hypoallergenic, yet is still breathable; it absorbs moisture and reduces humidity, which makes it cool in the summer and warm in the winter.While silk is one of the strongest fiber at 2.6 to 4.8 grams per denier, it can be weakened by perspiration, deodorants and sunlight. Silk is absorbent so it dyes easily, but some dye colors tend to bleed and fade in water and during stain removal procedures. Sunlight will fade silk items and turn white silk garments yellow.

1.4.12 Plant Fibres

Cotton

Cotton is a soft fiber that grows around the seeds of the cotton plant. Cool, soft and comfortable, cotton is presently the world's most used fiber. Every part of the cotton plant is useful and we see its application in industries such as apparel, home furnishings, medical and surgical, automobile, etc.

Grades of cotton range from low, medium to high quality grades like Egyptian cotton, Pima, Supima, American Egyptian and Sea Island cotton. Today, organic cotton is also available where the cotton plant is grown without the use of commercial pesticides and fertilizers.

Cotton fabrics have a pleasant matte luster, a soft drape and a smooth hand. They are very comfortable to wear due to their soft hand and other characteristics. Cotton fabrics have excellent absorbing capabilities. Cotton garments absorb perspiration, thus keeping the person more comfortable. "Absorbent" cotton will retain 24-27 times its own weight in water and is stronger when wet than dry. This fiber absorbs and releases perspiration quickly, thus allowing the fabric to "breathe".

Cotton can stand high temperatures and takes dyes easily. Chlorine bleach can be used to restore white garments to a clear white but this bleach may yellow chemically finished cottons or remove color in dyed cottons. Boiling and sterilizing temperatures can also be used on cotton without disintegration. Cotton can also be ironed at relatively high temperatures, stands up to abrasion and wears well.

Cotton products can typically be machine washed and dried. Colored cotton garments retain their color longer if they are washed in warm or cool water. Sunlight does harm cotton by causing it to oxidize and turn yellow. Fabrics that are 100% cotton do shrink if they have not been treated with a durable-press or a shrinkage-resistant finish.

More information regarding cotton may be found at www.cotton.org

Organic Cotton

Organic Cotton is cotton that is grown using methods and materials that have a low impact on the environment. Organic production systems replenish and maintain soil fertility, reduce the use of toxic and persistent pesticides and fertilizers, and build biologically diverse agriculture. Third-party certification organizations verify that organic producers use only methods and materials allowed in organic production.

Linen

Linen is a plant fiber made from the stalk of the flax plant. It is one of the earliest fibers to be made into string and cloth and is the strongest of the vegetable fibers, with 2 to 3 times the strength of cotton.

Like cotton, linen takes to dyes easily and can be boiled without damaging the fiber. Fabrics made from linen are comfortable, highly absorbent, and has a natural luster and crisp hand. Linen wrinkles easily but also presses easily. It has poor elasticity and does not spring back readily like wool.

Rayon

While rayon is man-made, it is not considered a synthetic fiber, but a manufactured regenerated cellulosic fiber. Made from cellulose, rayon is a very versatile fiber and exhibits the same comfort properties as other natural fibers. It can imitate the feel and texture of silk, wool cotton and linen. The fibers are easily dyed in a wide range of colors. Rayon drapes well, has a soft, silky hand, and has a smooth, napped, or bulky surface. Rayon is highly absorbent but does not insulate body heat, hence making rayon garments ideal for use in hot and humid climates. The durability and appearance retention of regular rayon are low and will wrinkle easily and may stretch when wet and shrink when washed. Rayon also has the lowest elastic recovery of any fiber.

Ramie

Ramie, also known as China grass, is one of the oldest and strongest natural plant fibers principally used in fabric production. Similar to linen, it is natural white in color, has a high luster and an unusual resistance to bacteria and molds. It is very absorbent (more absorbent than linen) and is even stronger when wet. It is, however, stiff and brittle and not as durable as other fibers, and is best in blends with other fibers such as cotton or wool.

Hemp

Hemp is a bast fiber plant similar to flax, kenaf, jute and ramie. It possesses properties similar to other bast fibers (flax, kenaf, jute and ramie) and excels in fiber length, strength, durability, absorbency, antimildew and antimicrobial properties.

The highest quality hemp comes from the "true" hemp plant called Cannabis Sativa. Sisal hemp and Manila hemp (also known as Abaca) are lower quality hemp fibers. Hemp can have a rather harsh hand. Therefore, it is best utilized in blends with other fibers (i.e. cotton, silk, wool, polyester).The finest hemp for fabric is produced in Italy. Hemp fabric is like linen in both hand and appearance. Hemp fabric withstands water better than any other textile product. It wrinkles easily and should not be creased excessively to avoid wear and breakage of the fibers.

Jute

Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads. Jute is commonly used in the production of bags, sacks, canvas, rope, jute yarn, twine and backings for carpet.

1.4.13 Manufactured/Synthetic Fibers

Acrylic Fiber

Acrylic fiber is a synthetic polymer fiber that contains at least 85% acrylonitrile. Soft, lightweight, springy and warm, acrylic is comfortable to wear and resembles wool, yet is easy to care and is machine washable. Fabrics made from acrylic are generally non-allergenic, resilient, durable, have outstanding wickability, and are resistant to moths, oils, chemicals and sunlight degradation. Acrylic fibers may frequently be found in combination with other natural fibers.

Polyamide (Nylon)

Polyamide (Nylon) Nylon was historically developed as a synthetic substitute for silk. It is lightweight, drapes well, has low absorbency and dries quickly, and is resistant to dirt, chemicals and perspiration. One of the strongest man-made fiber, the use of nylon can be found in apparel, home furnishings and outdoor equipment that take a lot of hard wear, like stockings, swimwear, activewear, upholstery, tents and life vests.

Polyester

PolyesterPolyester is a strong fiber that is resistant to crease, stretching and shrinkage, hence the ability to hold its shape well. Touted the best 'wash-and-wear' fiber, polyester is easy to care for and is washable, hence its wide usage in essentially every form of apparel and home furnishings. Blends of polyester with natural fibers such as cotton, rayon, or wool extend the durability of these blended fabrics.

Microfiber

Microfiber is a manufactured fiber with strands thinner than one denier. This is finer than the most delicate silk! Microfibers are not really fibers per se, but refer to ultrafine fibers. Microfibers available today include polyester microfibers, nylon microfiber, rayon microfiber and acrylic microfiber. Fabrics made with microfiber are extremely soft and drapeable, and insulates well against rain, wind and cold.

Olefin (also known as Polyolefin or Polypropylene)

Olefin is probably one of the less known manufactured fiber in the apparel industry. Strong, lightweight, comfortable, quick drying and resistant to stains, soil, chemicals, mildew, weather, sunlight and abrasion, olefin has been used almost exclusively in the home furnishings area and the high performance active-wear market, for such items as backpacking, canoeing, and mountain climbing apparel since its development in 1961. More recently, we are seeing a higher usage of olefin in activewear, sportswear, socks, thermal underwear and lining fabrics.

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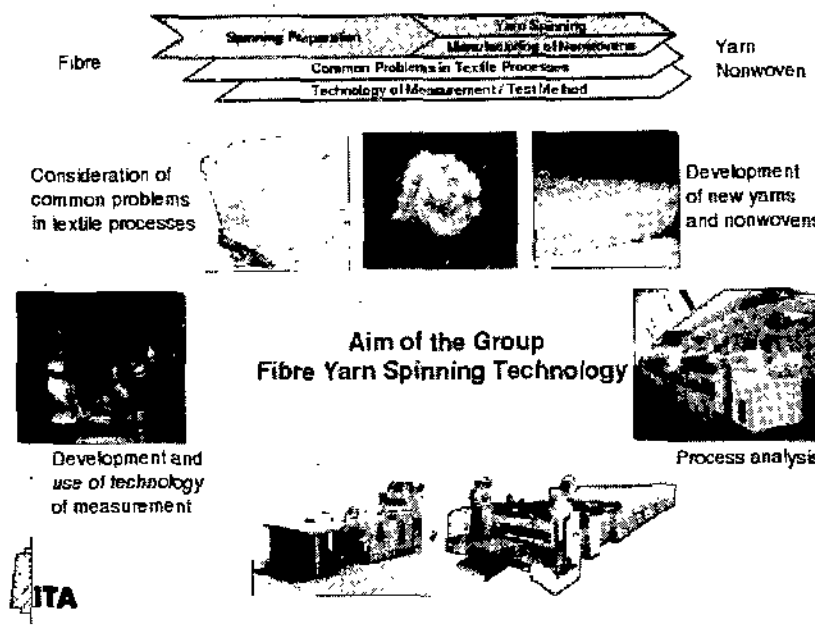

1.5 PRODUCING TEXTILES FOR STRETCH YARNS

Stretch yarns are frequently continuous-filament man-made yarns that are very tightly twisted, heat-set, and then untwisted, producing a spiral crimp giving a springy character. Although bulk is imparted in the process, a very high amount of twist is required to produce yarn that has not only bulk, but also stretch.

Stretch yarns are produced by thermoplastic filament or spun yarns with high degree of elastic stretch, rapid recovery, and a high degree of yarn curl. Texturing process machines like false-twist, knit-deknit, draw texturing and friction texturing may form this yarn type.

The resultant yarns can achieve 300-500 percent stretch. They have high extensibility, good recovery and good bulk. The stretch yarns of nylon are used extensively in men's and women's hosiery, pantyhose, leggings, football and jersey.

1.6 PRODUCING TEXTILES FOR HEAT SET THERMO PLASTIC YARNS

A thermal model of yarn during texturing with condensation heating has been developed so as to predict yam temperature response. Yarn temperature rise during the condensation heating process is dictated by the internal conduction of the yarn and hardly varies with the surface heat transfer coefficient. On the other hand, the cooling effect due to evaporation upon thread line emergence from the high pressure steam chamber depends on the final thickness of the condensate layer, which is a function of yarn speed. Yarn speed also has a considerable effect on the rate of temperature decrease during the convective cooling processes. Measurements of yarn temperature in the cooling zone of the experimental false twist process are in good agreement with predictions. Yarn quality is also consistent with the temperature history of the yarn.

1.7 PRODUCING TEXTILES FOR ELASTOMETRIC YARNS

These fibres are derived from an elastomer containing at least 85% of segmented polyurethane. These yarns are formed from an elastomer. Elastomeric yarn may either be incorporated into fabric in the bare state or wrapped with relatively inextensible fibres. Wrapping is done by covering, core spinning or uptwisting. Elastan and elastodiene yarns are examples. The fibre, when stretched under tensile force until three times its initial length, recovers rapidly this length as soon as tension is removed.

This fibre was launched in 1959 by an American producer, who is still their major producer in the world. Its use became however widespread only some years ago when the stretch comfort became a must, so that, at a certain moment, available capacities were no longer sufficient to cover the market demand, and expansions and new plants had to be provided. Some new producers were also attracted by this promising market outlet.

Concerning this leading fibre, it has to be taken in mind that the yarn, although looking like a single continuous filament yarn, is actually composed of a bundle of thin filaments joined together. Main end-uses are: stockings and panty-hoses, tubular knit fabrics for ladies' underwear and sportswear, warp knit fabrics for ladies' lingerie and swimwear, warp knit fabrics for corsetry and sundry applications.

The elastomeric yarn is used in different percentages, depending on type of fabric and on its end-use; even only 2% is sufficient to improve the quality of the product by imparting liveliness, drape and better recovery properties. The yarn has the same dyeability and processing characteristics as a synthetic fibre and can be integrated, in the nude state, into many textile structures. It can however be covered with another yarn or with another fibre. The covering can be either single or double; alternatively it is possible to produce stretch core yarns which, during weaving or knitting, are doubled with non-elastic yarns, thus obtaining fabrics of greater value, more comfortable and with better wear properties.

A third alternative is interlacing: an anelastic multifilament yarn is caused to pass through an air jet together with the strained elastomeric yarn. As a result of an air jet, the yarns get interlaced and the elastomeric yarn gets partially covered.

1.8 PRODUCING TEXTILES FOR BI-COMPONENT YARNS

Textile development today is witnessing a growing demand for specific performance to meet the needs of end uses in wide applications ranging from apparel to industrial uses. This high-tech performance starts with fibre and yarn innovation.

With increasingly diversified consumer and industry preferences for fibre, yarn and fabric properties and changing values reflecting the social environment in which we live there has been increasing demands for the development of *innovative yarns with particular qualities of stretch, softness, and good recovery.* Today's new yarns offer a vast variety of design options for creating innovative high performance textile products.

Bicomponent yarns are described as paired or *twinned,* this is because they are made from two generically similar polymers. Examples are two types of nylon or two types of acrylic or PET (polyester) and PEN polyester.

The first commercial bicomponent yarn was produced in the mid 1960s by Dupont. This was a side-by-side hosiery yarn called *Cantrese* and was made from two nylon polymers which, on retraction, formed a highly coiled elastic fibre.

Producing bicomponent yarns represents one of the newer techniques for producing synthetic filaments. Some authorities refer to these new textiles as the 'third generation'. Fabric structures made from polymer to fabric processes currently comprise about 40% of fabric manufactured and these fabrics are driving this growth area of the textile market.

Bicomponent yarns may be of two types:

- **Side-by-side bicomponent**: the process requires that the similar polymers be fed to the spinneret orifice together so that they exit from the spinneret opening side-by-side.
- **Core and sheath bicomponent**: the process requires that one component be completely surrounded by the other. The percentages of core and sheath can be modified, for example, 90% core and 10% sheath according to the end use. Variation in the shape of the orifice that contains the inner core can produce filaments with different behavioural characteristics.

1.9 PRODUCING TEXTILES FOR BI CONSTITUTE YARNS

Biconstituent fiber is made by mixing two different man-made generic fiber materials together in their fluid stage. Afterwards they are forced through a spinneret. Biconstituent melt-flow through a porous unit, known as the Interface Mixer Insert, is used to achieve adhesion within sheath/core fibers spun from two incompatible polymers, as exemplified herein by nylon and polyester. Sheath splitting and void formation at the interface are documented for nylon sheath/ polyester core filaments having essentially no adhesion between the sheath and the core. Improved adhesion as a function of Interface Mixer Insert filtration media is examined via optical and electron microscopy and correlated with a qualitative fabric-endurance evaluation as well as a quantitative adhesion-peel-strength test.

1.10 PRODUCING TEXTILES FOR CHEMICAL TREATED NATURAL FIBRE YARNS

Wool is different to other fibres because of its chemical structure. This chemical structure influences its texture, elasticity, staple and crimp formation. Wool is a protein fibre, composed of more than 20 amino acids. These amino acids form protein polymers. Wool also contains small amounts of fat, calcium and sodium. The fibers are artificially made by various chemical compositions. Some of them are manufactured from natural cellulose, including rayon, modal, and Lyocell. Nylon is a made from diamines and dicarboxylic acids and is used in many fabrics, mosquito netting, rope, and tire cords. Rayon is made from cellulose of cotton linters and wood pulp. Fiberglass is made from molten glass. It is strong, durable, and impervious to many caustics and to extreme temperatures and are used for curtains, drapery and for industrial purposes. Then, yarn is made of staple (short) fibers through several techniques including Ring, Open- End, Friction, Jet, Vortex, Centrifugal spinning etc. Ring method is the oldest and the most used technique. Open- end spinning is another important method. The basic manufacturing process of spinning includes carding, combing, drafting, twisting and winding. As the fibers pass through these processes, they are successively formed into lap, sliver, roving and finally yarn.

The raw fiber arrives at a spinning mill as compressed mass which goes through the processes of blending, opening and cleaning. Carding is the initial straightening process which puts the fiber into a parallel lengthwise alignment. Now the fiber is called 'Lap'. The lap is treated for removing the remaining trash, disentangling and molding it into a round rope like mass called 'Sliver'. The sliver is then straighten again which is called Combing. In this process, the short fibers are completely separated from the longer fibers. Drawing pulls the staple lengthwise over each other. After several stages of drawing out, the sliver is passed to the spindles where it is given

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its first twist and is then wound on bobbins. 'Roving' is the final product of the several drawing-out operations. The roving, on bobbins, is placed in the spinning frame, where it passes through several sets of rollers running at high speed and finally the 'Yarn' is produced of the sizes desired.

Open- End Spinning is a relatively new development. It begins with the carded sliver which is put into rollers. These rollers revolve at a faster speed. As a result, the sliver is completely opened up. The separated fibers are moved by an air stream and are collected as a thin layer in a groove on the inner surface of a funnel- shaped rotor, which rotates at a very high speed. There, it is spun around into yarn.

1.11 BULK YARNS

Bulky yarns are yarns formed form inherently bulky fibers, such as manufactured fibers that are hollow along parts or all of their length, or yarns formed from fibers that cannot be closely packed because of their cross-sectional shape, fiber alignment, stiffness, resilience, or natural crimp. Bulky yarns can be produced by any kind of filament fiber or spun yarn. The texturing process machines are stuffer box, air jet, draw texturing and friction texturing. The bulkiness of the yarn is further enhanced when the yarn is heat set or autoclaved. After it is dyed and finished, it can used as carpet, and sweaters to shoelaces.

1.11.1 High Bulk Yarns

High bulk yarns are known as free from stretch. It is the fibre with high random crimp, which caused by shrinkage of low-crimp fibers.

A latent shrinkage potential and retain their bulk indefinitely at room temperature can produce this kind of fabric. Latent shrinkage in a fiber can be achieved by heating, stretching and then cooling during stretched condition. Heat treatment of the product causes the high- shrinkage fibers to bulk because high shrinkage fibers are combined with non-shrinkage fibers in the same yarn. By regulating the heat stretching, the bulk can be controlled.

High shrinkage type yarn can be applied in the high-density carpet pile or fur-like fabrics as the ground yarns for weaving.

1.11.2 Producing Textiles for Lube Bulk Yarns

Lube may refer to Lubricant, a substance (usually a liquid) introduced between two moving surfaces to reduce the friction and wear between them. Bulk yarns have improved elasticity and recovery and methods for their manufacture are described as following. A first embodiment of the invention involves providing a solution-dyed multifilament yarn of polybutylene terephthalate (PBT) and a multifilament yarn of a second thermoplastic polymer to an air jet texturizer such that the PBT component forms a core and the other yarn forms a plurality of loops and coils extending outwardly from the core. In addition to a high degree of elasticity and recovery, the composite yarn also has a low amount of shrinkage, which enables the yarns to be used in the production of woven fabrics without significant losses in fabric yield.

Another embodiment of the invention involves false twisting a multifilament PBT yarn and a second multifilament yarn as individual threadlines to impart crimp thereto, then entangling the two components together using an air interlacing jet, to produce a bulk yarn having high elasticity and recovery. Because the two components have different optimal draw ratios, the process involves the simultaneous drawing of the components at different draw ratios such as by running different diameter first delivery rolls for the respective components on the first delivery shaft of the machine. Alternatively, a supplemental individually-controllable first delivery shaft can be provided on the machine for feeding one of the components at a different speed from the other, to thereby draw the components at different ratios relative to each other. The thus-crimped yarns are then entangled together using an air entanglement jet, to produce a bulk yarn having high elasticity and recovery.

Types of Lubricants for Yarns

Optaglide SW: A ready-to-use, fully-formulated, new generation polysiloxanebased product, designed for application as sewing thread finish.

Optaglide 037: A ready-to-use, fully-formulated, poly-siloxane based product, designed for application as sewing thread lubricant by PA Winding or Godet method.

Optaglide DGM: A ready-to-use, fully-formulated, new generation polysiloxaneand cost effective wax-based product, for application as sewing thread finish.

Optaglide 45A: A highly-concentrated, fully-formulated poly-siloxane basedproduct that can be applied as sewing thread finish. An aqueous thread lubricant provides good COF and avoids skin formation on bath.

BL1037: A ready-to-use, fully-formulated, poly-siloxane based product that can be used as sewing thread lubricant to reduce COF by PA Winding or Godet method.

DS08: A cost-effective po l y - s i loxane based product that can be used as sewing thread finish.

Optaglide AQVL: A ready-to-use, fully-formulated new generation poly siloxanebased product that is designed for application as sewing thread f i n i s h w i t h low shade variation.

Optaglide EW: An exhaustible wax emulsion for high pick up.

Optaglide VIDE: A highly-concentrated, fully-formulated, poly-siloxane based product that can be used as sewing thread finish.

Optaglide LW: A suitable lubricant for HTHP m/c application. It provides goodlustre.

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Optaglide W5: A poly-siloxane based product for application as sewing thread finish.

Optasol 085: A non-aqueous, fully-formulated, poly-siloxane based product that can be applied as a sewing thread lubricant.

Optasol NAXL: A non-aqueous, fully-formulated, poly-siloxane based product that can be used as a sewing thread lubricant. It also increases lustre.

Optasol 192: A non-aqueous, silicone and wax formulation for hot lube application.

DPL 282: A non-silicone, non-wax lubricant for trilobal polyester.

Optasol 192M: A concentrated silicone emulsion/ wax dispersion that is specially designed for application as sewing thread lubricant by lick roll method.

nnocelle FSL: It is a silicone emulsion/ wax dispersion that is specially designed for application as sewing thread lubricant by lick roll method. This product is recommended for cold and hot applications on substrates like polyester and core spun polyester.

RESILFEEL VL: A unique antistatic lubricant specially made for synthetic yarns that does not affect the shade or whiteness.

RESILFEEL CE: A cost-effective antistatic lubricant for synthetic yarns that does not affect shade or whiteness.

YarnX 125: A proprietary blend of speciality modified fatty amide derivatives that has been specially designed to give good lubrication and soft handle on yarns.

DPT 125A: A proprietary blend of speciality modified fatty amide derivatives that has been specially designed to give good lubrication and soft handle on yarns.

YarnX Conc: A concentrated fatty acid derivative for good lubrication on yarns.

YarnX PELF: A low-foaming polyethylene mixture, used to provide uniform lubrication to yarns.

YarnX YS: A quaternary fatty amide derivative and a low yellowing lubricant for textile yarns.

YarnX A102: A unique speciality blend of fatty acids and poly-siloxane for yarn lubrication and finishing.

YarnX Super: A fatty amide derivative, it is an excellent yarn lubricant and softener to enhance yarn gliding.

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YarnX PES: A cost-effective, unique yarn softener and lubricant with noeffect on shade/ whiteness. It also makes the yarn easy to

knit and weave.

Innocelle YL: A silicone emulsion of organomodified poly-siloxane that has been specially designed to give good lubrication, soft handle and hydrophilicity to yarns.

YarnX LQ: A shear stable silicone emulsion of modified organosilicone provides good hydrophilicity with softness.

Lube-A-Thread

Lube-A-Thread (LAT) KIT was developed in 1995 to prevent problems with thread shredding, breaking, lint build-up and to prolong the life of the needle. The Lube A Thread Kit (LAT) is composed of a Lube A Thread Applicator, a Lube It All 2 oz. bottle and instructions.

The **LAT Applicator** has self-adhesive to stick it on the machine anywhere in the normal thread path where it applies a very thin film of silicone lubricant on the thread. It is formulated to prevent gumming of the needle, thread shredding, mettallic thread dragging, to reduce thread stretch, prolong the life of the needle, reduce lint build-up in the machine, etc.

A two Ounce dispenser **bottle of lubricant** is included and is called **LUBE IT ALL**. After mounting the Applicator on the machine, Squeeze 2 drops on the **LAT Applicator,** which will last 2 to 3 hours of continuous sewing. After the first drops of lubricant are gone, apply 1 drop to continue sewing for another 2 to 3 hours of continuous use.Additional Bottles of Lubricant or individual applicators are available separately.

1.12 STUDENT ACTIVITY

1. What are the different types of yarns?

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2. Describe the methods of producing textiles for different types of yarns?

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3. Define the Bi-component yarns and Bi-constitute yarns.

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1.13 SUMMARY

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- Fibers, Yarns & Threads analysis is an essential activity for the whole fiber and yarn industry as they are important component of textile industry. As per the fiber report, the trends favor man made fibers, yarns and threads. They have grown considerably in the recent years which has resulted in significant increase in their production and consumption.
- The Growth trend of fiber is not even and is increasingly shifting towards developing economies particularly the Asian countries. Investors, particularly all the companies including fiber companies, yarn companies and thread industry, are installing new machinery in lower cost regions. In developed and newly industrialized countries, the spinners are facing increasing competition from filament yarns and non-wovens too. In spite of all these, many developed economies like Italy *are still competitive and have a flourished spinning industry* defeating its high labor costs. It is the result of practices adopted by the fiber and yarn industries, like economy exercised while production, state-of-the-art technology for minimizing labor cost, electronic monitoring system for improving productivity, speed, quality and flexibility, innovations in designs and fibers etc.
- Original bamboo fiber is also called as natural bamboo fiber. Original bamboo fiber is a kind of really natural, green, healthy, eco-friendly type fiber due to be directly picked up from natural bamboo, using physical and mechanical method to make pure natural bamboo fiber without any chemical additive. The appearance and functional property of original bamboo fiber is similar with ramie fiber or bast fiber and leaf fiber, but original bamboo fiber is finer and thinner than ramie fiber, and anti-bacterial, germicidal, deodorant and anti-UV effect of original bamboo fiber is stronger than ones of ramie fiber and bamboo pulp fiber (bamboo viscose fiber).

1.14 GLOSSARY

- **Textile:** Originally, a woven fabric; now applied generally to any one of the following:

1.Staple fibers and filaments suitable for conversion to or use as

yarns, or for the preparation ofwoven, knit, or nonwoven fabrics.

2. Yarns *made from natural or manufactured fibers.*

3. Fabricsand other manufactured products made from fibers as defined above and from yarns.

4. Garmentsand other articles fabricated from fibers, yarns, or fabrics when the products retain the characteristic flexibility and drape of the original fabrics.

• **Textile Materials:** A general term for fibers, yarn intermediates, yarn, fabrics, and

products made from fabrics that retain more or less completely the strength, flexibility, and other

typical properties of the original fiber or filaments.

• **Textile Processing:** Any mechanical operation used to translate a textile fiber or yarn toa fabric or other textile material. This includes such operations as opening, carding, spinning,plying, twisting, texturing, coning, quilling, beaming, slashing, weaving, and knitting.

• **Break Spinning:** A direct spinning process for converting manufactured fiber tows to spun yarn that incorporates prestretching and tow breaking with subsequent drafting and spinning in one operation.

• **Bi-component fiber:** Bi-constituent fiber is made by mixing two different man-made generic fiber materials together in their fluid stage. Afterwards they are forced through a spinneret.

• **Simple Yarns:** A yarn which is smooth and uniform and evenly twisted is called a simple yarn. It is commonly used for making fabric like poplin and cambric. Simple yarns are further classified into three types.

• **Complex/Novelty Yarns:** Complex yarns are the uneven yarns which may be thick and thin or have curls, loops, twists and even differently coloured areas along their length.

• **Lube Bulk Yarns:** These include the lubricants widely used in the production of the bulk yarns.

• ***Boucle Yarn:*** This is a blended yarn like cotton / nylon. The cotton is spun and the nylon thread is wrapped around the cotton end. The nylon becomes tight around the cotton, and the cotton puffs out in between the nylon wraps.

• **Bulked Yarn:** Qualitative term to describe a textured yarn. A bulked yarn develops morebulk than stretch in the finished fabric.

• **Coil Yarn:** A textured yarn that takes on a coil or spiral configuration when further processed. A coil yarn can be either a torque yarn or a nontorque yarn. A coil yarn can beformed by the false twist or edge crimp methods. Some bilateral fibers become coiled on further processing.

• **Core-Bulked Yarn:** A bulky or textured yarn composed of two sets of filaments, one ofwhich is straight to give dimensional stability and forms a core around and through which theother set is coiled or looped to give bulk.

• **Crinkle Yarn:** A torque-free textured yarn that is characterized by periodic waveconfigurations. Crinkle yarns can be formed by the stuffer box, gear crimping, or knit-de-knitmethods.

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- **Entangled Yarn:** A textured yarn of one variant that develops bulk by the air-jet texturing method.
- **Modified Stretch Yarn:** A stretch yarn that develops more bulk than usual but less bulk than a bulked yarn in the finished fabric.
- **Nontorque Yarn:** A yarn that does not rotate or kink when permitted to hang freely. A nontorque yarn may be the result of plying two equal but opposite torque yarns.
- **Set Yarn:** A textured yarn that is heat relaxed to reduce torque. Set yarns are not stretch yarns.
- **Stretch Yarn:** Qualitative term to describe a textured yarn. A stretch yarn develops more stretch than bulk in the finished fabric.
- **Torque Yarn:** When a torque yarn is permitted to hang freely, it rotates or kinks to relieve the torque introduced into the yarn during texturing.

1.15 REVIEW QUESTIONS

1. What do you know about different types of yarns?
2. Describe the methods of producing textiles for different types of yarns?
3. Define the Bi-component yarns.
4. Explain Bi-constitute yarns.
5. Discuss about chemical treated natural fibre yarns.
6. Elaborate the methods of producing textiles for bulk yarns and lube bulk yarns.
7. Write short notes on:
   (a) Elastometric yarns
   (b) Bulk yarns
   (c) Stretch yarns
   (d) Lube bulk yarns.

UNIT

2

SELECTION OF DYES

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STRUCTURE

2.1 LEARNING OBJECTIVE

After completion of this unit, you should be able to:

- Define the methods of selection of dyes.
- Describe the natural dyes and their uses.
- Define the different types of synthetic dyes.
- Explain the selection of dyes methods.
- Learn about the tests to determine color fastness.

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2.2 INTRODUCTION

Dyeing fabric makes old fabrics and textiles look new again. Making your own fabric dyes is a simple and inexpensive process—the supplies are in your kitchen and backyard. Berries, flowers and other plant materials combine with a fixative to make beautiful colors for your fabrics. Homemade plant dyes work best on natural fabrics including cotton, wool and silk. Experiment with different dye materials and fabrics to find favorite colours and combinations.

Dyeing is the process of adding color to textile products like fibers, yarns, and fabrics. Dyeing is normally done in a special solution containing dyes and particular chemical material. After dyeing, dye molecules have uncut Chemical bond with fiber molecules. Thetemperature and time controlling are two key factors in dyeing. There are mainly two classes of dye, natural and man-made.

2.3 TYPES OF DYES

For most of the thousands of years in which dyeing has been used by humans to decorate clothing, or fabrics for other uses, the primary source of dye has been nature, with the dyes being extracted from animals or plants. In the last 150 years, humans have produced artificial dyes to achieve a broader range of colors, and to render the dyes more stable to resist washing and general use. Different classes of dyes are used for different types of fiber and at different stages of the textile production process, from loose fibers through yarn and cloth to completed garments.

Acrylic fibers are dyed with basic dyes, Nylon and protein fibers such as wool and silk are dyed with acid dyes, polyester yarn is dyed with disperse dyes. Cotton is dyed with a range of dye types, including vat dyes, and modern synthetic reactive and direct dyes.

2.3.1 History

Archaeologists have found evidence of textile dyeing dating back to the Neolithic period. The earliest surviving evidence of textile dyeing was found at the large Neolithic settlement at Çatalhöyük in southern Anatolia, where traces of red dyes, possible from ochre (iron oxide pigmentsfrom clay), were found. In China, dyeing with plants, barks and insects has been traced back more than 5,000 years. Early evidence of dyeing comes from Sindh (Pakistan), where a piece of cotton dyed with a vegetable dye has been recovered from the archaeological site àtMohenjo-daro (3rd millennium BCE). The dye used in this case was madder, which, along with other dyes such as indigo, was introduced to other regions through trade. Natural insect dyes such as Tyrian purple and kermes and plant-based dyes such as woad, indigo and madder were important elements of the economies of Asia and Europe until the discovery of man-made synthetic dyes in the mid-19th century. The first synthetic dyes was William Perkins's mauveine in 1856, derived from coal tar. Alizarin, the red dye present in madder, was the first natural pigment to be duplicated synthetically, in 1869, a development which led to the collapse of the market for naturally grown madder. The development of new, strongly colored synthetic dyes followed quickly, and by the 1870s commercial dyeing wth natural dyestuffs was disappearing.

2.3.2 Methods

Dyes are applied to textile goods by dyeing from dye solutions and by printing from dye pastes.

Direct Application: The term "direct dye application" stems from some dyestuff having to be either fermented as in the case of some natural dye or chemically reduced as in the case of synthetic vat and sulfur dyes before being applied. This renders the dye soluble so that it can be absorbed by the fiber since the insoluble dye has very little substantivity to the fiber. Direct dyes, a class of dyes largely for dyeing cotton, are water soluble and can be applied directly to the fiber from an aqueous solution. Most other classes of synthetic dye, other than vat and surface dyes, are also applied in this way.

The term may also be applied to dyeing without the use of mordants to fix the dye once it is applied. Mordants were often required to alter the hue and intensity of natural dyes and improve their color fastness. Chromium salts were until recently extensively used in dying wool with synthetic mordant dyes. These were used for economical high color fastness dark shades such asblack and navy. Environmental concern has now restricted their use, and they have been replaced with reactive and metal complex dyes which need no mordant.

Yarn Dyeing: There are many forms of yarn dyeing. Common forms are the at package form and the at hanks form. Cotton yarns are mostly dyed at package form, and acrylic or wool yarn are dyed at hank form. In the continuous filament industry, polyester or polyamide yarns are always dyed at package form, while viscose rayon yarns are partly dyed at hank form because of technology.

The common dyeing process of cotton yarn with reactive dyes at package form is as follows:

1. The raw yarn is wound on a spring tube to achieve a package suitable for dye penetration.
2. These softened packages are loaded on a dyeing carrier's spindle one on another.
3. The packages are pressed up to a desired height to achieve suitable density of packing.
4. The carrier is loaded on the dyeing machine and the yarn is dyed.
5. After dyeing, the packages are unloaded from the carrier into a trolly.
6. Now the trolly is taken to hydro extractor where water is removed.

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7. The packages are hydro extracted to remove the maximum amount of water leaving the desired color into raw yarn.
8. The packages are then dried to achieve the final dyed package.

After this process, the dyed yarn packages are packed and delivered.

2.3.3 Removal of Dyes

In order to remove natural or unwanted colour from material, the opposite process of bleaching or discharging is carried out.

If things go wrong in the dyeing process, the dyer may be forced to remove the dye already applied by a process that is normally known as stripping. This normally means destroying the dye with powerful reducing agents (sodium hydrosulphite) or oxidizing agents (hydrogen peroxide or sodium hypochlorite). The process often risks damaging the substrate (fiber). Where possible, it is often less risky to dye the material a darker shade, with black often being the easiest or last option.

2.4 SYNTHETICS

Synthetic fibres are the result of extensive development by scientists to improve upon the naturally occurring animal and plant fibres. In general, synthetic fibers are created by forcing, or extruding, fibre forming materials through holes (called spinnerets) into the air, thus forming a thread. Before synthetic fibres were developed, cellulose fibers were made from natural cellulose, which comes from plants.

The first artificial fibre, known as art silk from 1799 onwards, became known as viscose around 1894, and finally rayon in 1924. A similar product known as cellulose acetate was discovered in 1865. Rayon and acetate are both artificial fibres, but not truly synthetic, being made from wood. Although these artificial fibres were discovered in the mid-nineteenth century, successful modern manufacture began much later in the 1930s. Nylon, the first synthetic fibre, made its debut in the United States as a replacement for silk, and was used for parachutes and other military uses.

The techniques used to process these fibres in yarn are essentially the same as with natural fibres, modifications have to be made as these fibers are of great length, and have no texture such as the scales in cotton and wool that aid meshing.

2.5 SYNTHETIC FIBRES

Synthetic fibres are made from polymers that have been synthetically produced from chemical elements or compounds developed by the petrochemical industry. Unlike natural fibres (wool, cotton and silk), which date back to antiquity, synthetic fibres have a relatively short history dating

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back to the perfection of the viscose process in 1891 by Cross and Bevan, two British scientists. A few years later, rayon production started on a limited basis, and by the early 1900s, it was being produced commercially. Since then, a large variety of synthetic fibres has been developed, each designed with special characteristics that make it suitable for a particular kind of fabric, either alone or in combination with other fibres. Keeping track of them is made difficult by the fact that the same fibre may have different trade names in different countries.

The fibres are made by forcing liquid polymers through the holes of a spinneret to produce a continuous filament. The filament can be directly woven into cloth or, to give it the characteristics of natural fibres, it can, for example, be textured to add bulkiness, or it can be chopped into staple and spun.

2.5.1 Classes of Synthetic Fibres

The main classes of synthetic fibres used commercially include:

- **Polyamides (nylons):** The names of the long-chain polymeric amides are distinguished by a number which indicates the number of carbon atoms in their chemical constituents, the diamine being considered first. Thus, the original nylon produced from hexamethylene diamine and adipic acid is known in the United States and the United Kingdom as nylon 66 or 6.6, since both the diamine and the dibasic acid contain 6 carbon atoms. In Germany, it is marketed as Perlon T, in Italy as Nailon, in Switzerland as Mylsuisse, in Spain as Anid and in the Argentine as Ducilo.
- **Polyesters:** First introduced in 1941, polyesters are made by reacting ethylene glycol with terephthalic acid to form a plastic material made of long chains of molecules, which is pumped in molten form from spinnerets, allowing the filament to harden in cold air. A drawing or stretching process follows. Polyesters are known, for example, as Terylene in the UK, Dacron in the United States, Tergal in France, Terital and Wistel in Italy, Lavsan in the Russian Federation, and Tetoran in Japan.
- **Polyvinyls:** Polyacrylonitrile or acrylic fibre, first produced in 1948, is the most important member of this group. It is known under a variety of trade names: Acrilan and Orlon in the United States, Crylor in France, Leacril and Velicren in Italy, Amanian in Poland, Courtelle in the UK and so on.
- **Polyolefins:** The most common fibre in this group, known as Courlene in the UK, is made by a process similar to that for nylon. The molten polymer at 300°C is forced through spinnerets and cooled in either air or water to form the filament. It is then drawn or stretched.
- **Polypropylenes:** This polymer, known as Hostalen in Germany, Meraklon in Italy and Ulstron in the UK, is melt spun, stretched or drawn, and then annealed.

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- **Polyurethanes:** First produced in 1943 as Perlon D by the reaction of 1,4 butanediol with hexamethylene diisocyanate, the polyurethanes have become the basis of a new type of highly elastic fibre called spandex. These fibres are sometimes called snap-back or elastomeric on account of their rubber-like elasticity. They are manufactured from a linear polyurethane gum, which is cured by heating at very high temperatures and pressures to produce a "vulcanized" cross-linked polyurethane which is extruded as a monofil. The thread, which is widely used in garments requiring elasticity, can be covered by rayon or nylon to improve its appearance while the inner thread provides the "stretch". Spandex yarns are known, for example, as Lycra, Vyrene and Glospan in the United States and Spandrell in the UK.

2.5.2 Special Processes

Stapling

Silk is the only natural fibre that comes in a continuous filament; other natural fibres come in short lengths or "staples". Cotton has a staple of about 2.6 cm, wool of 6 to 10 cm and flax from 30 to 50 cm. The continuous synthetic filaments are sometimes passed through a cutting or stapling machine to produce short staples like the natural fibres. They can then be re-spun on cotton or wool spinning machines in order to produce a finish free of the glassy appearance of some synthetic fibres. During the spinning, combinations of synthetic and natural fibres or mixtures of synthetic fibres may be made.

Crimping

To give synthetic fibres the look and feel of wool, the twisted and tangled cut or stapled fibres are crimped by one of a number of methods. They may be passed through a crimping machine, in which hot, fluted rollers impart a permanent crimp. Crimping can also be done chemically, by controlling the coagulation of the filament so as to produce a fibre with an asymmetrical cross section (i.e., one side being thick-skinned and the other thin). When this fibre is wet, the thick side tends to curl, producing a crimp. To make crinkled yarn, known in the United States as non-torque yarn, the synthetic yarn is knitted into a fabric, set and then wound from the fabric by back-winding. The newest method passes two nylon threads through a heater, which raises their temperature to 180 °C and then passes them through a high-speed revolving spindle to impart the crimp. The spindles in the first machine ran at 60,000 revolutions per minute (rpm), but newer models have speeds of the order of 1.5 million rpm.

2.6 SYNTHETIC FIBRES FOR WORK CLOTHES

The chemical resistance of polyester cloth makes the fabric particularly suitable for protective clothing for acid-handling operations. Polyolefin

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fabrics are suitable for protection against long exposures to both acids and alkalis. High-temperature-resistant nylon is well adapted for clothing to protect against fire and heat; it has good resistance at room temperature to solvents such as benzene, acetone, trichlorethylene and carbon tetrachloride. The resistance of certain propylene fabrics to a wide range of corrosive substances makes them suitable for work and laboratory clothing.

The light weight of these synthetic fabrics makes them preferable to the heavy rubberized or plastic-coated fabrics that would otherwise be required for comparable protection. They are also much more comfortable to wear in hot and humid atmospheres. In selecting protective clothing made from synthetic fibres, care should be taken to determine the generic name of the fibre and to verify such properties as shrinkage; sensitivity to light, dry-cleaning agents and detergents; resistance to oil, corrosive chemicals and common solvents; resistance to heat; and susceptibility to electrostatic charging.

2.6.1 Hazards and Their Prevention

Accidents

In addition to good housekeeping, which means keeping floors and passageways clean and dry to minimize slips and falls (vats must be leak proof and, where possible, have baffles to contain splashes), machines, drive belts, pulleys and shaftings must be properly guarded. Machines for spinning, carding, winding and warping operations should be fenced to keep materials and parts from flying out and to prevent workers' hands from entering the dangerous zones. Lockout devices must be in place to prevent restart of machines while they are being cleaned or serviced.

Fire and explosion

The synthetic-fibres industry uses large amounts of toxic and flammable materials. Storage facilities for flammable substances should be out in the open or in a special fire-resistant structure, and they should be enclosed in bunds or dykes to localize spills. Automation of the delivery of toxic, flammable substances by a well-maintained system of pumps and pipes will reduce the hazard of moving and emptying containers. Appropriate fire-fighting equipment and clothing should be readily available and workers trained in their use through periodic drills, preferably conducted in concert with or under the observation of local fire-fighting authorities.

As the filaments emerge from the spinnerets to be dried in air or by means of spinning, large amounts of solvent vapours are released. These constitute a considerable toxic and explosion hazard and must be removed by LEV. Their concentration must be monitored to be sure that it remains below the solvent's explosive limits. The exhausted vapours may be distilled and recovered for further use or they may be burned off; on no account should they be released into the general environmental atmosphere.

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Where flammable solvents are used, smoking should be prohibited and open lights, flames and sparks eliminated. Electrical equipment should be of certified flameproof construction, and machines should be earthed (grounded) to prevent the build-up of static electricity, which might lead to catastrophic sparks.

Toxic hazards

Exposures to potentially toxic solvents and chemicals should be maintained below the relevant maximum allowable concentrations by adequate LEV. Respiratory protective equipment should be available for use by maintenance and repair crews and by workers charged with responding to emergencies caused by leaks, spillage and/or fire.

2.7 DYES

Your choice of dye depends directly on what kind of fabric you are using. You'll get bad results if you use a wool dye on cotton, or a cotton dye recipe on wool, or either on polyester.

Dyes for Cellulose Fibers

These are your choices if you want to dye a t-shirt. Cellulose fibers include cotton, linen, rayon, hemp, ramie, lyocell (Tencel), bamboo, and pineapple plant fiber.

- Fiber Reactive Dyes (best choice)
- Direct Dye (hot water dye, less washfast)
- Vat Dyes (more complex method)
- Naphthol dyes (more hazardous, less available)
- All purpose Dye (hot water dye, less washfast)

Dyes for Protein Fibers

Protein fibers include all fibers made by animals: wool, angora, mohair, cashmere, as well as silk. Silk is the only non-hair animal fiber, and can be dyed like wool *or* like cellulose fibers, above. The high-pH recipes used for most cellulose dyes will ruin animal hair fibers.

Dyes that can be used for protein fibers include the following:

- Acid dyes
- Food coloring
- One Shot Dyes
- Reactive dyes used as acid dyes
- All purpose Dye (contains acid dye)
- Natural dyes (these work better on wool than on cotton)

- Lanaset/Sabraset dyes
- Vat Dyes

Soy Silk' is a new plant fiber, but, because it is made from soybean protein, it should be dyed like animal fibers, instead. Like real silk, it can also be dyed with fiber reactive dyes.

Dyes for Synthetic Fibers

Polyester

Polyester requires the use of **disperse dyes**.

Nylon

Surprisingly, nylon, which is a truly synthetic fiber, happens to dye quite well with the same acid dyes that work on wool and other animal fibers, in *addition to dyes that work on polyester. You'll want to test a swatch before* committing yourself to the project, as nylons vary.

Spandex

Spandex can be dyed with metal complex acid dyes, but it is much more common for hand-dyers to dye only the cotton portion of a cotton/spandex blend. *Polyester/spandex blends cannot be dyed.*

Acetate

Acetate, also known as rayon acetate, requires the use of disperse dye. (The other type of rayon, which is a cellulose fiber, is also known as viscose rayon.)

Acrylic

Acrylic fiber can be dyed with disperse dyes or with **basic dyes**.

Ingeo

Ingeo is the trademark for a new synthetic fiber, polylactic acid (PLA), made from corn. It is dyed like polyester, using disperse dyes, though it is evidently somewhat less washfast.

Polypropylene

Polypropylene (Herculon, Olefin) is dyed while still in liquid form, before it is extruded into a fiber. It cannot be dyed at home.

Dyeing blends

Most cotton/polyester blends are best dyed as for cotton, using fiber reactive dyes, leaving the polyester undyed. Cotton/nylon blends may be dyed with all-purpose dye, or by successive dyeing with a fiber reactive dye such as Procion MX, first with soda ash at room temperature to dye the cotton, then in hot water with vinegar to dye the nylon.

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Fabric Paints

Pigments that are not naturally attracted to fibers may be mixed with a gluelike binder to attach them to the fiber. "Pigment dyes" are not dyes at all, but a type of fabric paint.

2.7.1 Natural Dyes

Historically, natural dyes were used to color clothing or other textiles, and by the mid-1800's chemists began producing synthetic substitutes for them. By the early part of this century only a small percentage of textile dyes were extracted from plants. Lately there has been increasing interest in natural dyes, as the public becomes aware of ecological and environmental problems related to the use of synthetic dyes. Use of natural dyes cuts down significantly on the amount of toxic effluent resulting from the synthetic dye process.

Natural dyes generally require a mordant, which are metallic salts of aluminum, iron, chromium, copper and others, for ensuring the reasonable fastness of the color to sunlight and washing. Customers who have become accustomed to the dazzling colors and wash and light fastness of synthetic dyes are hard to convince, as only a few of the natural dyes have good all round fastness

Quality standards for natural dyes vary widely, so it is necessary to first contact an importer to find out what they are looking for. The problem arises with standardization of the colors as no two dye lots are identical. While paint manufacturers might be interested in the uniqueness of each batch of color produced, technicians in the pharmacology, food and textile industry loathe this lack of consistency.

This latter group has attempted to standardize natural dyes by imposing a color index that attempts to classify and name them. Each dye is thus named according to the following pattern:

Natural + Base colour + Number

These dyes are thereby specifically identified as dyes of the stated colour, but it does not specify whether the dyes are derived from animals or plants. This is because it is a classification based on the dye's source and color, and it contains no chemical information, nor does it imply that dyes with similar names but unique numbers are in any way related. It also gives no information about the mechanism by which staining occurs. This is done in order to authenticate the synthesized organic dyes along with natural dyes under the same universal classification system.

Some examples include carmine which comes from cochineal (natural red 4), lac (natural red 25) and hematein which comes from the logwood tree (natural black 1). The FDA in the US has taken an additional step and given colors used in foods, drugs and cosmetics their own labels (FD&C) after passing them as being fit for human consumption or use.

Natural dyes are a class of colorants extracted from vegetative matter and animal residues. They can be broken down into the following categories:

Table 1: Categories of Natural Dyes		
Colors	**Chemical Classifications**	**Common Names**
Yellow and Brown	Flavone Dyes	Weld, Quercitron, Fustic, Osage, Chamomile, Tesu, Dolu, Marigold, Cutch
Yellow	Iso-quinoline Dyes	Barberry
Orange-Yellow	Chromene Dyes	Kamala
Brown and Purple-Grey	Naphthoquinone Dyes	Henna, Walnut, Alkanet, Pitti
Red	Anthraquinone Dyes	Lac, Cochineal,Madder (Majithro)
Purple and Black	Benzophyrone Dyes	Logwood
Blue	Indigoid Dyes	Indigo
Neutrals	VegetableTannins: gallotannins, ellagitannins an catechol tannins	Wattle, Myrobalan, Pomegranate, Sumach, Chestnut, Eucalyptus
Source: Color TrendsDeveloped under the auspices of the RAISE program and through the sponsorship of the U.S. Agency for International Development.		

2.7.2 Synthetic Dyes

The first human-made (synthetic) organic dye, mauveine, was discovered serendipitously by William Henry Perkin in 1856. Many thousands of synthetic dyes have since been prepared.

Synthetic dyes quickly replaced the traditional natural dyes. They cost less, they offered a vast range of new colors, and they imparted better properties to the dyed materials. Dyes are now classified according to how they are used in the dyeing process.

Types of Synthetic Dyes:

- **Acid Dyes** comes in a wide variety of colors, it is fairly fast to light and to washing. It is named acid dyes because they work best when applied in an acid bath. It is mainly used on nylon, silk and wool.

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- **Azoic (or Naphthol) Dyes** this type of dyes are extremely fast to light, it is commonly used to dye a material red, orange or maroon. It is mainly used in cotton.
- **Basic Dyes** this type of dye is just fair when it comes to fastness to light and to washing, however this type can create a brilliant color. It is mainly used on natural and acrylic fibers, it is also sometimes used for wool and silk. This dye is also used to color paper. **Acetic acid** is usually added to the dyebath to help in the quick penetration of the dye onto the fiber.
- **Chrome (or Mordant) Dyes** this type of dye is fairly fast to light and to washing, it is especially useful for black and navy shades. The choice of mordant is very important as different mordants can alter the final color significantly, it is important to know also that many mordants, particularly those in the hard metal category can be hazardous to health, that is why caution should be followed when using it. It is mainly used for wool and silk.

Mordant is a chemical that is mixed with the dye and the fiber, the modern mordants are dichromates and chromium complexes, that is why it is also called chrome dye.

- **Developed (or Diazo) Dyes** are used to treat certain dyed fabrics to improve their fastness to light and to washing and also to change fabric's color. The treatment are used primarily on cotton. Diazotizing is the treatment which involves the use of chemical called a developer. It is mainly used on cotton.
- **Direct Dyes** this type is one of the easiest to use and has a wide range of colors, it is not fast to washing, but its fastness is often improved by more treatment. It is mainly used on cotton, rayon leather, wool, silk and nylon. It is also used as pH indicators and as biological stains.
- **Disperse (or Acetate) Dyes** this dyes is finely ground in the presence of dispersing agent, its dyeing rate is greatly influenced by the dispersing agent used during the grinding. Disperse dyes were developed because other dyes would not work with acetate it is also used on different manmade fibers, including acrylic, acetate, and polyester fibers.
- **Reactive (or Fiber-reactive) Dyes** this type of dye have a good fastness to light and to washing. Reactive dyes create a strong chemical bonds with the material being dyed which makes it the most permanent of dyes, this dye is by far the best choice for dyeing cotton, nylon, wool and other cellulose fibers at home or in the art studio.
- **Sulphur Dyes** this dye are especially fast to washing and if the best for material that is washed frequently. Sulphur dyes are colorless(upon application), but upon exposure to air they are oxidized a d turn into their respective colors. They come mainly in dark, dull colors and used on cotton, linen and rayon.

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- **Vat Dyes** this type is superior compared to the other dye when it comes to its fastness to light and to washing. Vat dyes like sulphur dyes must be oxidized before their real color comes out. This dye is mainly used for cotton, linen, wool and silk. The indigo color of blue jeans is vat dye.

Raw fibers are generally dyed by the dipping process. They are placed in a perforated metal cylinder that is dipped into a vat full of dye.

Velour cloth and furs are often hand-dyed. The dye is applied with a brush that has been dipped in a dye solution.

Batik is an ancient method of applying colored dyes to fabrics, usually cotton and silk. It originates in Java and now widely used throughout the world.

Tie dyeing, a hand-dyeing technique often practiced as a craft, can be used to create multi-colored patterns.

2.7.3 Basic Dyes

Basic dyes are water-soluble cationic dyes that are mainly applied to acrylic fibers, but find some use for wool and silk. Usually acetic acid is added to the dyebath to help the uptake of the dye onto the fiber. Basic dyes are also used in the coloration of paper.

2.7.4 Oxidation Dyes

Oxidation dyes are typically colourless, low molecular weight products. They can pass through the cuticle into the hair shaft, where they oxidise to generate a larger, coloured molecule trapped inside the hair. A permanent or long lasting result is achieved giving good grey coverage.The oxidation dyes fall into two categories, oxidation base (primary intermediate) and coupler (secondary intermediate). To generate colour using these products, at least *one of each type must be combined with a suitable oxidant* under alkaline conditions.The application conditions determine the durability of the colour result. A permanent colour capable of lightening the hair's natural pigmentation will typically contain ammonia and will be used with hydrogen peroxide 6% or higher. A softer alkali may be used with low strength hydrogen peroxide to provide a long lasting result with less impact on the structure of the hair. The latter is unable to produce a colour result lighter than the original hair.A typical permanent hair colorant pack will contain at least two, usually three separate components. The colorant in liquid or cream form will be mixed together with the developer (peroxide) immediately prior to application. The colour is often followed by treatment with a special conditioner that is included in the package.Because of the ability to cover grey and give long lasting results, oxidation dyes are the most popular class of hair colorants. They provide the largest range of shades to suit many markets, including fashion, colour enhancement and grey control.

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2.7.5 Acid Dyes

Acid dyes are water-soluble anionic dyes that are applied to fibers such as silk, wool, nylon and modified acrylic fibers using neutral to acid dye baths. Attachment to the fiber is attributed, at least partly, to salt formation between anionic groups in the dyes and cationic groups in the fiber. Acid dyes are not substantive to cellulosic fibers. Most synthetic food colors fall in this category.

Moreover Acidic dyes contain sulphonic acid groups, which are usually present as sodium sulphonate salts. These increase solubility in water, and give the dye molecules a negative charge. In an acidic solution, the $-NH_2$ functionalities of the fibres are protonated to give a positive charge: $-NH_3^+$. This charge interacts with the negative dye charge, allowing the formation of ionic interactions. As well as this, Van-der-Waals bonds, dipolar bonds and hydrogen bonds are formed between dye and fibre. As a group, acid dyes can be divided into two sub-groups: *acid-leveling* or *acid-milling*.

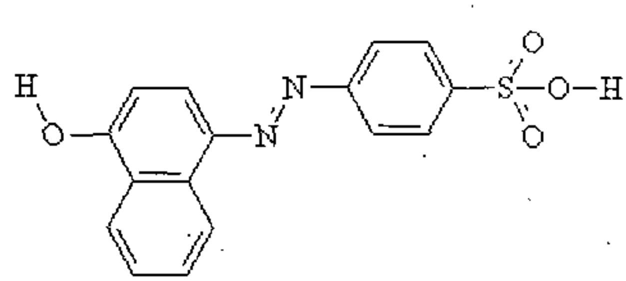
Acid-leveling dyes

These planar dyes tend to be small or medium sized, and show moderate inter-molecular attractions for wool fibres. This means that the dye molecules can move fairly easily through the fibres and achieve an even colour[2]. This is somewhat similar to the process that occurs during chromatography- the molecules with the strongest affinity for the substrate move the least distance from the point of origin whereas molecules with less affinity move much further. However, the low affinity means that these dyes are not always very resistant to washing

Acid Milling Dyes

Acid-milling dyes are larger than acid-leveling dyes, and show a much stronger affinity for wool fibres. Because of this, the resultant colour may be less even, but they are much more resistant to washing.

As well as intermolecular interactions, *intra*molecular interactions play an important part in the properties of the dye. Compare the two molecules shown below. They are isomers, but the one on the right (with hydrogen bonding) shows a much greater resistance to washing in alkali, and much increased light fastness.



show up on the reverse side of transparently thin fabrics. These fabrics may be confused with the woven designs where yarn dyed warp and filling are used. If the design is printed on such a fabric, the yarns will show some areas on which colour is not equally distributed.

3.7 COTTON

Cotton production practices begin after the previous crop is harvested. The first operations usually include shredding stalks, ripping out roots and disking the soil. Fertilizer and herbicides generally are applied and incorporated into the soil before the land is bedded in preparation for needed irrigation or planting. Since soil characteristics and past fertilization and cropping practices can cause a wide range of fertility levels in cotton soils, fertility programmes should be based on soil test analyses. Control of weeds is essential to obtain high lint yield and quality. Cotton yields and harvesting efficiency can be reduced by as much as 30% by weeds. Herbicides have been widely used in many countries for weed control since the early 1960s. Application methods include pre-planting treatment to foliage of existing weeds, incorporation into pre-plant soil and treatment at pre-emergence and post-emergence stages.

Several factors that play an important role in achieving a good stand of cotton plants include seed-bed preparation, soil moisture, soil temperature, seed quality, seedling disease infestation, fungicides and soil salinity. Planting high-quality seed in a well-prepared seed-bed is a key factor in achieving early, uniform stands of vigorous seedlings. High-quality planting seed should have a germination rate of 50% or higher in a cool test. In a cool/warm test, the seed vigour index should be 140 or higher. Seeding rates of 12 to 18 seeds/metre of row are recommended to obtain a plant population of 14,000 to 20,000 plants/hectare. A suitable planter metering system should be used to ensure uniform spacing of seed regardless of seed size. Seed germination and seedling emergence rates are closely associated with a temperature range of 15 to 38 °C.

Early-season seedling diseases can hamper uniform stands and result in the need to replant. Important seedling disease pathogens such as Pythium, Rhizoctonia, Fusarium and Thielaviopsis can reduce plant stands and cause long skips between seedlings. Only seed that has been properly treated with one or more fungicides should be planted.

Cotton is similar to other crops with respect to water use during different plant developmental stages. Water use is generally less than 0.25 cm/day from emergence to the first square. During this period, loss of soil moisture by evaporation may exceed the amount of water transpired by the plant. Water use increases sharply as the first blooms appear and reaches a maximum level of 1 cm/day during the peak bloom stage. Water requirement refers to the total amount of water (rainfall and irrigation) needed to produce a crop of cotton.

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Insect populations can have an important impact on cotton quality and yield. Early-season population management is important in promoting balanced fruiting/vegetative development of the crop. Protecting early fruit positions is essential to achieving a profitable crop. Over 80% of the yield is set in the first 3 to 4 weeks of fruiting. During the fruiting period, producers should scout their cotton at least twice a week to monitor insect activity and damage.

A well-managed defoliation programme reduces leaf trash that can adversely affect the grade of the harvested cotton. Growth regulators such as PIX are useful defoliators because they control vegetative growth and contribute to earlier fruiting.

3.8 HISTORY OF COTTON

Cotton fabrics discovered in a cave near Tehuacán, Mexico have been dated to around 5800 B.C.E., although it is difficult to know for certain due to fibre decay. Cotton was first cultivated in the Old World 7,000 years ago (5th–4th millennia BC), by the inhabitants of the Indus Valley Civilization, which covered a huge swath of the northwestern part of the South Asia, comprising today parts of eastern Pakistan and northwestern India. The Indus cotton industry was well developed and some methods used in cotton spinning and fabrication continued to be used until the modern industrialization of India. Well before the Common Era, the use of cotton textiles had spread from India to the Mediterranean and beyond.

Greeks and the Arabs were not familiar with cotton until the Wars of Alexander the Great, as his contemporary Megasthenes told Seleucus I Nicator of "there being trees on which wool grows" in "Indica".

According to the *Columbia Encyclopedia*, sixth edition: Cotton has been spun, woven, and dyed since prehistoric times. It clothed the people of ancient Pakistan, India, Egypt, and China. Hundreds of years before the Christian era, cotton textiles were woven in India with matchless skill, and their use spread to the Mediterranean countries.

In Iran (Persia), the history of cotton dates back to the Achaemenid era (5th century BC); however, there are few sources about the planting of cotton in pre-Islamic Iran. The planting of cotton was common in Merv, Ray and Pars of Iran. In the poems of Persian poets, especially Ferdowsi's Shahname, there are references to cotton ("panbe" in Persian). Marco Polo (13th century) refers to the major products of Persia, including cotton. John Chardin, a French traveler of 17th century, who had visited the Safavid Persia, has approved the vast cotton farms of Persia.

During the Han dynasty, cotton was grown by non chinese peoples in the southern Chinese province of Yunnan.

In Peru, cultivation of the indigenous cotton species *Gossypium barbadense* was the backbone of the development of coastal cultures, such as the Norte Chico, Moche and Nazca. Cotton was grown upriver, made into nets and traded with fishing villages along the coast for large supplies of fish. The Spanish who came to Mexico and Peru in the early 16th century found the people growing cotton and wearing clothing made of it.

During the late medieval period, cotton became known as an imported fiber in northern Europe, without any knowledge of how it was derived, other than that it was a plant; noting its similarities to wool, people in the region could only imagine that cotton must be produced by plant-borne sheep. John Mandeville, writing in 1350, stated as fact the now-preposterous belief: "There grew there [India] a wonderful tree which bore tiny lambs on the endes of its branches. These branches were so pliable that they bent down to allow the lambs to feed when they are hungrie." This aspect is retained in the name for cotton in many European languages, such as German *Baumwolle*, which translates as "tree wool" (*Baum* means "tree"; *Wolle* means "wool"). By the end of the 16th century, cotton was cultivated throughout the warmer regions in Asia and the Americas.

India's cotton-processing sector gradually declined during British expansion in India and the establishment of colonial rule during the late 18th and early 19th centuries. This was largely due to aggressive colonialist mercantile policies of the British East India Company, which made cotton processing and manufacturing workshops in India uncompetitive. Indian markets were increasingly forced to supply only raw cotton and were forced, by British-imposed law, to purchase manufactured textiles from Britain.

3.8.1 Industrial revolution in Britain

The advent of the Industrial Revolution in Britain provided a great boost to cotton manufacture, as textiles emerged as Britain's leading export. In 1738, Lewis Paul and John Wyatt, of Birmingham, England, patented the roller spinning machine, and the flyer-and-bobbin system for drawing cotton to a more even thickness using two sets of rollers that traveled at different speeds. Later, the invention of the spinning jenny in 1764 and Richard Arkwright's spinning frame (based on the roller spinning machine) in 1769 enabled British weavers to produce cotton yarn and cloth at much higher rates. From the late 18th century onwards, the British city of Manchester acquired the nickname *"Cottonopolis"* due to the cotton industry's omnipresence within the city, and Manchester's role as the heart of the global cotton trade. Production capacity in Britain and the United States was improved by the invention of the cotton gin by the American Eli Whitney in 1793. Improving technology and increasing control of world markets allowed British traders to develop a commercial chain in which raw cotton fibers were (at first) purchased from colonial plantations, processed into cotton cloth in the mills of Lancashire, and then exported on British ships to captive colonial markets in West Africa, India, and China (via Shanghai and Hong Kong).

By the 1840s, India was no longer capable of supplying the vast quantities of cotton fibers needed by mechanized British factories, while shipping bulky, low-price cotton from India to Britain was time-consuming and expensive. This, coupled with the emergence of American cotton as a superior type (due to the longer, stronger fibers of the two domesticated native American species, *Gossypium hirsutum* and *Gossypium barbadense*), encouraged British traders to purchase cotton from plantations in the United States and the Caribbean. By the mid 19th century, "King Cotton" had become the backbone of the southern American economy. In the United States, cultivating and harvesting cotton became the leading occupation of slaves.

During the American Civil War, American cotton exports slumped due to a Union blockade on Southern ports, also because of a strategic decision by the Confederate government to cut exports, hoping to force Britain to recognize the Confederacy or enter the war, prompting the main purchasers of cotton, Britain and France to turn to Egyptian cotton. British and French traders invested heavily in cotton plantations and the Egyptian government of Viceroy Isma'il took out substantial loans from European bankers and stock exchanges. After the American Civil War ended in 1865, British and French traders abandoned Egyptian cotton and returned to cheap American exports, sending Egypt into a deficit spiral that led to the country declaring bankruptcy in 1876, a key factor behind Egypt's annexation by the British Empire in 1882.

During this time, cotton cultivation in the British Empire, especially India, greatly increased to replace the lost production of the American South. Through tariffs and other restrictions, the British government discouraged the production of cotton cloth in India; rather, the raw fiber was sent to England for processing. The Indian Mahatma Gandhi described the process:

1. English people buy Indian cotton in the field, picked by Indian labor at seven cents a day, through an optional monopoly.
2. This cotton is shipped on British ships, a three-week journey across the Indian Ocean, down the Red Sea, across the Mediterranean, through Gibraltar, across the Bay of Biscay and the Atlantic Ocean to London. One hundred per cent profit on this freight is regarded as small.
3. The cotton is turned into cloth in Lancashire. You pay shilling wages instead of Indian pennies to your workers. The English worker not only has the advantage of better wages, but the steel companies of England get the profit of building the factories and machines. Wages; profits; all these are spent in England.
4. The finished product is sent back to India at European shipping rates, once again on British ships. The captains, officers, sailors of these ships, whose wages must be paid, are English. The only Indians who profit are a few lascars who do the dirty work on the boats for a few cents a day.
5. The cloth is finally sold back to the kings and landlords of India who got the money to buy this expensive cloth out of the poor peasants of India who worked at seven cents a day. (Fisher 1932 pp 154–156)

In the United States, Southern cotton provided capital for the continuing development of the North. The cotton produced by enslaved African Americans not only helped the South, but also enriched Northern merchants. Much of the Southern cotton was transshipped through the northern ports.

Cotton remained a key crop in the Southern economy after emancipation and the end of the Civil War in 1865. Across the South, sharecropping evolved, in which free black farmers and landless white farmers worked on white-owned cotton plantations of the wealthy in return for a share of the profits. Cotton plantations required vast labor forces to hand-pick cotton, and it was not until the 1950s that reliable harvesting machinery was introduced into the South (prior to this, cotton-harvesting machinery had been too clumsy to pick cotton without shredding the fibers). During the early 20th century, employment in the cotton industry fell, as machines began to replace laborers, and the South's rural labor force dwindled during the First and Second World Wars. Today, cotton remains a major export of the southern United States, and a majority of the world's annual cotton crop is of the long-staple American variety.

3.8.2 Tanguis cotton

In 1901, Peru's cotton industry suffered because of a fungus plague caused by a plant disease known as "cotton wilt" or, more correctly, "fusarium wilt", caused by the fungus *Fusarium vasinfectum*. The plant disease, which spread throughout Peru, entered plant's roots and worked its way up the stem until the plant was completely dried up. Fermín Tangüis, a Puerto Rican agriculturist who lived in Peru, studied some species of the plant that were affected by the disease to a lesser extent and experimented in germination with the seeds of various cotton plants. In 1911, after 10 years of experimenting and failures, Tangüis was able to develop a seed which produced a superior cotton plant resistant to the disease. The seeds produced a plant that had a 40% longer (between 29 mm and 33 mm) and thicker fiber that did not break easily and required little water. The Tangüis cotton, as it became known, is the variety which is preferred by the Peruvian national textile industry. It constituted 75% of all the Peruvian cotton production, both for domestic use and apparel exports. The Tangüis cotton crop was estimated at 225,000 bales that year.

Successful cultivation of cotton requires a long frost-free period, plenty of sunshine, and a moderate rainfall, usually from 600 to 1200 mm (24 to 48 inches). Soils usually need to be fairly heavy, although the level of nutrients does not need to be exceptional. In general, these conditions are met within the seasonally dry tropics and subtropics in the Northern and Southern hemispheres, but a large proportion of the cotton grown today is cultivated in areas with less rainfall that obtain the water from irrigation. Production of the crop for a given year usually starts soon after harvesting the preceding autumn. Planting time in spring in the Northern hemisphere varies from the beginning of February to the beginning of June. The area of the United

States known as the South Plains is the largest contiguous cotton-growing region in the world. While dryland (non-irrigated) cotton is successfully grown in this region, consistent yields are only produced with heavy reliance on irrigation water drawn from the Ogallala Aquifer. Since cotton is somewhat salt and drought tolerant, this makes it an attractive crop for arid and semiarid regions. As water resources get tighter around the world, economies that rely on it face difficulties and conflict, as well as potential environmental problems. For example, improper cropping and irrigation practices have led to desertification in areas of Uzbekistan, where cotton is a major export. In the days of the Soviet Union, the Aral Sea was tapped for agricultural irrigation, largely of cotton, and now salination is widespread.

Cotton can also be cultivated to have colors other than the yellowish off-white typical of modern commercial cotton fibers. Naturally colored cotton can come in red, green, and several shades of brown.

3.8.3 Genetic modification

Genetically modified (GM) cotton was developed to reduce the heavy reliance on pesticides. The bacterium *Bacillus thuringiensis* (Bt) naturally produces a chemical harmful only to a small fraction of insects, most notably the larvae of moths and butterflies, beetles, and flies, and harmless to other forms of life. The gene coding for Bt toxin has been inserted into cotton, causing cotton to produce this natural insecticide in its tissues. In many regions, the main pests in commercial cotton are lepidopteran larvae, which are killed by the Bt protein in the transgenic cotton they eat. This eliminates the need to use large amounts of broad-spectrum insecticides to kill lepidopteran pests (some of which have developed pyrethroid resistance). This spares natural insect predators in the farm ecology and further contributes to noninsecticide pest management.

KINDS AND TYPES OF COTTON

There are several species of cotton that grows wild but they are not economically feasible. There are five types of cotton that are being grown commercially around the world. Some are very common to our ears and we see them in stores everyday. These types are Egyptian, Sea Island, American Prima, Asiatic and American Upland. These various kinds have some resemblance but differ in color of flowers, fiber and time of blooming

Asiatic Cotton: This type of fine quality cotton is produced in countries like India, China and the Near east. The cotton is often used for apparel home furnishing and surgical supplies.

Egyptian Cotton: This type of cotton fiber is light brown in color, fine, strong and widely sold all over the world. It is used in applications where fine and strong yarns are required. Egyptian cotton is often used for manufacturing bead sheets, cushion covers etc

American Pima: This popular type of cotton is grown in Texas, New Mexico, Arizona and Southern California. . The fiber if fine, strong, silky, lustrous and creamy white in color. The cotton type is widely used for different kinds of apparel and home furnishing fabrics

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Asiatic Cotton: This type of fine quality cotton is produced in countries like India, China and the Near east. The cotton is often used for apparel home furnishing and surgical supplies.

Upland Cotton: This type of cotton in widely grown in different parts of America. It is often used wholly or as a component of blend with man made fibers, for use in different industries.

3.9 COTTON FROM FIELD TO MILL

Cotton accounts for almost 50% of the worldwide consumption of textile fibre. China, the United States, the Russian Federation, India and Japan are the major cotton-consuming countries. Consumption is measured by the amount of raw cotton fibre purchased and used to manufacture textile materials. Worldwide cotton production is annually about 80 to 90 million bales (17.4 to 19.6 billion kg). China, the United States, India, Pakistan and Uzbekistan are the major cotton-producing countries, accounting for over 70% of world cotton production. The rest is produced by about 75 other countries. Raw cotton is exported from about 57 countries and cotton textiles from about 65 countries. Many countries emphasize domestic production to reduce their reliance on imports.

Yarn manufacturing is a sequence of processes that convert raw cotton fibres into yarn suitable for use in various end-products. A number of processes are required to obtain the clean, strong, uniform yarns required in modern textile markets. Beginning with a dense package of tangled fibres (cotton bale) containing varying amounts of non-lint materials and unusable fibre (foreign matter, plant trash, motes and so on), continuous operations of opening, blending, mixing, cleaning, carding, drawing, roving and spinning are performed to transform the cotton fibres into yarn.

Even though the current manufacturing processes are highly developed, competitive pressure continues to spur industry groups and individuals to seek new, more efficient methods and machines for processing cotton which, one day, may supplant today's systems. However, for the foreseeable future, the current conventional systems of blending, carding, drawing, roving and spinning will continue to be used. Only the cotton picking process seems clearly destined for elimination in the near future.

Yarn manufacturing produces yarns for various woven or knitted end-products (e.g., apparel or industrial fabrics) and for sewing thread and cordage. Yarns are produced with different diameters and different weights per unit length. While the basic yarn manufacturing process has remained unchanged for a number of years, processing speeds, control technology and package sizes have increased. Yarn properties and processing efficiency are related to the properties of the cotton fibres processed. End-use properties of the yarn are also a function of processing conditions.

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3.9.1 Cultivating Cotton

Cotton is a shrubby plant that is a member of the Mallow family. Its name refers to the cream-colored fluffy fibers surrounding small cottonseeds called a boll. The small, sticky seeds must be separated from the wool in order to process the cotton for spinning and weaving. De-seeded cotton is cleaned, carded (fibers aligned), spun, and woven into a fabric that is also referred to as cotton. Cotton is easily spun into yarn as the cotton fibers flatten, twist, and naturally interlock for spinning. Cotton fabric alone accounts for fully half of the fiber worn in the world.

The materials required to take cotton bolls to spun cotton include cottonseeds for planting; pesticides, such as insecticides, fungicides, and herbicides, to battle disease and harmful insects; and fertilizers to enrich the soil.

Cotton is grown anywhere with long, hot dry summers with plenty of sunshine and low humidity. Indian cotton, gossypium arboreum, is finer but the staple is only suitable for hand processing. American cotton, gossypium hirsutum, produces the longer staple needed for machine production. Planting is from September to mid November and the crop is harvested between March and May.

3.9.2 Harvesting

Two types of mechanical harvesting equipment are used to harvest cotton: the spindle picker and the cotton stripper. The spindle picker is a selective-type harvester that uses tapered, barbed spindles to remove seed cotton from bolls. This harvester can be used on a field more than once to provide stratified harvests. On the other hand, the cotton stripper is a nonselective or once-over harvester that removes not only the well-opened bolls but also the cracked and unopened bolls along with the burs and other foreign matter.

Agronomic practices that produce a high-quality uniform crop will generally contribute to good harvesting efficiency. The field should be well drained and rows laid out for effective use of machinery. Row ends should be free of weeds and grass, and should have a field border of 7.6 to 9 m for turning and aligning the harvesters with the rows. The border also should be free of weeds and grass. Disking creates adverse conditions in rainy weather, so chemical weed control or mowing should be used instead. Plant height should not exceed about 1.2 m for cotton that is to be picked, and about 0.9 m for cotton that is to be stripped. Plant height can be controlled to some extent by using chemical growth regulators at the proper growth stage. Production practices that set the bottom boll at least 10 cm above the ground should be used. Culturing practices such as fertilization, cultivation and irrigation during the growing season should be carefully managed to produce a uniform crop of well-developed cotton.

Chemical defoliation is a culturing practice that induces abscission (shedding) of foliage. Defoliants may be applied to help minimize green-leaf-trash contamination and promote faster drying of early morning dew on the lint. Defoliants should not be applied until at least 60% of the bolls are open. After a defoliant is applied, the crop should not be harvested for at least 7 to 14 days (the period will vary depending on chemicals used and weather conditions). Chemical desiccants may also be used to prepare plants for harvest. Desiccation is the rapid loss of water from the plant tissue and subsequent death of the tissue. The dead foliage remains attached to the plant.

The current trend in cotton production is toward a shorter season and one-time harvest. Chemicals that accelerate the boll opening process are applied with the defoliant or soon after the leaves drop. These chemicals allow earlier harvests and increase the percentage of bolls that are ready to be harvested during the first harvest. Because these chemicals have the ability to open or partially open immature bolls, the quality of the crop may be severely impacted (i.e., the micronaire may be low) if the chemicals are applied too early.

3.9.3 Storage

The moisture content of cotton before and during storage is critical; excess moisture causes stored cotton to overheat, resulting in lint discolouration, lower seed germination and possibly spontaneous combustion. Seed cotton with a moisture content above 12% should not be stored. Also, the internal temperature of newly built modules should be monitored for the first 5 to 7 days of cotton storage; modules that experience a 11 °C rise or are above 49 °C should be ginned immediately to avoid the possibility of major loss.

Several variables affect seed and fibre quality during seed cotton storage. Moisture content is the most important. Other variables include length of storage, amount of high-moisture foreign matter, variation in moisture content throughout the stored mass, initial temperature of the seed cotton, temperature of the seed cotton during storage, weather factors during storage (temperature, relative humidity, rainfall) and protection of the cotton from rain and wet ground. Yellowing is accelerated at high temperatures. Both temperature rise and maximum temperature are important. Temperature rise is directly related to the heat generated by biological activity.

3.9.4 Ginning Process

About 80 million bales of cotton are produced annually worldwide, of which about 20 million are produced by about 1,300 gins in the United States. The principal function of the cotton gin is to separate lint from seed, but the gin must also be equipped to remove a large percentage of the foreign matter from the cotton that would significantly reduce the value of the ginned lint. A ginner must have two objectives: (1) to produce lint of satisfactory quality for the grower's market and (2) to gin the cotton with minimum reduction in fibre spinning quality, so that the cotton will meet the demands of its ultimate users, the spinner and the consumer. Accordingly, quality preservation during ginning requires the proper selection and operation of each machine in a ginning system. Mechanical handling and drying may modify the natural quality characteristics of cotton. At best, a ginner can only preserve the quality characteristics inherent in the cotton when it enters the gin. The following paragraphs briefly discuss the function of the major mechanical equipment and processes in the gin.

3.9.5 Seed-Cotton Machinery

Cotton is transported from a trailer or module into a green-boll trap in the gin, where green bolls, rocks and other heavy foreign matter are removed. The automatic feed control provides an even, well-dispersed flow of cotton so that the gin's cleaning and drying system will operate more efficiently. Cotton that is not well dispersed can travel through the drying system in clumps, and only the surface of that cotton will be dried.

In the first stage of drying, heated air conveys the cotton through the shelves for 10 to 15 seconds. The temperature of the conveying air is regulated to control the amount of drying. To prevent fibre damage, the temperature to which the cotton is exposed during normal operation should never exceed 177°C. Temperatures above 150°C can cause permanent physical changes in cotton fibres. Dryer-temperature sensors should be located as near as possible to the point where cotton and heated air come together. If the temperature sensor is located near the exit of the tower dryer, the mixpoint temperature could actually be 55 to 110°C higher than the temperature at the downstream sensor. The temperature drop downstream results from the cooling effect of evaporation and from heat loss through the walls of machinery and piping. The drying continues as the warm air moves the seed cotton to the cylinder cleaner, which consists of 6 or 7 revolving spiked cylinders that rotate at 400 to 500 rpm. These cylinders scrub the cotton over a series of grid rods or screens, agitate the cotton and allow fine foreign materials, such as leaves, trash and dirt, to pass through the openings for disposal. Cylinder cleaners break up large wads and generally condition the cotton for additional cleaning and drying. Processing rates of about 6 bales per hour per metre of cylinder length are common.

The stick machine removes larger foreign matter, such as burs and sticks, from the cotton. Stick machines use the centrifugal force created by saw cylinders rotating at 300 to 400 rpm to "sling off" foreign material while the fibre is held by the saw. The foreign matter that is slung off the reclaimer feeds into the trash-handling system. Processing rates of 4.9 to 6.6 bales/hr/m of cylinder length are common.

3.9.6 Ginning (lint-seed separation)

After going through another stage of drying and cylinder cleaning, cotton is distributed to each gin stand by the conveyor-distributor. Located above the gin stand, the extractor-feeder meters seed cotton uniformly to the gin stand at controllable rates, and cleans seed cotton as a secondary function. The moisture content of cotton fibre at the extractor-feeder apron is critical.

The moisture must be low enough that foreign matter can be easily removed in the gin stand. However, the moisture must not be so low (below 5%) as to result in the breakage of individual fibres as they are separated from the seed. This breakage causes an appreciable reduction both in fibre length and lint turnout. From a quality standpoint, cotton with a higher content of short fibres produces excessive waste at the textile mill and is less desirable. Excessive breakage of fibres can be avoided by maintaining a fibre moisture content of 6 to 7% at the extractor-feeder apron.

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Two types of gins are in common use—the saw gin and the roller gin. In 1794, Eli Whitney invented a gin that removed fibre from the seed by means of spikes or saws on a cylinder. In 1796, Henry Ogden Holmes invented a gin having saws and ribs; this gin replaced Whitney's gin and made ginning a continuous-flow process rather than a batch process. Cotton (usually Gossypium hirsutum) enters the saw gin stand through a huller front. The saws grasp the cotton and draw it through widely spaced ribs known as huller ribs. The locks of cotton are drawn from the huller ribs into the bottom of the roll box. The actual ginning process—separation of lint and seed—takes place in the roll box of the gin stand. The ginning action is caused by a set of saws rotating between ginning ribs. The saw teeth pass between the ribs at the ginning point. Here the leading edge of the teeth is approximately parallel to the rib, and the teeth pull the fibres from the seed, which are too large to pass between the ribs. Ginning at rates above those recommended by the manufacturer can cause fibre quality reduction, seed damage and choke-ups. Gin stand saw speeds are also important. High speeds tend to increase the fibre damage done during ginning.

Roller-type gins provided the first mechanically aided means of separating extra-long staple cotton (Gossypium barbadense) lint from seed. The Churka gin, which has an unknown origin, consisted of two hard rollers that ran together at the same surface speed, pinching the fibre from the seed and producing about 1 kg of lint/day. In 1840, Fones McCarthy invented a more efficient roller gin that consisted of a leather ginning roller, a stationary knife held tightly against the roller and a reciprocating knife that pulled the seed from the lint as the lint was held by the roller and stationary knife. In the late 1950s, a rotary-knife roller gin was developed by the US Department of Agriculture (USDA) Agricultural Research Service's Southwestern Cotton Ginning Research Laboratory, US gin manufacturers and private ginneries. This gin is currently the only roller-type gin used in the United States.

3.9.7 Lint Cleaning

Cotton is conveyed from the gin stand through lint ducts to condensers and formed again into a batt. The batt is removed from the condenser drum and fed into the saw-type lint cleaner. Inside the lint cleaner, cotton passes through the feed rollers and over the feed plate, which applies the fibres to the lint cleaner saw. The saw carries cotton under grid bars, which are aided by centrifugal force and remove immature seeds and foreign matter. It is

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important that the clearance between the saw tips and grid bars be properly set. The grid bars must be straight with a sharp leading edge to avoid reducing cleaning efficiency and increasing lint loss. Increasing the lint cleaner's feed rate above the manufacturer's recommended rate will decrease cleaning efficiency and increase loss of good fibre. Roller-ginned cotton is usually cleaned with non-aggressive, non-saw-type cleaners to minimize fibre damage.

Lint cleaners can improve the grade of cotton by removing foreign matter. In some cases, lint cleaners may improve the colour of a lightly spotted cotton by blending to produce a white grade. They may also improve the colour grade of a spotted cotton to light spotted or perhaps white colour grade.

3.9.8 Packaging

The cleaned cotton is compressed into bales, which must then be covered to protect them from contamination during transportation and storage. Three types of bales are produced: modified flat, compress universal density and gin universal density. These bales are packaged at densities of 224 and 449 kg/m^3 for the modified flat and universal density bales, respectively. In most gins cotton is packaged in a "double-box" press wherein the lint is initially compacted in one press box by a mechanical or hydraulic tramper; then the press box is rotated, and the lint is further compressed to about 320 or 641 kg/m^3 by modified flat or gin universal density presses, respectively. Modified flat bales are recompressed to become compress universal density bales in a later operation to achieve optimum freight rates. In 1995, about 98% of the bales in the United States were gin universal density bales.

3.9.9 Fibre Quality

Cotton quality is affected by every production step, including selecting the variety, harvesting and ginning. Certain quality characteristics are highly influenced by genetics, while others are determined mainly by environmental conditions or by harvesting and ginning practices. Problems during any step of production or processing can cause irreversible damage to fibre quality and reduce profits for the producer as well as the textile manufacturer.

Fibre quality is highest the day a cotton boll opens. Weathering, mechanical harvesting, handling, ginning and manufacturing can diminish the natural quality. There are many factors that indicate the overall quality of cotton fibre. The most important ones include strength, fibre length, short fibre content (fibres shorter than 1.27 cm), length uniformity, maturity, fineness, trash content, colour, seedcoat fragment and nep content, and stickiness. The market generally recognizes these factors even though not all are measured on each bale.

The ginning process can significantly affect fibre length, uniformity and the content of seedcoat fragments, trash, short fibres and neps. The two ginning practices that have the most impact on quality are the regulation of fibre moisture during ginning and cleaning and the degree of saw-type lint cleaning used.

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The recommended lint moisture range for ginning is 6 to 7%. Gin cleaners remove more trash at low moisture but not without more fibre damage. Higher fibre moisture preserves fibre length but results in ginning problems and poor cleaning, as illustrated in figure 89.7 . If drying is increased to improve trash removal, yarn quality is reduced. Although yarn appearance improves with drying up to a point, because of increased foreign-matter removal, the effect of increased short-fibre content outweighs the benefits of foreign-matter removal.

Cleaning does little to change the true colour of the fibre, but combing the fibres and removing trash changes the perceived colour. Lint cleaning can sometimes blend fibre so that fewer bales are classified as spotted or light spotted. Ginning does not affect fineness and maturity. Each mechanical or pneumatic device used during cleaning and ginning increases the nep content, but lint cleaners have the most pronounced influence. The number of seedcoat fragments in ginned lint is affected by the seed condition and ginning action. Lint cleaners decrease the size but not the number of fragments. Yarn strength, yarn appearance and spinning-end breakage are three important spinning quality elements. All are affected by length uniformity and, therefore, by the proportion of short or broken fibres. These three elements are usually preserved best when cotton is ginned with minimum drying and cleaning machinery.

Recommendations for the sequence and amount of gin machinery to dry and clean spindle-harvested cotton were designed to achieve satisfactory bale value and to preserve the inherent quality of cotton. They have generally been followed and thus confirmed in the US cotton industry for several decades. The recommendations consider marketing-system premiums and discounts as well as the cleaning efficiency and fibre damage resulting from various gin machines. Some variation from these recommendations is necessary for special harvesting conditions.

When gin machinery is used in the recommended sequence, 75 to 85% of the foreign matter is usually removed from cotton. Unfortunately, this machinery also removes small quantities of good-quality cotton in the process of removing foreign matter, so the quantity of marketable cotton is reduced during cleaning. Cleaning cotton is therefore a compromise between foreign matter level and fibre loss and damage.

3.9.10 Safety and Health Concerns

The cotton ginning industry, like other processing industries, has many hazards. Information from workers' compensation claims indicates that the number of injuries is highest for the hand/fingers, followed by back/spine, eye, foot/toes, arm/shoulder, leg, trunk and head injuries. While the industry has been active in hazard reduction and safety education, gin safety remains a major concern. The reasons for the concern include the high frequency of accidents and workers' compensation claims, the large number of lost work days and the severity of the accidents. Total economic costs for gin injuries and health disorders include direct costs (medical and other compensation) and indirect costs (time lost from work, downtime, loss in earning power, higher insurance costs for workers' compensation, loss of productivity and many other loss factors). Direct costs are easier to determine and much less expensive than indirect costs.

Many international safety and health regulations affecting cotton ginning are derived from US legislation administered by the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA), which promulgates pesticides regulations.

Other agricultural regulations may also apply to a gin, including requirements for slow-moving vehicle emblems on trailers/tractors operating on public roadways, provisions for rollover protective structures on tractors operated by employees and provisions for proper living facilities for temporary labour. While gins are considered agricultural enterprises and are not specifically covered by many regulations, ginners will likely want to conform to other regulations, such as OSHA's "Standards for General Industry, Part 1910". There are three specific OSHA standards that ginners should consider: those for fire and other emergency plans (29 CFR 1910.38a), exits (29 CFR 1910.35-40) and occupational noise exposure (29 CFR 1910.95). Major exit requirements are given in 29 CFR 1910.36 and 29 CFR 1910.37. In other countries, where agricultural workers are included in mandatory coverage, such compliance will be compulsory. Compliance with noise and other safety and health standards is discussed elsewhere in this Encyclopaedia.

3.9.11 Employee participation in safety programmes

The most effective loss control programmes are those in which management motivates employees to be safety conscious. This motivation can be accomplished by establishing a safety policy that gets the employees involved in each element of the programme, by participating in safety training, by setting a good example and by providing employees with appropriate incentives.

Occupational health disorders are lessened by requiring that PPE be used in designated areas and that employees observe acceptable work practices. Hearing (plugs or muffs) and respiratory (dust mask) PPE should be used whenever working in areas having high noise or dust levels. Some people are more susceptible to noise and respiratory problems than others, and even with PPE should be reassigned to work areas with lower noise or dust levels. Health hazards associated with heavy lifting and excessive heat can be handled by training, use of materials-handling equipment, proper dress, ventilation and breaks from the heat.

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All persons throughout the gin operation must be involved in gin safety. A safe work atmosphere can be established when everyone is motivated to participate fully in the loss control programme.

detaches the seeds by drawing them through teeth in circular saws and revolving brushes which clean them away.

The ginned cotton fibre, known as lint, is then compressed into bales which are about 1.5 m tall and weigh almost 220 kg. Only 33% of the crop is usable lint. Commercial cotton is priced by quality, and that broadly relates to the average length of the staple, and the variety of the plant. Longer staple cotton (2½ in to 1¼ in) is called Egyptian, medium staple (1¼ in to ¾ in) is called American upland and short staple (less than ¾ in) is called Indian.

The cotton seed is pressed into a cooking oil. The husks and meal are processed into animal feed, and the stems into paper.

3.11 BAILING OF COTTON

Cotton mills get the cotton shipped to them in large, 500 pound bales. When the cotton comes out of a bale, it is all packed together and still contains vegetable matter. The bale is broken open using a machine with large spikes. It is called an **Opener**.In order to fluff up the cotton and remove the vegetable matter, the cotton is sent through a picker, or similar machines. A **picker** looks similar to the carding machine and the cotton gin, but is slightly different. The cotton is fed into the machine and gets beaten with a beater bar, to loosen it up. It is fed through various rollers, which serve to remove the vegetable matter. The cotton, aided by fans, then collects on a screen and gets fed through more rollers till it emerges as a continuous soft fleecy sheet, known as a lap.

3.12 BYPRODUCTS OF COTTON

3.12.1 Yarn Manufacturing Processes

Opening, blending, mixing and cleaning

Typically, mills select bale mixes with the properties needed to produce yarn for a specific end-use. The number of bales used by different mills in each mix ranges from 6 or 12 to over 50. Processing begins when the bales to be mixed are brought to the opening room, where bagging and ties are removed. Layers of cotton are removed from the bales by hand and placed in feeders equipped with conveyors studded with spiked teeth, or entire bales are placed on platforms which move them back and forth under or over a plucking mechanism. The aim is to begin the sequential production process by converting the compacted layers of baled cotton into small, light, fluffy tufts

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that will facilitate the removal of foreign matter. This initial process is referred to as "opening". Since bales arrive at the mill in various degrees of density, it is common for bale ties to be cut approximately 24 hours before the bales are to be processed, in order to allow them to "bloom". This enhances opening and helps regulate the feeding rate. The cleaning machines in mills perform the functions of opening and first-level cleaning.

PROCESSING OF COTTON

The manufacture of cotton cloth is a complex process, involving many highly skilled workers, each performing a particular critical step in the overall process. The many complex steps can be divided into three general categories - *Preparation, Spinning,* and *Weaving.* In addition to this, there is the process of preparing the design that will be applied to the woven cloth. Cotton cloth manufacturing was indeed a "high-tech" venture in the 1880s!

Preparation

1. Bales of cotton of various grades are moved from the WAREHOUSE to the BALE OPENING room.
2. Selected bales are opened and placed in position beside the BREAKING and OPENING machine. This is actually a line of machines, working as a unit, that tear apart and partially clean matted, compressed, and baled cotton. The result is small loose bunches of cotton.
3. The cotton is then placed into the BLENDING MACHINE. This is a group of devices that are synchronized to proportion definite amounts of various grades of cotton which are to be blended together.
4. At this time, matted cotton and waste yarn salvaged from operations in the mill are placed into the WASTE MACHINE. This machine beats, pulls apart, and fluffs up waste cotton to prepare it for re-use.
5. Cotton from both the BLENDING MACHINE and the WASTE MACHINE is fed into the BREAKER PICKER. In this unit the raw cotton is partially cleaned by beating and fluffing and then fed into the FINISHER PICKER.
6. The FINISHER PICKER receives partially cleaned cotton in the form of LAP from the BREAKER PICKER and completes the cleaning and fluffing process. LAP is a general term used to designate wide sheets of loosely matted cotton.
7. The cotton is next processed by a CARDING MACHINE, where dirt and short fibers are removed, other fibers are laid parallel and formed into a ropelike strand called a SLIVER. The SLIVER is deposited in large cylindrical containers called CANS.
8. Subsequent processing depends on whether better grade (combed) yarn, or lower grade (carded) yarn is desired. For the lower grade, processig continues at the DRAWING FRAME

9. For better grade yarn, the SLIVER is first processed by the SLIVER LAPPING MACHINE, which draws and combines several strands of SLIVER into a sheet of LAP and winds it on a spool ready for RIBBON LAPPING or COMBING.

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10. The LAP is processed by a RIBBON LAPPING MACHINE which draws and combines several rolls of LAP into one roll of RIBBON LAP, straightening the fibers slightly and making the lap more uniform in weight and texture, ready for feeding to a COMBING MACHINE. RIBBON LAP is a roll of closely matted cotton fibers, about 10 inches wide.
11. COMBING is the process of extracting fibers below a predetermined length and removing any remaining dirt. Output of the COMBING MACHINE is deposited in CANS.
12. The cotton is next processed by the DRAWING FRAME. It is a machine in which several strands of SLIVER are combined into one strand and DRAWN OUT so that the combined strands approximate the weight and size of any one of the original strands. The term DRAWN OUT means to stretch a strand of cotton, usually by running the strand between several pairs of rollers, each pair turning faster than the pair before it.
13. The SLUBBING MACHINE then draws out strands of SLIVER and twists them together loosely in order to give the strands (now called ROVING) sufficient strength to withstand subsequent operations.
14. The ROVING is processed by the FLY FRAME. This machine progressively combines two strands of partially processed ROVING into one, draws out the combined strands until they are of prescribed weight, and twists them loosely in order to give them sufficient strength to withstand subsequent operations.

Spinning

1. The cotton is now ready for SPINNING. Spinning is the process of making YARN from cotton fibers by drawing out and twisting the fibers into a thin strand. That is, one or more strands of slightly twisted ROVING are used to produce one strand of spun YARN. The yarn is wound on bobbins.
2. The next step is to produce either WARP or FILLING. WARP is the set of yarn strands which run lengthwise in a piece of cloth. FILLING, also called WOOF and WELT, is the yarn which is interlaced through the WARP to produce cloth.

Making FILLING:

a. FILLING may be single-ply or multiple-ply. For multiple-ply, steps (a) and (b) for making WARP below are completed before the yarn is conditioned. For single-ply, the yarn is immediatly conditioned after spinning.

Conditioning is the act of exposing bobbins of FILLING YARN to steam or to a spray of conditioning solution in order to set the twist, to remove kinks from the yarn, and to prevent its kinking in subsequent processes.

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Making WARP:

a. The DOUBLING MACHINE winds two or more strands of yarn onto one PACKAGE without twisting them. PACKAGE is simply a general term for any wound arrangement of YARN.

b. The yarn is then TWISTED. The TWISTING MACHINE twists two or more strands of spun yarn into a heavier, stronger, single strand. This process may be repeated until the desired number of plys is produced.

c. The WINDING MACHINE winds yarn from several bobbins in a continuous length onto a spool. Output is CHEESES or CONES of yarn to be used for WARP. The term CHEESE refers to a roll of yarn built up on a paper or wooden tube in a form that resembles a bulk cheese. A CONE is a tapered cylinder of wood, metal, or cardboard around which yarn is wound.

3. The WARP may, or may not, be dyed. If not, then it is next processed by the WARPING MACHINE. This machine takes about 500 strands of yarn and winds them side by side onto one large spool called a SECTION BEAM. The SECTION BEAM is about three feet in diameter. Processing continues at step 6 below.

4. If the WARP is to be dyed, it is processed by the BALL WARPING MACHINE. This machine takes about 500 strands of yarn and gathers them together into a large, loose, rope-like strand, and winds it on a wooden core preparatory to dyeing. The yarn is then dyed in a different location, producing rolls of dyed WARP YARN.

5. The dyed yarn is processed by the BEAMER MACHINE which separates the individual strands of dyed yarn and winds them onto one large spool (BEAM). The result is the same as step 3 above.

6. The SLASHING MACHINE takes the yarns from several SECTION BEAMS and winds them side by side onto one wider spool called a LOOM BEAM.

WEAVING

1. WEAVING is the interlacing of WARP and FILLING YARN to form a cloth.

1. The inputs to the weaving process, performed on a LOOM, are (1) the WARP YARN from the LOOM BEAM (2) the FILL YARN from a bobbin, and (3) the mechanism that controls the design to be applied to the cloth.

2. If there is no LOOM BEAM currently in the LOOM, the new BEAM must be DRAWN-IN. DRAWING IN is the process of threading the WARP filaments from the LOOM BEAM into the LOOM in the order

indicated by the design to be applied to the cloth. If the current LOOM BEAM has been exhausted, the yarn ends from the new BEAM are twisted or knotted to the ends of the exhausted BEAM.

3. As the LOOM runs, the longitudinal strands of WARP YARN are positioned so that every other strand is raised. A pointed block of wood called a SHUTTLE pulls the FILLING YARN through the strands. The position of the WARP YARN strands are then reversed and the SHUTTLE pulls the FILLING YARN in the reverse direction. This process then repeats. Note that this description is for a simple weave.
4. As bobbins are emptied, any remaining yarn is removed from them and returned to the waste machine for salvage. The clean bobbins are then returned to the spinning operations.
5. Cloth produced by the loom is wound on a large roll and sent to the STITCHING MACHINE, where lengths of cloth are stitched together.
6. The SHEARING MACHINE cuts away knots and loose yarn ends from the surface of the cloth to give it a smooth surface.
7. Finally, the cloth is inspected, graded for quality, and delivered to shipping.

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DESIGNING

1. Designing is the process of deciding on the pattern that is to be woven into a cloth and also the basic weave (plain, twill, or satin). The design is drawn on cross-section paper and called a DESIGN DRAFT.
2. There are two primary types of LOOMS - the DOBBY LOOM and the JACQUARD LOOM. The former is adequate for simple weaves, while the latter is required for more complex weaves. The main difference in the two LOOMs lies in how the individual WARP YARN threads are controlled, as explained below.

DOBBY LOOM

a. The HEDDLE is a fiber or metal strand, pierced with a hole (eye), through which a WARP YARN strand is threaded.

b. The HARNESS is an assemblage of HEDDLES attached to a HARNESS FRAME. A separate HARNESS is used for each group of WARP YARN strands that must be moved independently to weave a desired pattern.

c. Each HARNESS FRAME is fastened to a mechanism that raises and lowers it in proper sequence to form the SHEDS through which the SHUTTLE carries the FILLING YARN to produce cloth of a specified pattern. The SHED is the opening made across the WARP by the raising of some threads and the depressing of others. It is through this opening that the SHUTTLE passes and lays the cross of FILLING YARN of a fabric.

d. A two-harness LOOM (one with two sets of HEDDLES) can produce plain weaves. Three or more HARNESSES are required to produce

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twill fabrics. Other types of fabrics may require a minimum of five HARNESSES.

e. The cloth designer converts the DESIGN DRAFT into a PATTERN CHAIN, an arrangement of wooden crossbars and metal pegs which is used to control the WEAVING of cloth designs and patterns on the DOBBY LOOM. The metal pegs, about an inch long, determine which HARNESSES are raised and when.

JACQUARD LOOM

a. Each strand of WARP YARN can be individually controlled. The HEDDLE HARNESS of the DOBBY LOOM is replaced by a series of upright wires with hooks at their upper ends. The hooks are attached to a controlling head high above the loom. The Jacquard head is controlled by a punch card system.

b. The cloth designer converts the DESIGN DRAFT into punched cards. The presence or absence of holes in each card determines whether each WARP YARN strand is raised or lowered. The cards are fed through the Jacquard head at the rate of one card for each pass of the SHUTTLE.

c. Since the cards are small, and each one can control only a few WARP YARN strands, a number of cards are laced together to control the full width of the LOOM.

Yarn Manufacturing Processes

Opening, blending, mixing and cleaning

Typically, mills select bale mixes with the properties needed to produce yarn for a specific end-use. The number of bales used by different mills in each mix ranges from 6 or 12 to over 50. Processing begins when the bales to be mixed are brought to the opening room, where bagging and ties are removed. Layers of cotton are removed from the bales by hand and placed in feeders equipped with conveyors studded with spiked teeth, or entire bales are placed on platforms which move them back and forth under or over a plucking mechanism. The aim is to begin the sequential production process by converting the compacted layers of baled cotton into small, light, fluffy tufts that will facilitate the removal of foreign matter. This initial process is referred to as "opening". Since bales arrive at the mill in various degrees of density, it is common for bale ties to be cut approximately 24 hours before the bales are to be processed, in order to allow them to "bloom". This enhances opening and helps regulate the feeding rate. The cleaning machines in mills perform the functions of opening and first-level cleaning.

Carding and Combing

The card is the most important machine in the yarn manufacturing process. It performs second- and final-level cleaning functions in an overwhelming majority of cotton textile mills. The card is composed of a system of three wire-covered cylinders and a series of flat, wire-covered bars that successively work small clumps and tufts of fibres into a high degree of separation or openness, remove a very high percentage of trash and other foreign matter, collect the fibres into a rope-like form called a "sliver" and deliver this sliver in a container for use in the subsequent process (see figure 89.4).

Historically, cotton has been fed to the card in the form of a "picker lap", which is formed on a "picker", a combination of feed rolls and beaters with a mechanism made up of cylindrical screens on which opened tufts of cotton are collected and rolled into a batt. The batt is removed from the screens in an even, flat sheet and then is rolled into a lap. However, labour requirements and the availability of automated handling systems with the potential for improved quality are contributing to the obsolescence of the picker.

The elimination of the picking process has been made possible by the installation of more efficient opening and cleaning equipment and chute-feed systems on the cards. The latter distribute opened and cleaned tufts of fibres to cards pneumatically through ducts. This action contributes to processing consistency and improved quality and reduces the number of workers required.

A small number of mills produce combed yarn, the cleanest and most uniform cotton yarn. Combing provides more extensive cleaning than is provided by the card. The purpose of combing is to remove short fibres, neps and trash so that the resulting sliver is very clean and lustrous. The comber is a complicated machine composed of grooved feed rolls and a cylinder that is partially covered with needles to comb out short fibres.

3.12.3 Drawing and Roving

Drawing is the first process in yarn manufacturing that employs roller drafting. In drawing, practically all draft results from the action of rollers. Containers of sliver from the carding process are staked in the creel of the drawing frame. Drafting occurs when a sliver is fed into a system of paired rollers moving at different speeds. Drawing straightens the fibres in the sliver by drafting to make more of the fibres parallel to the axis of the sliver. Parallelization is necessary to obtain the properties desired when the fibres are subsequently twisted into yarn. Drawing also produces a sliver that is more uniform in weight per unit of length and helps to achieve greater blending capabilities. The fibres that are produced by the final drawing process, called finisher drawing, are nearly straight and parallel to the axis of the sliver. Weight per unit length of a finisher-drawing sliver is too high to permit drafting into yarn on conventional ring-spinning systems.

The roving process reduces the weight of the sliver to a suitable size for spinning into yarn and inserting twist, which maintains the integrity of the draft strands. Cans of slivers from finisher drawing or combing are placed in the creel, and individual slivers are fed through two sets of rollers, the second of which rotates faster, thus reducing the size of the sliver from about 2.5 cm in diameter to that of the diameter of a standard pencil. Twist is imparted to the fibres by passing the bundle of fibres through a roving "flyer". The product is now called "roving", which is packaged on a bobbin about 37.5 cm long with a diameter of about 14 cm.

3.12.4 Spinning

Spinning is the single most costly step in converting cotton fibres to yarn. Currently, over 85% of the world's yarn is produced on ring-spinning frames, which are designed to draft the roving into the desired yarn size, or count, and to impart the desired amount of twist. The amount of twist is proportional to the strength of the yarn. The ratio of the length to the length fed can vary on the order of 10 to 50. Bobbins of roving are placed onto holders that allow the roving to feed freely into the drafting roller of the ring-spinning frame. Following the drafting zone, the yarn passes through a "traveller" onto a spinning bobbin. The spindle holding this bobbin rotates at high speed, causing the yarn to balloon as twist is imparted. The lengths of yarn on the bobbins are too short for use in subsequent processes and are doffed into "spinning boxes" and delivered to the next process, which may be spooling or winding.

In the modern production of heavier or coarse yarns, open-end spinning is replacing ring spinning. A sliver of fibres is fed into a high-speed rotor. Here the centrifugal force converts the fibres into yarns. There is no need for the bobbin, and the yarn is taken up on the package required by the next step in the process.

Considerable research and development efforts are being devoted to radical new methods of yarn production. A number of new spinning systems currently under development may revolutionize yarn manufacturing and could cause changes in the relative importance of fibre properties as they are now perceived. In general, four of the different approaches used in the new systems appear practical for use on cotton. Core-spun systems are currently in use to produce a variety of specialty yarns and sewing threads. Twistless yarns have been produced commercially on a limited basis by a system that bonds the fibres together with a polyvinyl alcohol or some other bonding agent. The twistless yarn system offers potentially high production rates and very uniform yarns. Knit and other apparel fabrics from twistless yarn have excellent appearance. In air-vortex spinning, currently under study by several machinery manufacturers, drawing sliver is presented to an opening roller, similar to rotor spinning. Air-vortex spinning is capable of very high production speeds, but prototype models are particularly sensitive to fibre length variations and foreign matter content such as trash particles.

3.12.5 Winding and Spooling

Once the yarn is spun, the manufacturers must prepare a correct package. The type of package depends on whether the yarn will be used for weaving or knitting. Winding, spooling, twisting and quilling are considered preparatory steps for weaving and knitting yarn. In general, the product of spooling will be used as warp yarns (the yarns that run lengthwise in woven fabric) and the product of winding will be used as filling yarns, or weft yarns (the yarns that run across the fabric). The products from open-end spinning by-pass these steps and are packaged for either the filling or warp. Twisting produces ply yarns, where two or more yarns are twisted together before further processing. In the quilling process yarn is wound onto small bobbins, small enough to fit inside the shuttle of a box loom. Sometimes the quilling process takes place at the loom.

3.12.6 Waste Handling

In modern textile mills where control of dust is important, the handling of waste is given greater emphasis. In classical textile operations, waste was collected manually and delivered to a "wastehouse" if it could not be recycled into the system. Here it was accumulated until there was enough of one type to make a bale. In the present state of the art, central vacuum systems automatically return waste from opening, picking, carding, drawing and roving. The central vacuum system is used for cleaning of machinery, automatically collecting waste from under machinery such as fly and motes from carding, and for returning unusable floor sweeps and wastes from filter condensers. The classical baler is a vertical upstroke press which still forms a typical 227-kg bale. In modern wastehouse technology, wastes are accumulated from the central vacuum system in a receiving tank which feeds a horizontal bale press. The various waste products of the yarn manufacturing industry can be recycled or reused by other industries. For example, spinning can be used in the waste spinning industry to make mop yarns, garnetting can be used in the cotton batting industry to make batting for mattresses or upholstered furniture.

1.13 BLENDING AND MIXING COTTON

Scutching refers to the process of cleaning cotton of its seeds and other impurities. A scutching machine for cotton was first invented in 1797, but didn't get much attention until it was introduced in Manchester in 1808 or 1809. By 1816 it had been generally adopted. The scutching machne worked by passing the cotton through a pair of rollers, and then striking it with iron or steel bars called beaters. The beaters, which turn very quickly, strike the cotton hard and knock the seeds out. This process is done over a series of parallel bars so as to allow the seeds to fall through. At the same time a breeze is blown across the bars, which carries the cotton into a cotton chamber.

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Figure 3.1: Carding Machine

Carding: the fibres are separated and then assembled into a loose strand (sliver or tow) at the conclusion of this stage.

The cotton comes off of the picking machine in laps, and is then taken to carding machines. The carders line up the fibres nicely to make them easier to spin. The carding machine consists mainly of one big roller with smaller ones surrounding it. All of the rollers are covered in small teeth, and as the cotton progresses further on the teeth get finer (i.e. closer together). The cotton leaves the carding machine in the form of a sliver; a large rope of fibres.

Note: In a wider sense Carding can refer to these four processes: Willowing- loosening the fibres; Lapping- removing the dust to create a flat sheet or lap of cotton; Carding- combing the tangled lap into a thick rope of 1/2 in in diameter, a sliver; and Drawing- where a drawing frame combines 4 slivers into one- repeated for increased quality.

- **Combing** is optional,but is used to remove the shorter fibres, creating a stronger yarn.

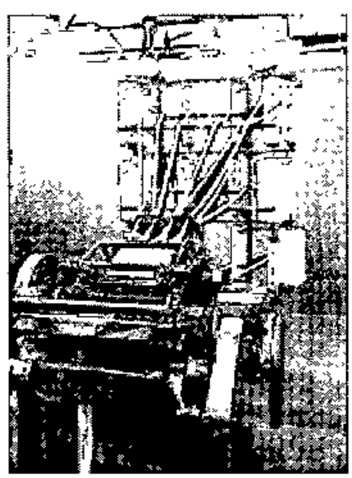

Figure 3.2: A Combing Machine

- **Drawing the fibres are straightened:** Several slivers are combined. Each sliver will have thin and thick spots, and by combining several slivers together a more consistent size can be reached. Since combining several slivers produces a very thick rope of cotton fibres, directly after being combined the slivers are separated into rovings. These rovings (or slubbings) are then what are used in the spinning process.

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Generally speaking, for machine processing, a roving is about the width of a pencil.

- Drawing frame: Draws the strand out
- Slubbing Frame: adds twist, and winds on to bobbins
- Intermediate Frames: are used to repeat the slubbing process to produce a finer yarn.
- Roving frames: reduces to a finer thread, gives more twist, makes more regular and even in thickness, and winds on to a smaller tube.

3.13.1 Spinning- yarn manufacture

- **Spinning:** The spinning machines take the roving, thins it and twists it, creating yarn which it winds onto a bobbin.

  In mule spinning the roving is pulled off a bobbin and fed through some rollers, which are feeding at several different speeds.This thins the roving at a consistent rate. If the roving was not a consistent size, then this step could cause a break in the yarn, or could jam the machine. The yarn is twisted through the spinning of the bobbin as the carriage moves out, and is rolled onto a cop as the carriage returns. Mule spinning produces a finer thread than the less skilled ring spinning.[13]

  The mule was an intermittent process, as the frame advanced and returned a distance of 5ft.It was the descendant of 1779 Crompton device. It produces a softer less twisted thread that was favoured for fines and for weft.

  The ring was a descendant of the Arkwright water Frame 1769. It was a continuous process, the yard was coarser, had a greater twist and was stronger so was suited to be warp. Ring spinning is slow due to the distance the thread must pass around the ring, other methods have been introduced. These are collectively known as Break or Open-end spinning.

  Sewing thread, was made of several threads twisted together, or doubled.

- **Checking:** This is the process where each of the bobbins is rewound to give a tighter bobbin.
- **Folding and twisting:** Plying is done by pulling yarn from two or more bobbins and twisting it together, in the opposite direction that in which it was spun. Depending on the weight desired, the cotton may or may not be plied, and the number of strands twisted together varies.[15]
- **Gassing:** Gassing is the process of passing yarn, as distinct from fabric very rapidly through a series of Bunsen gas flames in a gassing frame,

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in order to burn off the projecting fibres and make the thread round and smooth and also brighter. Only the better qualities of yarn are gassed, such as that used for voiles, poplins, venetians, gabardines, many Egyptian qualities, etc. There is a loss of weight in gassing, which varies' about 5 to 8 per cent., so that if a 2/60's yarn is required 2/56's would be used. The gassed yarn is darker in shade afterwards, but should not be scorched.

3.13.2 Measurements

Units of textile measurement

- **Cotton Counts:** The number of pieces of thread, 840 yards long needed to make up 1 lb weight. 10 count cotton means that 10x840 yd weighs 1 lb. This is coarser than 40 count cotton where 40x840 yards are needed. In the United Kingdom, Counts to 40s are coarse (Oldham Counts), 40 to 80s are medium counts and above 80 is a fine count. In the United States ones to 20s are coarse counts.
- **Hank:** A length of 7 leas or 840 yards
- **Thread:** A length of 54 in (the circumference of a warp beam)
- **Bundle:** Usually 10 lb
- **Lea:** A length of 80 threads or 120 yards
- **Denier:** this is an alternative method. It is defined as a number that is equivalent to the weight in grams of 9000m of a single yarn. 15 denier is finer than 30 denier.
- **Tex:** is the weight in grams of 1 km of yarn.

The worsted hank is only 560 yd

3.14 STUDENT ACTIVITY

1. What are the different types of dyes used for printing?

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   ....

   ....

2. What are the kinds and types of cotton?

   ....

   ....

   ....

3. Write a note on the processing of cotton from field to mill.

   ....

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   ....

3.15 FINISHING COTTON FABRICS

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What is a Finishing?

When we go to the market to buy a fabric, we buy the material after a lot of questioning. Isn't it? We ask whether it is colour fast, will the fabric shrink after washing? Do you have a thicker and stiffer fabric? The salesman replies at once, "No, It is a good quality fabric, as it is 'colour fast' or 'wrinkle free'. These terms are often given on the lable of the fabric too, but most of the time it does not make much sense to you as a consumer.

So the question arises, what exactly do these terms mean? Are they printed on the fabric only to fool the consumer or do they have some relevance?

These terms refer to the 'finishes' applied on the fabric. But what is a finish? Why do we apply them on the fabrics?

It is important to:

- Explain the meaning of finish;
- Explain the necessity of applying finishes;
- Classify finishes as basic or special;
- Explain the procedure for application of some finishes like cleaning, bleaching,
- Stiffening, mercerisation, shrinkage control, water-proofing, etc.
- Finish the fabric with colour and create designs;
- Classify the various dyes available.

Finishing is anything that is done to a fabric after weaving or knitting to change the appearance (what you see), the hand (what you feel) and the performance (what the fabric does). Have you ever seen a fabric that comes from a weaver? It is generally rough to feel, dirty, with stains on it and is known as *'gray cloth'*. But when we buy a fabric from a shop it is smooth, neat and clean.

What happens in between? Yes, a finish has been applied. So we understand that 'FINISH' is a process which is applied to a fabric to improve its properties and its and use. When a finish is applied, say on cotton, I t might become more shiny (lustrous), stronger or resist shrinking on washing. Similarly, a finish may be applied to some other fabric to make it waterproof so that it can be used to make raincoats or umbrella cloth.

3.15.1 Classification of Finishing's

Finishes are given to improve the serviceability and appearance of a fabric. Now, you will learn about the most common finishing processes. Fabrics may be given more than one finish to get the desired effect.

Finishes can be classified as:

(a) Basic finishes, and (b) Special finishes

(a) Basic finishings are applied to almost all fabrics to improve their appearance.

(b) Special finishings are applied with a specific purpose for which it is to be used.

Basic	Special	Finishing with colour
e.g. Scouring	e.g. Mercerisation	e.g Dyeing
Bleaching	Shrinkage control	Printing
Stiffening	Water proofing	
Calendering/Ironing		

We come across the problem of the fabric losing its stiffness after washing, or the fabric crushing badly after wearing. So we starch the fabric and iron it after every wash.

These are called ***temperory finishes.*** But some finishes stay on the fabric for its entire life. They are not affected by washing, dry, cleaning or ironing. These finishes are called ***permanent finishes.*** They can not be applied at home.

3.15.2 Some Common Finishes

Let us now discuss the basic characteristics of different finishes that can be applied on a fabric.

A. Basic Finishes

(i) **Scouring/Cleaning:** Fabrics require scouring or cleaning to remove oil spots, dirt stains acquired during construction. Complete removal of these impurities is important before applying any other finish. Scouring, is a chemical washing process carried out on cotton fabric to remove natural wax and non-fibrous impurities (eg the remains of seed fragments) from the fibres and any added soiling or dirt. Scouring is usually carried in iron vessels called kiers. The fabric is boiled in an alkali, which forms a soap with free fatty acids. (saponification). A kier is usually enclosed, so the solution of sodium hydroxide can be boiled under pressure, excluding oxygen which would degrade the cellulose in the fibre. If the appropriate reagents are used, scouring will also remove size from the fabric although desizing often precedes scouring and is considered to be a separate process known as fabric preparation. Preparation and scouring are prerequisites to most of the other finishing processes. At this stage even the most naturally white cotton fibres are yellowish, and bleaching, the next process, is required.[27]

Cleaning is not only done with soap solutions but is also aided by various chemicals. After cleaning, the fabric becomes smooth, neat and more absorbent.

(ii) **Bleaching:** Bleaching improves whiteness by removing natural coloration and remaining trace impurities from the cotton; the degree of bleaching necessary is determined by the required whiteness and

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absorbency. Cotton being a vegetable fibre will be bleached using an oxidizing agent, such as dilute sodium hypochlorite or dilute hydrogen peroxide. If the fabric is to be dyed a deep shade, then lower levels of bleaching are acceptable, for example. However, for white bed-sheetings and medical applications, the highest levels of whiteness and absorbency are essential.

When the fabrics are made, they are not white in colour. To make them white or to dye them in light colours they are bleached. Suitable bleaching agents are used to remove the colour from the fabric. Bleaching is done for cottons, woollens and silks. Manmade fabrics do not need bleaching as they are naturally white.

Bleaching has to be done very carefully as the chemical which can destroy the colour may also damage the fabric to some extent. Hydrogen peroxide is a bleach which can be applied to all kinds of fabrics.

(iii) Stiffening: To make a fabric stiff, a finish has to be applied. How do you stiffen your cotton clothes at home? Do you use maida starch or rice water? This process of stiffening is a finish done for cottons, mainly by using starch and for silk by gum. Stiffening gives body, smoothness and lusture to the fabric. Sometimes when you go to the market and you rub the fabric between your hand, some white powder comes out. It is because the fabric has been overstarched to make the fabric look better. Take a starched fabric and rub it against your fingers. Then hold it against a light bulb, the weave will look more open in that area, because the starch has been removed.

(iv) Calendering: It is an ironing process. Creases are pressed out by passing the fabric between the steam heated rollers. This flathens the fabric and increases smoothness and shine.

B. Special Finishes

(i) Mercerisation: Before dyeing and printing, cotton is a dull fabric which wrinkles easily. When it is mercerised by using chemicals, it becomes strong, shinning and dyes well as it is now more absorbent. This is a permanent finish. This finish is applied with an alkali (sodium hydroxide) under controlled conditions. Nowadays, this finish has becomes almost a routine finish for cottons. A further possibility is mercerizing during which the fabric is treated with caustic soda solution to cause swelling of the fibres. This results in improved lustre, strength and dye affinity. Cotton is mercerized under tension, and all alkali must be washed out before the tension is released or shrinkage will take place. Mercerizing can take place directly on grey cloth, or after bleaching. Many other chemical treatments may be applied to cotton fabrics to produce low flammability, crease resist and other special effects but four important non-chemical finishing treatments are:

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- **Singeing:** Singeing is designed to burn off the surface fibres from the fabric to produce smoothness. The fabric passes over brushes to raise the fibres, then passes over a plate heated by gas flames.
- **Raising:** Another finishing process is raising. During raising, the fabric surface is treated with sharp teeth to lift the surface fibres, thereby imparting hairiness, softness and warmth, as in flannelette.
- **Calendering:** Calendering is the third important mechanical process, in which the fabric is passed between heated rollers to generate smooth, polished or embossed effects depending on roller surface properties and relative speeds.
- **Shrinking (Sanforizing):** Finally, mechanical shrinking(sometimes referred to as sanforizing), whereby the fabric is forced to shrink width and/or lengthwise, creates a fabric in which any residual tendency to shrink after subsequent laundering is minimal.

(ii) **Shrinkage control:** What happens when your new shirt becomes smaller after washing? It becomes unfit for wearing. Reduction in size of a fabric after it is washed is known as shrinkage. If the label on the fabric reads 'sanforised' then it means the fabric has received a shrinkage control finish and will not shrink on washing. If this finish is not given to the fabric, you may shrink the fabric yourself at home. You probably do it yourself at home. You soak the saree fall in the water before putting it on the Saree or soak the cloth before getting a dress made out of it. For this, while purchasing the fabric, buy some extra amount. Soak the fabric overnight, squeeze it and dry it. The garment made from this fabric will not shrink further on washing.

(iii) **Waterproofing:** Fabrics to be used for raincoats, umbrellas and tarpaulins have to be treated with chemicals or coated with rubber so that water will not pass through them. The finish is called waterproofing. This is a permanent finish.

(iv) **De-sizing:** Depending on the size that has been used, the cloth may be steeped in a dilute acid and then rinsed, or enzymes may be used to break down the size.

(v) **Dyeing:** Finally, cotton is an absorbent fibre which responds readily to colouration processes. Dyeing, for instance, is commonly carried out with an anionic direct dye by completely immersing the fabric (or yarn) in an aqueous dyebath according to a prescribed procedure. For improved fastness to washing, rubbing and light, other dyes such as vats and reactives are commonly used. These require more complex chemistry during processing and are thus more expensive to apply.

(vi) **Printing:** Printing, on the other hand, is the application of colour in the form of a paste or ink to the surface of a fabric, in a predetermined pattern. It may be considered as localised dyeing. Printing designs on to already dyed fabric is also possible.

3.16 SUMMARY

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- Cotton is used to make a number of textile products. These include terrycloth for highly absorbent bath towels and robes; denim for blue jeans; chambray, popularly used in the manufacture of blue work shirts (from which we get the term "blue-collar"); and corduroy, seersucker, and cotton twill. Socks, underwear, and most T-shirts are made from cotton. Bed sheets often are made from cotton. Cotton also is used to make yarn used in crochet and knitting.
- Fabric also can be made from recycled or recovered cotton that otherwise would be thrown away during the spinning, weaving, or cutting process. While many fabrics are made completely of cotton, some materials blend cotton with other fibers, including rayon and synthetic fibers such as polyester. It can either be used in knitted or woven fabrics, as it can be blended with elastine to make a stretchier thread for knitted fabrics, and apparel such as stretch jeans.
- In addition to the textile industry, cotton is used in fishnets, coffee filters, tents, gunpowder (see nitrocellulose), cotton paper, and in bookbinding. The first Chinese paper was made of cotton fiber. Fire hoses were once made of cotton.
- The cottonseed which remains after the cotton is ginned is used to produce cottonseed oil, which, after refining, can be consumed by humans like any other vegetable oil. The cottonseed meal that is left generally is fed to ruminant livestock; the gossypol remaining in the meal is toxic to monogastric animals. Cottonseed hulls can be added to dairy cattle rations for roughage. During the American slavery period, cotton root bark was used in folk remedies as an abortifacient, that is, to induce a miscarriage.[35]
- Cotton linters are fine, silky fibers which adhere to the seeds of the cotton plant after ginning. These curly fibers typically are less than 1/8 in (3 mm) long. The term also may apply to the longer textile fiber staple lint as well as the shorter fuzzy fibers from some upland species. Linters are traditionally used in the manufacture of paper and as a raw material in the manufacture of cellulose.

3.17 GLOSSARY

- **Developing:** A stage in dyeing or printing in which leuco compounds, dyes, or dye intermediates are converted to the final, stable state or shade.

- **Decorticating:** A mechanical process for separating the woody matter from the bast fiber of such plants as ramie and hemp.
- **Deep-Dyeing Variants:** Polymers that have been chemically modified to increase their dyeability. Fibers and fabrics made therefrom can be dyed to very heavy depth.
- **Defects:** A general term that refers to some flaw in a textile product that detracts from either performance or appearance properties.
- **Finishing:** All the processes through which fabric is passed after bleaching, dyeing, or printing in preparation for the market or use. Finishing includes such operations as heat-setting, napping, embossing, pressing, calendering, and the application of chemicals which change the character of the fabric. The term finishing is also sometimes used to refer collectively to all processing operations above, including bleaching, dyeing, printing, etc
- **Decatizing:** A finishing process in which fabric, wound tightly on a perforated roller, either has hot water circulated through it (wet decatizing), or has steam blown through it (dry decatizing). The process is aimed chiefly at improving the hand and removing wrinkles.
- **Electrical Finish:** A finish designed to increase or maintain electrical resistivity of a textile material.

3.18 REVIEW QUESTIONS

1. What do you mean by printing and flocking?
2. How can designs be created by tie and dye?
3. Define dyeing and printing. How are they different?
4. What is textile finishing?
5. What is the difference between basic and special finishes?
6. Why is shrinkage control required in fabrics?
7. Write short notes on:
   (a) Rollor printing
   (b) Photo printing
   (c) Cultivation of cotton
   (d) Gining of cotton

UNIT 4
COMPARATIVE CHARACTERISTICS

STRUCTURE

4.1 LEARNING OBJECTIVE

After completion of this unit, you should be able to:

- Define the comparative characteristics of fabrics
- Describe the strength, elasticity and resilience.
- Define the derivatively in the fabric yarn.
- Explain the heat conductivity, absorbency, cleanliness and stability of fabric.

4.2 INTRODUCTION

It is very important to identify the characteristics of a fabric. More important is the comparison of fabrics. This makes us know the true quality of a fabric by differentiating it from its substitutes. It gives information about the weaves of the fabric, its characteristics and the uses, the important part of comparison. Fabric characteristics can vary depending on quality, blend, dye and whether the item is colour - fast and has been pre-shrunk. Always check individual items for washing instructions before treating. A number of processes are carried by the textile production units where different chemicals find their usage. These processes include, Scouring, Bleaching, Desizing, Softening, Mercerization, Dyeing, etc.

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4.3 COMPARATIVE CHARACTERISTICS OF FABRICS

The comparative characteristics of a fabric can be well understood from the following chart, which gives a complete information upon different types of fabric at a glance, also it shows the comparison of only the characteristics of few fabrics. For example, water retention is very high in cotton and the lowest in polypropylene. It is same with the drying time taken, very long in cotton and vice versa in polypropylene. Cotton and wool shrinks more than polyester and nylon.

Table: Comparative Characteristics of Fabrics

Fabrics	Weaves	Characteristics	Uses
Acetate		Soft, crisp feel and durable.	Clothing, uniforms, lingerie, linings, interlinings.
Acrylic		Durable, soft and wooly feel.	Used as replacement of wool.
Alpaca	Various weaves, knits and weights.	Fine, silk-like, soft, lightweight, and warm.	Men's and Women's suits, coats, and sportswear, linings, sweaters.
Angora goat	Various weaves and knitted.	Smooth, very strong, and high luster.	Carpet, upholstery, curtain, and automobile cloth.
Angora rabbit	Various weaves and knitted.	Long, very fine, light weight, extremely warm and fluffy.	Knit wear - gloves, scarves, sweaters, etc. for children and women.
Beaver		Soft, silky, shiny.	Fur coats, trimming fur and fabric garments.
Broadcloth	Plain weave.	Closely woven with smooth finish.	Shirts, dresses, particularly the tailored type in plain colors, blouses, summer wear.
Camel hair	Twill or plain	Light weight, lustrous and soft.	Coats, women's suits, sports coats, sweaters, some blankets and put in some very expensive oriental rugs. Also used in (fine) over coating, top coating, hosiery and transmission belts.

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Table: Comparative Characteristics of Fabrics			
Fabrics	**Weaves**	**Characteristics**	**Uses**
Canvas	Plain.	Mostly rugged.	Hair canvas is an interfacing material in various weights.
Cashmere (Kashmir)	All weaves but mostly plain or twill. All knits.	Soft, silky and very lightweight.	Knitted into sweaters for men and women, also women's dresses.
Challis	Plain.	Soft and very lightweight.	Women's and children's dresses and blouses, kimonos, neckties, and sportswear.
Chiffon	Plain.	Lightweight, sheer, and transparent.	Evening wear, blouses and scarves.
Crepe	Mostly plain but various weaves.	Crinkled and puckered surface with rough feel and appearance.	Depending on weight, it is used for dresses of all types, including long dinner dresses, suits, and coats.
Damask	Figured on Jacquard loom.	Reversible fabric with woven pattern. Sheds dirt.	
Denim	Twill - right hand - may be L2/1 or L3/1.	Originally had dark blue, brown or dark gray warp with a white or gray filling giving a mottled look and used only for work clothes. Comes in heavy and lighter weights.	Pants, caps, uniforms, bedspreads, slipcovers, draperies, upholstery, sportswear.
Douppioni	Plain.	Irregular with many slubs. It is imitated in rayon and some synthetics	
Drill	Twill.	Closer, flatter wales that gabardine.	Uniforms, work clothes, slip covers, sportswear, and many industrial uses.

NOTES

Table: Comparative Characteristics of Fabrics			
Fabrics	**Weaves**	**Characteristics**	**Uses**
Flannel	Usually twill, some plain.	Soft, with a napped surface that partially cancels the weave. Dull finish. Made in a variety of weights. Shrinks if not pre-shrunk. Sags with wear, unless underlined. Does not shine or hold a crease.	Blazers, dresses, skirts, suits and coats. Boys suits, jackets, and shirts.
Gabardine	Steep twill	Clear finish, tightly woven, firm, durable. Wears extremely well. Inclined to shine with wear. Hard to press properly.	Men's and women's tailored suits, coats, raincoats, uniforms, and men's shirts.
Georgette	Plain.	It is characterized by it's crispness, body and outstanding durability. It is sheer and has a dull face.	
Herringbone twill	Twill.	It is usually created in wool and has varying qualities.	Suitings, top coatings, sports coats.
Houndstooth	Broken twill weave.	Weaned into an irregular check of a four pointed star.	sportcoats, suits.
Mohair	Plain or twill or knitted.	Smooth, glossy, and wiry.	Linings, pile fabrics, suitings, upholstery fabrics, braids, dress materials, felt hats, and sweaters.
Nylon		Very strong, resistant to both abrasion chemicals. It is elastic, easy to wash and is quite lustrous. It returns easily to it's original shape and is non-	Women's hosiery, knitted or woven lingerie, socks and sweaters.

Table: Comparative Characteristics of Fabrics			
Fabrics	**Weaves**	**Characteristics**	**Uses**
		absorbent. It is fast drying, resistant to some dyes.	
Organdy	Plain.	Made with tightly twisted yarns. Crispness is due to a finish with starch and calendaring which washes out, or a permanent crispness obtained with chemicals. Wrinkles badly unless given a wrinkle-free finish.	Collars and cuffs, artificial flowers, millinery, summer formals, blouses, aprons.
Organza	Plain.	Fine, sheer, lightweight, crisp fabric. It has a very wiry feel. It crushes or musses fairly easily, but it is easily pressed. Dressy type of fabric, sometimes has a silvery sheen.	Evening dresses, trimming, millinery, underlinings for delicate, sheer materials.
Oxford	Plain variations - usually basket 2 x 1.	Warp has two fine yarns which travel as one and one heavier softly-spun bulky filling which gives it a basket-weave look. Rather heavy.	Men's shirts mostly. Summer jackets, shirts, skirts, dresses, and sportswear.
Polyester		It is lightweight, strong and resistant to creasing, shrinking, stretching, mildew and abrasion. It is readily washable and is not damaged by sunlight or weather and is resistant to moths and mildew.	Vary, depending on blend.

NOTES

Table: Comparative Characteristics of Fabrics			
Fabrics	**Weaves**	**Characteristics**	**Uses**
Pongee	Plain.	Light or medium weight.	Dresses, blouses, summer suits.
Rayon		It's drapability and dyeability are excellent and it is fairly soft. Rayon does have a tendency to shrink but does not melt in high temperatures. It is resistant to moths and is not affected by ordinary household bleaches and chemicals.	Clothing, hose.
Sateen	Sateen filling-face weave.	Lustrous and smooth with the sheen in a filling direction. Better qualities are mercerized to give a higher sheen.	Dresses, sportswear, robes, pajamas.
Satin	Satin.	Usually has a lustrous surface and a dull back. Made in many colors, weights, varieties, qualities, and degrees of stiffness.	Slips, evening wear, coats, capes, and jackets, lining fabrics, millinery.
Spandex		It is lightweight and flexible. It resists deterioration from perspiration, detergent and body oils. It is characterized by it's strength and durability..	Athletic wear and foundation garments.
Taffeta	Usually plain with a fine cross rib.	It is smooth with a sheen on its surface. The textures vary considerably. They have a crispness and stiffness.	Dressy evening wear: suits and coats, slips, ribbons, blouses, dresses.

NOTES

Table: Comparative Characteristics of Fabrics			
Fabrics	**Weaves**	**Characteristics**	**Uses**
Tussah	Usually plain but also in twill.	It is coarse, strong, and uneven. Dull lustre and rather stiff. Has a rough texture with many slubs, knots, and bumps.	In lighter weights, dresses. In heavier weights, coats and suits and ensembles.
Velour	Thick, plush pile, with a plain or satin ground, or sometimes knitted.	The pile is characterized by uneven lengths (usually two) which gives it a rough look. The two lengths of pile create light and shaded areas on the surface. A rather pebbled effect.	Dressing gowns, dresses, waist-coats.
Velvet	Pile, made with an extra warp yarn.	velvet may be crush resistant, water resistant, and drapes well. Has to be handled with care, and pressed on a velvet board.	Eveningwear, at home wear.
Voile	Plain, loosely woven.	Sheer and very light weight. To obtain a top quality fabric, very highly twisted yarns are used. Voile drapes and gathers very well.	Dresses, blouses.
Wool		It is very resilient and resistant to wrinkling. It is renewed by moisture and well known for its warmth.	Clothing, blankets, winter wear.

3.1 Strength

The strength of a fabric has much to do with its wearing quality, but there can be no fixed standard. Each fabric should be sufficiently strong for the purpose for which it is intended. The warp and filling threads should be equally balanced

NOTES

There are three modes of heat transfer:

- Convection
- Conduction
- Radiation

All three are different. Convection relies on movement of a fluid. Conduction relies on transfer of energy between molecules within a solid or fluid. Radiation is a form of electromagnetic energy transmission and is independent of any substance between the emitter and receiver of such energy. However, all three modes of heat transfer rely on a temperature difference for the transfer of energy to take place. The greater the temperature difference the more rapidly will the heat be transferred. Conversely, the lower the temperature difference, the slower will be the rate at which heat is transferred. When discussing the modes of heat transfer it is the rate of heat transfer Q that defines the characteristics rather than the quantity of heat. As it was mentioned earlier, there are three modes of heat transfer, convection, conduction and radiation. Although two, or even all three, modes of heat transfer may be combined in any particular thermodynamic situation, the three are quite different and will be introduced separately.

The coupled heat and liquid moisture transport of porous material has wide industrial applications in textile engineering and functional design of apparel products. Heat transfer mechanisms in porous textiles include conduction by the solid material of fibers, conduction by intervening air, radiation, and convection Meanwhile, liquid and moisture transfer mechanisms include vapor diffusion in the void space and moisture sorption by the fiber, evaporation, and capillary effects.

Water vapor moves through textiles as a result of water vapor concentration differences. Fibers absorb water vapor due to their internal chemical compositions and structures. The flow of liquid moisture through the textiles is caused by fiber-liquid molecular attraction at the surface of fiber materials, which is determined mainly by surface tension and effective capillary pore distribution and pathways. Evaporation and/or condensation take place, depending on the temperature and moisture distributions. The heat transfer process is coupled with the moisture transfer processes with phase changes such as moisture sorption/desorption and evaporation/condensation.

Mass transfer in the drying of a wet fabric will depend on two mechanisms: movement of moisture within the fabric which will be a function of the internal physical nature of the solid and its moisture content; and the movement of water vapour from the material surface as a result of water vapour from the material surface as a result of external conditions of temperature, air humidity and flow, area of exposed surface and supernatant pressure

3.5 Absorbency

A body that has a surface that will absorb all the radiant energy it receives is an ideal radiator, termed a "black body". Such a body will not only absorb radiation at a maximum level but will also emit radiation at a maximum level. However, in practice, bodies do not have the surface characteristics of a black body and will always absorb, or emit, radiant energy at a lower level than a black body. It is possible to define how much of the radiant energy will be absorbed, or emitted, by a particular surface by the use of a correction factor, known as the "emissivity" and given the symbol ε. The emissivity of a surface is the measure of the actual amount of radiant energy that can be absorbed, compared to a black body.

Similarly, the emissivity defines the radiant energy emitted from a surface compared to a black body. A black body would, therefore, by definition, has an emissivity ε of 1. It should be noted that the value of emissivity is influenced more by the nature of texture of clothes, than its colour.

The practice of wearing white clothes in preference to dark clothes in order to keep cool on a hot summer's day is not necessarily valid.

The amount of radiant energy absorbed is more a function of the texture of the clothes rather than the colour.

3.6 Cleanliness

Vacuuming

One of the safest and easiest ways to clean textiles is to vacuum them. The fabric is placed on a clean, flat work surface. If the specimen is particularly delicate, or simply as a precaution, a fibre glassscreen edged with twill tape may be placed over the textile. The screen allows dirt and dust to pass through, but prevents individual threads from being pulled loose or unravelled further by the suction. Using a vacuum attachment and the lowest power setting, move the suction over the screen until the entire area has been cleaned. If needed, move the screen to a new area and begin again. Always remember to vacuum both sides of the textile, as dirt may filter through to the other side . Hanging textiles will need to be vacuumed less often than horizontal pieces, as there are fewer places where dust can collect.

Wet cleaning

One of the key standards of preservation is that of reversibility: anything done to preserve a piece should be able to be undone with minimal damage to the piece itself. Because wet cleaning is a chemical process, it is not reversible, and so should be used only when absolutely necessary.

Before cleaning a textile, certain questions should be asked to determine both the best treatment for that particular combination of textile and soil, and to ascertain whether the piece is able to be cleaned, or may sustain damage during the process.

What is the chemical composition of the textile? In other words, does it have a high acid content? Where there chemicals used in its production that might contribute to how it reacts to water? Or how it may react to cleaning chemicals?

What are the characteristics of the fibres? For instance, cotton and linen, being plant fibers, are both stronger wet than dry, and so may be able to withstand a more mechanical stress than something like silk. Wool can absorb large amounts of water, but mats if washed in high temperatures. All silks become brittle with age, but weighted silks decay more quickly, and thus must be handled with extreme care . Additionally, some silks, once wet, can be permanently spotted. Learn the basic characteristics of the type of fibres you have, and how they have been treated before undertaking any kind of cleaning.

What colourants have been used, and how will they react to cleaning? This can apply not only to dyes but to mordants as well. Different parts of the world may have different dye processes, so here is where knowledge of when and where a textile originated, as well as a working knowledge of chemistry, can come in handy. If in doubt as to the wash ability of a dye, apply a drop or two of water to an inconspicuous place and blot with a clean white cloth. If the dye transfers to the cloth, even in small amounts, the textile should not be washed.

Are there finishes or surface treatments that must be preserved? For example, is the fabric painted? If so, it should never be washed; some other cleaning method should be used .

What kinds of soils are there? The older the stain, the more difficult it is to remove. After a certain point, it may be best to leave the stain or soil, or remove it only partially, in order to preserve the rest of the piece. Additionally, soils which may not be detectable to the naked eye might be present in the textile; flags, for instance, may be highly acidic due to long exposure to air pollutants, and should be treated by a professional conservator.

What cleaner is safest and most effective? Commercial detergents should never be used on antique textiles, whatever their claims of gentleness: the chemicals used in most clothes detergents are too harsh for old fibres to withstand. A wide range of speciality detergents are available from conservation suppliers, though most sources suggest Ivory dish soap as a last-minute substitution if needed. Never use chemical spot cleaners, as they are likewise too harsh for old fibres to tolerate. This is especially important for pieces in situ, as this may endanger other nearby pieces as well (the wooden part of an upholstered piece of furniture, for instance) .

What additives and cleaning aids are needed? This can include physical supplies (water, screens, a vacuum cleaner), as well as chemical (water softener, cleaning agents, etc.).

How long can the specimen be exposed to the cleaner? Prolonged exposure may cause additional damage to the fibres.

What mechanical action can be used? The older and more fragile a textile, the less movement it will be able to tolerate during the cleaning process, so this should be considered before undertaking a cleaning.

Once the best cleaning process has been determined, the piece should be prepared for washing. Usually, this involves vacuuming to remove any surface dirt. Linings and backing should also be removed, vacuumed, and washed separately. This is not only to prevent colour bleeding, but to avoid trapping dirt between the layers, which may cause discolouration from the inside. Additionally, different fibres react differently to cleaning, and fabrics may shrink or stretch, which, if still attached together, may cause rippling and distortion in the lining and outer layer of the textile.

As with moving or working with dry pieces, the textile should be washed in a flat, fully supported position. Usually this is achieved through the use of screens like the ones used in vacuuming, though these may be supported in a frame of some kind for added stability. The textile should be sandwiched between two screens. If the piece is particularly delicate or fragile, it may be wrapped in netting, then placed between the screens.

The cleaning solution should be prepared using distilled water. If that is unavailable, softened water may be substituted. The main concern is to avoid hard water, which will leave deposits of minerals in the fibres. The solution should be placed in a container large enough for the textile to lie flat in. For large pieces, it may be necessary to construct a temporary basin outside or in a large room: Putnam and Finch suggest using boards or bricks to constrict a frame, then lining it with a large piece of plastic, weighted on the sides, and strong enough to support the water that will be poured into it. If a smaller basin is used, it should be of ceramic, stainless steel or a stable plastic.

The screen-encased textile is lowered into the solution. The textile can then be washed by pressing a soft sponge directly down onto the fibres. DO NOT RUB the sponge, as this will cause unnecessary abrasion at a moment when the textile is already weak from the water. The textile may be submerged for no more than an hour, and should be rinsed at least four times after it is cleaned (Mailand). The final rinse should always be with distilled water. The textile should be placed to dry on a flat surface or screen, in a well-ventilated room away from heat.

Dry Cleaning

Dry cleaning is generally only used for oil stains, as it is a very stressful process of the textile. Commercial dry cleaners should never be used, as the chemicals used in the process are too strong for old fabrics to withstand without damage. If dry cleaning is absolutely necessary, consult a professional conservator.

Steaming and Ironing

Steaming and ironing textiles should be done with caution, as the heat may affect the viability of the fibres. More importantly, the fabric should always be cleaned before either of these processes is used, since heat may trap dirt and stains in the fibres to such an extent that the stain becomes permanent. Always use the lowest setting for either of these procedures. If a garment relies on folds to maintain its proper shape, it may be better to finger-press the folds into place when the garment is damp and allow it to dry that way, rather than subject it to the added stress of ironing.

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4.4 STABILITY OF FABRIC

Stability properties of any building material are important. If a material changes in size due to change in temperature or humidity, these changes need to be considered when engineering the building. This is very important when designing a tension membrane structure with synthetic resin coated fabric since patterns are cut to a given size to allow for a given pre-tension on the building.

The dimensional stability of an architectural fabric is directly related to the base fabric and the polyester yarns. Seaman only uses polyester yarns in architectural based fabrics, unless a specific design would favor a nylon base cloth. Nylon fibers are not dimensionally stable and should only be used in applications that require growth and shrinkage of the material. The dimensional stability of a base fabric made from polyester yarns is so good that this performance property is generally not specified or tested, other than to require a polyester base fabric. Dimensional stability can be tested and evaluated using ASTM D1204.

4.4.1 Textile Instability

In some cases, the textiles are weakened not by outside causes such as light or pests, but by chemical reactions taking place within the fabric itself, such as *the oxidation of iron-based mordants over time*, which can cause darkening and discolouration in the surrounding fibres.

One example which is cited frequently throughout the literature is the case of "shattered silk." During the late nineteenth and early twentieth centuries, many silk manufacturers treated their fabrics with metallic salts (usually containing tin and iron) to give them a heavier, more luxurious feel. However, as these fabrics have aged, the metals in the fibres have accelerated their decay and caused them to become extremely brittle. The shredded or "shattered" effect this causes is the reason for the name. In this case, the environment of the textile contributes very little to the deterioration from the metallic salts, though exposure to light may accelerate it even further.

Textile preservationists should be familiar with their collections and the history and provenance of their pieces. Chemical tests can reveal the types of dyes and mordants used, as well as any other treatments applied to the fabric. Such knowledge can lead to the prevention of further decay by learning which pieces need to be handled with particular care.

4.5 REACTION TO BLEACHES

4.5.1 Bleaching

If cloth is to be finished white or is to be given serface ornamentation, all natural colours must be removed. This process of decolorization of raw textile material is bleaching. Bleaching is classified in to oxidative bleaching and reductive bleaching. Generally oxidative bleaching is carried out using sodium hypochlorite, sodium chlorite or hydrogen peroxide. Natural fibres like cotton, ramie, jute, wool, bamboo are all generally bleached with oxidative methods. Reductive method of bleaching is done with Sodium hydrosulphite, a powerful reducing agent. Fibers like Polyamide, Polyacrylics and Polyacetates are generally bleached using reductive bleaching technology. After scouring and bleaching, Optical Brightening Agents (OBA), avaialable in different tints such as blue, violet and red, are applied to give the textile material a brilliant white look.

Bleach Clean up

Bleaches are highly reactive chemicals and any such chemicals left on the fabric can hinder the process of dyeing. Thus cleaning of bleach is also done. The bleach is neutralized with a precisely controlled reducing agent.

Bleaching powder may be used for bleaching cotton and linen. The fabric is soaked in a weak aqueous suspension of bleaching powder and exposed to the air when hypochlorous acid is liberated and causes bleaching by oxidation. The process is completed after repeated boiling, washing and exposure to sunlight for up till 6 months.

Uses of Bleaching

Bleach helps the cleaning process by removing and / or decolorizing stains (i.e whiten or lighten colors). The key mechanism is a chemical reaction that "cuts" the stain molecules in smaller pieces that are more easily removed. Bleach can also acts by removing their color so that the stains become invisible. These processes may all work simultaneously on any given organic stain.

Bleach is not only effective on stains but also allows achieving whiteness and dingy cleaning. Dinginess is the overall greyish appearance that white fabrics sometimes develop over time and after many wash cycles.

The first mechanism of bleach action is quite similar to what enzymes do: the larger stain molecules are broken down into smaller, more water-soluble fragments, which are more easily removed by mechanical action or through the action of other detergent ingredients. Unlike enzymes, however, the action mechanism of bleach is a self-destructive one: the bleaching agents disappear in the course of the wash cycle.

The action of bleach complements that of the surfactants and enzymes in the wash. Some soils that surfactants and enzymes may leave behind, or may only partially remove, are removed by bleach. Also, the fragmenting action of bleach makes the job of surfactants and enzymes during the wash easier.

Chlorine can destroy silk and wool which contain proteins, of which the peptide group would be hydrolysed in acid, therefore commercial hypochlorite bleaches should never be used on silk fibres. Instead, hydantoin and cyanurate bleaches, which release chlorine slowly in water, are used. Hence there is less chance of damaging the fabrics. However they impart a hard –to-eliminate odor to fabrics.

4.5.2 Shrinkage

Shrinkage is when a fabric becomes smaller than its original size, usually through the process of laundry. Novice users of modern laundry machines sometimes experience accidental shrinkage of garments, especially when applying heat. Others may intentionally try to shrink a garment in their size. Some may purchase a garment one or more sizes larger in anticipation of shrinkage

4.5.3 Effect of Heat

Heat and humidity can both contribute and a textile's deterioration. However, excessive dryness may also cause damage, especially to elastic fibers, such as wool, which rely on some amount of moisture to maintain their flexibility (Putnam and Finch). Additionally, temperature and humidity should be kept as constant as possible; changes in either of these may cause the textile fibers to expand and contract, which, over time, can also cause damage and deterioration to the textile. For this reason, both storage and display areas should be fitted with monitoring equipment to gauge the temperature and humidity of rooms, display cases, enclosed storage facilities, and work areas.

Ideally, temperature should be kept around 70 degrees Fahrenheit, though some slight fluctuation in either direction is permissible, as long as it occurs gradually . For instance, temperature may be slightly lower in winter to save energy costs, but the change should be effected slowly, so as not to place the fibers under undue stress.

As for humidity, the preservationist or conservator should aim for a relative humidity of 50%, though, as with temperature, some small fluctuation is allowable, as long as it occurs gradually (Mailand). In enclosed display or storage cases, humidity can be somewhat maintained through the use of silica gel crystals. These crystals should not be placed in contact with the textiles, but may be placed in breathable muslin bags and hung inside the case to maintain a constant humidity; they should be monitored periodically, however, to be sure that they are working.

In areas where climate control is unavailable (such as in historic buildings), the conservator can still moderate the temperature and relative humidity through use of fans, humidifiers and dehumidifiers, and portable heating or cooling units.

In addition to temperature and humidity, air flow is also a concern for textile preservation. Textiles should never be sealed in plastic or other air-tight casing unless it is part of a treatment or cleaning process. Proper circulation, combined with the suggested humidity, will help to prevent the growth of mold and mildew, which may stain or weaken antique textiles.

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4.5.4 Pests

Heat setting is a term used in the textile industry to describe a thermal process taking place mostly in either a steam atmosphere or a dry heat environment. The effect of the process gives fibers, yarns or fabric dimensional stability and, very often, other desirable attributes like higher volume, wrinkle resistance or temperature resistance. Very often, heat setting is also used to improve attributes for subsequent processes. Yarns tend to have increased torquing just after spinning, cabling or twisting. Heat setting can influence or even eliminate this tendency to undesirable torquing. At the winding, twisting, weaving, tufting and knitting processes, an increased tendency to torquing can cause difficulties in processing the yarn. When using heat setting for carpet yarns, desirable results include not only the diminishing of torquing but also the stabilization or fixing of the fiber thread. Both twist stabilization and stabilization of frieze effect are results of the heat setting process. Heat setting benefits staple yarns as well as bulked continuous filament (BCF) yarns. Heat setting often causes synthetic fibers to gain volume as well. This volume growth is commonly described as "bulk development". All processes using temperature and/or moisture to give textiles one of the above mentioned attributes are known as heat setting. The term "thermal fixation" is used less frequently. In the carpet industry, the process is exclusively called "heat setting".

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4.5.5 Effect of Light

Light can have a variety of effects on textiles over time. In some cases, it may contribute to fading or discoloration, but of more concern is the damage which the fibers may suffer under prolonged exposure to non-visible light, such as ultraviolet and infrared lighting. Ideally, textiles should be stored or displayed in as little light as possible, and preferably in total darkness. However, as this is impractical for display and care of the piece, knowing the limits of lighting as well as the safest amounts of lighting, become important.

Natural light is the most common source of ultraviolet light, and as such, care should be taken to avoid exposure to direct sunlight at all costs, and indirect sunlight whenever possible. This may mean storing or displaying textiles in an area without windows, or with blackout curtains, which can be pulled whenever the room is not in use. If a room relies on natural light, UV screens or coatings can be applied to the windows to block harmful rays while still allowing light to pass through. These filters should be checked periodically, however, as they have a limited lifespan and may need to be replaced every few years.

Fluorescent and halogen-produced light can also produce large amounts of UV radiation, though filters which fit over the bulbs are available to limit the damaging light . These filters will need to be replaced when the bulbs are changed, so maintenance staff should be aware of them and their use.

One advantage of fluorescent lights is that they produce little heat, which may also be harmful to textiles. Incandescent lights produce a large amount of heat in addition to large quantities of infrared radiation, which is likewise damaging to the fibers in antique textiles. If incandescent lights must be used, they should be placed far enough away from display cases that their heat does not affect the contents.

In the case of particularly delicate textiles, display organizers might consider motion-activated or timed lighting, or lighting controlled though a visitor-activated switch, which would allow the textiles to remain in darkness when they are not under view . All textiles should be displayed on a rotating schedule, allowing them a few months of display, then the rest of the year in dark storage, to prolong their life.

4.5.6 Effect of Mildew

Mildew is a thin, often whitish to bluish-green growth produced by molds on many surfaces. Molds are simple plants belonging to the group known as fungi. Though molds are always present in the air, those that cause mildew only need moisture and a certain temperature in order to grow.

4.5.7 Effects of Mold and Mildew

Molds that cause mildew to flourish in areas that are damp, warm, poorly lighted or where air is not circulated: basements, crawl spaces of houses without basements and closets. Mold and Mildew also grow on draperies, rugs and shower curtains -- anything from which they can get enough food. This includes cellulose products such as cotton, linen, wood, paper and protein substances such as silk, leather and wool.

In addition to an unpleasant musty odor, molds and mildew cause considerable damage if permitted to grow. Mold and Mildew discolor fabrics and sometimes eat into them until the fabrics rot and fall apart. Leather, paper and wood also become discolored and are eventually damaged by mold and mildew.

Prevention is the best mildew policy. If things are kept clean, well-ventilated and dry, your chances of having mildew are greatly lessened.

Mildew Prevention

Keep Things Clean

Keep closets, dresser drawers, basements - any place where mildew is likely to grow - as clean as possible. Soil on articles can supply enough food for mildew to start growing when moisture and temperature are right. Greasy films, such as those that form on kitchen walls, also contain many nutrients for mildew-causing molds.

Get Rid of Excess Moisture

1. Remove the cause

The first step in mildew control is to try to control the dampness inside the home. Cooking, laundering and bathing, without adequate ventilation, adds three gallons of water to the air everyday. Dampness in any structure is caused by condensation of moisture from humid air onto cooler surfaces. Excessive moisture collection may mean that a corrective measure is needed in the attic, crawl space or basement walls. (For information, please request "Moisture Control in Homes").

2. Dry the air

Cleaning Mildew Mechanically. Cool air holds less moisture than warm air. Properly-installed air-conditioning systems remove moisture from the air of the living space by taking up warm air, cooling it (removing the moisture) and circulating cool, dry air back into the room. Use dehumidifiers in areas that are not air conditioned, especially the basement. You can attach a humidistat to the unit to control the humidity. If necessary, heat the house for a short time to get rid of dampness. Then open doors and windows to let out the moisture-laden air. Use an exhaust fan to force it out. Dry air in closets and other small areas with a continuously-burning electric light (60 to 100-watt bulb). The heat from the bulb will prevent mildew if the space is not too large.

Cleaning Mildew Chemically

Moisture-absorbing silica gel, activated alumina, anhydrous calcium sulfate and a product called "Molecular sieves" may be used to dry the air. These chemicals

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are not harmful to fabrics and feel dry even when saturated; they hold half their weight of water.

To use, hang cloth bags of the chemical in clothing closets. Or place open container of it in the closet - on a shelf preferably, or on the floor. See that the door is well sealed and kept closed so that moisture from outside air will not go in. You may scatter the dry granules through layers of clothing and other articles that are to be stored in tightly-closed chests or trunks. Another moisture-absorbing chemical is anhydrous calcium chloride. It is available in small, white granules that hold twice their weight of water. Because it liquefies as it absorbs moisture, do not let this chemical touch clothing or household textiles; it can make holes in them.

To use anhydrous calcium chloride, place the granules in a simple cup-shaped container made from nonrusting screen or waxed cardboard perforated with small holes. Support the container in an enameled pot so the liquid can drip away from the container, leaving the calcium chloride to take up more moisture. Then place the pot in the closet, preferably on the shelf, and keep the door shut tightly and sealed. One pound of calcium chloride will last from two weeks to two months, depending on the humidity. When only liquid is left, discard and start over.

3. Circulate the Air

Air movement is very important to removing moisture. When the air outside is drier than the air inside, the dry air enters, takes up excess moisture and then travels back outside. When natural breezes are not sufficient, you can use electric fans. Poorly-ventilated closets get damp and musty during continued wet weather, and articles stored in them are apt to mildew. Try to improve the air circulation by opening the closet doors or by installing a fan. In addition, hang clothes loosely so air can circulate around them. Cooking, laundering, and bathing may add three gallons of water a day to the house, which can cause the moisture build-up unless circulation is adequate. It is often necessary to use some type of exhaust fan.

Get Rid of Musty Odors

Musty odors, which indicate mold growth, are sometimes noticeable in basements and shower stalls. Take special precautions to get rid of musty odors as soon as possible to prevent further objectionable and damaging mold growth. Usually musty odors disappear if the area is well heated, ventilated and dried. If odors remain, the following treatments may be necessary.

Basements. Use chlorinated lime (commonly called chloride of lime or bleaching powder) to remove musty odors in basements. Sprinkle this chemical over the floor. Leave it until all mustiness disappears, then sweep it up.

Cement and Tile. Scrub cement floors, tiled walls and bathroom floors with a very dilute solution of sodium hypochlorite or any chlorine bleach available in grocery stores. Use one-half to one cup of liquid household bleach to a gallon of water. Rinse with clear water and wipe as dry as possible.

Keep windows open until walls and floors are thoroughly dry. Aerosol sprays for cleaning and sanitizing bathroom walls are also available.

Mildew Removal

Mildew Removal from Clothing and Fabrics

Remove mildew spots as soon as you discover them. Brush off surface growth outdoors to prevent scattering the spores in the house. Sun and air fabrics thoroughly. If any mildew spots remain, treat washable articles as described below. Dry-clean non-washable articles. Wash mildew-stained articles once with soap and water, rinse them well and dry them in the sun. If any stain remains, use one of the following bleaches:

1. Lemon juice and salt. Moisten stain with lemon juice, spread on salt and place in the sun to dry. Rinse thoroughly. Use with care on colored fabrics.
2. Perborate bleach. Mix one tablespoon sodium perborate bleach and one pint of water. Use hot water if it won't damage the fabric, otherwise use lukewarm water. Sponge or soak the stained area. Allow to remain one-half hour, then rinse. Test on colored garments first.
3. Chlorine bleach. Mix two tablespoons of liquid chlorine bleach with one quart of warm water. Sponge the stain or soak the stained area in the solution. Allow the bleach to remain on the fabric from five to 15 minutes, then rinse.

An additional soaking in weak vinegar (two tablespoons to a cup of water) will stop further bleach action. Never use a chlorine bleach on silk, wool, or Spandex fabrics. Some fabrics with wash-and-wear or other special finishes may be damaged by chlorine bleaches. Articles with such fine finishes usually have a warning label or on a hang tag attached to the garment when it is sold.

Mildew Removal from Upholstered Articles, Mattresses

For cleaning mildew, first, remove loose mold from outer covering by brushing. Do this outdoors if possible. Run a vacuum cleaner attachment over the surface to draw out more of the mold. Do everything conveniently possible to dry the article, such as using an electric heater. Sun and air the article to stop mold and mildew growth.

Another way mildew removal from upholstered furniture is to wipe it with a cloth wrung out in a solution of one part denatured alcohol to one cup of water. Dry thoroughly. Use a fungicide available in aerosol cans to get rid of musty odors and mildew. You can use vapors of paradichlorobenzene or paraformaldehyde in closed areas. Mildew that has reached the padding of cushions and mattresses must be cleaned by a storage company that has facilities for fumigation.

Cleaning Mildew from Rugs and Carpets

To remove mildew stains sponge rugs and carpets with thick, dry soap or detergents suds and wipe clean with a damp cloth, or clean them with an electric

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shampoo machine. If the problem is that of excess water (example -- flooding due to burst pipes or washer overflow) the procedure is somewhat different. Immediate action is important to keep mildew from starting up. First, determine how much water has been absorbed by the carpet. To check, raise a portion of the carpet by pulling it off the installation strips at one corner. If the pad is wet, the entire carpet and pad will have to be removed. This is necessary so the sub-floor can dry, which in many cases prevents it from buckling.

When both carpet and pad have been saturated, the best recommendation is to have a professional pick up the carpet and transport it to the plant, where it can be cleaned, deodorized and dried. Some shrinkage should be expected (one to two inches). However if the carpet backing is in good repair, it can be re-stretched to fit the room by a power stretcher. If professional services are not available, it is possible to dry a saturated carpet at home. Using a hot water extraction unit, vacuum the carpet until no more water can be removed. Then place the carpet on a flat surface outside in the fresh air and sunshine. It is important to turn the rug or carpet upside down so that, as the carpet dries, any soil in the carpet backing or along the carpet fibers will be drawn toward the base of the carpet rather than to the surface.

Once the sub-flooring has dried, the dry pad and carpet can then be re-installed. If a musty odor is present in the padding, it is best to replace it. Do not re-install the padding, thinking that, in time the odor will disappear. Once the carpet is placed over the musty odor, the problem will only get worse, since the moisture cannot readily escape. Musty carpet can be deodorized by professional cleaners.

If only the carpet is wet, (padding and sub-flooring are dry) a hot water extraction vacuum may be sufficient to remove the water. These units can be rented in many cities from rental agencies, hardware and grocery stores. Do not attempt to use a home vacuum unless it is specifically designed as a wet vacuum.

4.5.7 Resistance to Insects

Textile preservation refers to the processes by which textiles are cared for and maintained to be preserved from future damage. The field falls under the category of art conservation as well as library preservation, depending on the type of collection. In this case, the concept of textile preservation applies to a wide range of artifacts, including tapestries, carpets, quilts, clothing, flags and curtains, as well as objects which "contain" textiles, such as upholstered furniture, dolls, and accessories such as fans, parasols, gloves and hats or bonnets. Many of these artifacts require specialized care, often by a professional conservator.

Pests are another significant threat to textile collections, as there are a number of creatures which can cause damage to fibres. Among the most common are clothes moths, carpet beetles, silverfish, firebrats and rodents.

Clothes moths are attracted to protein fibres, and so are especially drawn to silk, wool, and feathers. An infestation might be identified through the evidence of white cocoons (or the remnants thereof) on the textiles, or of sighting the insects themselves. They are roughly 8 centimetres long and white in colour .

Like clothes moths, carpet beetles are likewise drawn to proteins, and can be quite destructive. Evidence of an infestation may take of the form of chewed holes, carcasses, or larvae, which appear as small pale worm-like insects .

Silverfish and firebrats are related insects which consume starch, usually found in sizing or other treatments applied to fabrics, as well as plant-based textiles such as linen and cotton. Both are attracted to dark, moist climates, though silverfish prefer cooler temperatures, while firebrats tend towards warmer. Both are about 12 millimetres in length and either light or dark in colouring, depending on which type is present .

Rodent infestations can be identified in the usual ways, such as seeing droppings, nests, or comparatively large chewed areas of textile where they have caused damage.

In all cases, chemical means of pest control should be avoided if possible, not only due to harm to humans who come in contact with them, but because the chemicals may cause damage to the very textiles the conservator is trying to save. For rodents, snap traps may be effective, and if needed, a professional exterminator should be called. Poison baited traps should be avoided, as the rodent could die somewhere inaccessible, and provide a breeding ground for further pests . Also, in the case of a rodent infestation, all access points to the room (such as cracks or holes) through which they might be entering should be located and sealed if possible .

For insects, keeping clean storage, display, and work environment is the best method of prevention. Also, sticky traps (replaced often) around doors, windows, and display cases may be useful for monitoring the insect population. Furthermore, the population of carnivorous insects, such as spiders, should be observed. While such insects are not harmful to textiles by themselves, they may indicate another population of insects which are .

If the infestation can be limited to one or a few pieces, the insects may be killed through freezing of the object. The textile should be wrapped in plastic and vacuum-sealed, then brought to a freezing temperature as quickly as possible, to prevent the insects from adjusting to the cold. The object may be left frozen for several days, but should be brought slowly back up to room temperature to avoid further damage . Note that while this method should kill adults, it may not destroy any eggs that are present.

If chemical means must be employed, it would be best to consult with a professional conservator to be certain that the treatment will not harm the textiles themselves.

Even if no signs of an infestation are present, textiles should still be inspected periodically to be certain that there is no outbreak that has gone unobserved. Additionally, when dealing with a new acquisition which shows signs of insect damage, the specimen should bequarantined until it can be

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determined whether the insects are still present before introducing it to the rest of the collection.

4.5.8 Scouring

Raw textile materials, in their natural form,haveadditives, dirt, soil and other impurities that are not suitable for clothing materials. Pesticides, fungicides, worm killers, etc are also there in these raw materials. The removal of these matters is called scouring. It is done by adding suitable wetting agents, alkali or other chemical or non chemical materials. After scouring, the fabric gives better wetting and penetration properties. This makes the subsequent bleach process easy resulting in better dye uptake.

4.6 REACTION TO ALKALIS AND ACIDS

Continuous contact with the human perspiration also affects the fastness of some the dyed fabrics. In fact the perspiration is found to be either slightly alkaline or acidic in nature. When fabric is subjected to this alkaline or acidic perspiration continuously some times the tone and depth of the dyed shade gets affected. We can see how this change can be tested by artificially simulating the perspiration condition.

4.5.1 Affinity for Dyes

A dye can generally be described as a colored substance that has a chemical affinity to the substrate to which it is being applied. The dye is generally applied in an aqueous solution, and may require a mordant to improve the fastness of the dye on the fiber. Dyeing is the process of imparting color to a textile material in loose fiber, yarn, cloth or garment form by treatment with a dye

While dyeing, large volume of dyestuff, thickening agent and small amount of water are used. Many textile chemicals like Dispersing agent, Leveling agent, Acid buffer etc are used during the process. The dyestuff have to be either fermented (for natural dye) or chemically reduced (for synthetic vat and sulfur dyes) before being applied. This makes the dye soluble so that it can be absorbed by the fiber. Direct dyes are water soluble and can be applied directly to the fiber from an aqueous solution. Most other classes of synthetic dyes, other than vat and sulfur dyes, are also applied in this way.

Dyeing decorates fabric by imparting colours which can further be enhanced by printing colour designs on the finished cloths. Many kinds of dyes are used for printing including vat, reactive, naphthol, disperse and pigment colours among others. These are fixed to the fiber by means of resins. Sometimes cheap prints are also made with basic colours mixed with tartar emetic and tannic acid. Silk is usually printed with acid colours. Wool is treated with chlorine to make it more receptive to colours and to prevent shrinking and is printed with acid or chrome dyes. Fabics made of synthetic fibers are generally printed with disperse and cationic dyes.

4.7 PROBLEMS IN FINISHING PROCESSES AND THEIR SOLUTIONS

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It has been found that 70% of the problems in finishing processes are due to poor treatment of the fabric. Thus it becomes essential to give emphasis on right kind of chemicals and process control parameters right from pretreatment to ultimate dyeing and printing steps for getting best finished textile.

Some of the faults due to poor pretreatment can be listed as poor absorbency, catalytic damage or poor fluidity, stains , Moire effect, shade change from selvedge to selvedge, shrinkage/distortion, creasing/chafe marks, inferior brightness/luster, cloudy dyeing, skitteriness, pale areas, darkspots, ropemarks etc. Most of these faults can be easily corrected with certain precautions like use of specialty chemicals, suitable heat setting temperatures, thorough relaxation of the material, controlled tension and uniformity of batching during pretreatment and checking for rough patches in the machine.

While dyeing, selection of dyes with better dispersion stability, use of efficient dispersants, controlled heating when the dye exhibits a particularly high rate of exhaustion, use of anti foamers and special chemicals like welting agent or defoamer combinations etc. can give the best results.

4.8 SOME OTHER CHEMICAL BASED PROCEDURES OF TEXTILE MANUFACTURING

4.8.1 Desizing

During weaving, specially for the fabrics made from cotton or blends, the warp threads are coated with an adhesive substance known as 'size'. This is done to prevent the threads from breaking during weaving. Starch and its derivatives are the most common sizing agents. After weaving, the 'size' is removed again in order to prepare the fabric for dyeing and finishing. This is called Desizing. It is done by treating the fabric with chemicals such as acids, alkali or oxidising agents.

4.8.2 Fabric softening

Fabric softener also called Fabric Conditioner is used to prevent static cling and make fabric softer. Their use may however reduce the water absorption capabilities of the fabric. Fabric softeners work by coating the surface of the cloth fibers with a thin layer of chemicals. These chemicals have lubricant properties and are electrically conductive, resulting in smoother feel and preventing the buildup of static electricity. It also increases resistance to stains and reduces wrinkling.

4.8.3 Mercerization

In this process, textiles (typically cotton) are treated with a caustic solution for improving properties such as fiber strength, shrinkage resistance, luster, and

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dye affinity. Higher-end fabrics may be double or triple mercerized for added benefits. The treatment consists of dipping the yarn or fibre in a solution of sodium hydroxide and then treating the material with water or acid to neutralize the sodium hydroxide.

4.9 STUDENT ACTIVITY

1. Write a note on the comparative characteristics of fabrics.

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2. Write a note on the strength, elasticity and resilience in fabrics.

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   ....

4.10 SUMMARY

- Textiles, of fabrics, are materials which are comprised of natural or artificial fibers, thread or yarns. Raw fibers like wool, cotton, and linen a few of the most common fibers used to create the fabrics we use to create clothes. The fibers are woven, knitted, crochet, knotted or pressed together to create different types of textured cloth. Knowing the properties and characteristics of textiles is one of the basic skills for anyone interesting in fashion design or tailoring.
- The strength of a fabric has much to do with its wearing quality, but there can be no fixed standard. Each fabric should be sufficiently strong for the purpose for which it is intended.
- Various processes are carried by the textile production units where different chemicals find their usage. These processes include, Scouring, Bleaching, Desizing, Softening, Mercerization, Dyeing, etc.

4.11 GLOSSARY

- Dye: A dye can generally be described as a colored substance that has a chemical affinity to the substrate to which it is being applied. The dye is generally applied in an aqueous solution, and may require a mordant to improve the fastness of the dye on the fiber. Dyeing is the process of imparting color to a textile material in loose fiber, yarn, cloth or garment form by treatment with a dye.
- Heat-Setting: The process of conferring dimensional stability and often other desirable properties such as wrinkle resistance and improved heat resistance to man-made fibers, yarns, and fabrics by means of either moist or dry heat.

- Synthetic Dyes: Synthetic dyes quickly replaced the traditional natural dyes. They cost less, they offered a vast range of new colors, and they imparted better properties upon the dyed materials. Dyes are now classified according to how they are used in the dyeing process.
- Acid Dyes: Acid dyes are water-soluble anionic dyes that are applied to fibers such as silk, wool, nylon and modified acrylic fibers using neutral to acid dyebaths. Attachment to the fiber is attributed, at least partly, to salt formation between anionic groups in the dyes and cationic groups in the fiber. Acid dyes are not substantive to cellulosicfibers.
- Basic Dyes: Basic dyes are water-soluble cationic dyes that are mainly applied to acrylic fibers, but find some use for wool and silk. Usually acetic acid is added to the dyebath to help the uptake of the dye onto the fiber. Basic dyes are also used in the coloration of paper.
- Direct Dyeing: Direct or substantive dyeing is normally carried out in a neutral or slightly alkaline dyebath, at or near boiling point, with the addition of either sodium chloride (NaCl) or sodium sulfate ($Na2SO4$). Direct dyes are used on cotton, paper, leather, wool, silk and nylon. They are also used as pH indicators and biological stains.
- Vat Dyes: Vat dyes are essentially insoluble in water and incapable of dyeing fibers directly. However, reduction in alkaline liquor produces the water soluble alkali metal salt of the dye, which, in this leuco form, has an affinity for the textile fiber. Subsequent oxidation reforms the original insoluble dye.
- Hydrophilic: having strong affinity for or the ability to absorb water.
- Hydrophobic: lacking affinity for or the ability to absorb water.
- Hydroscopic: Having the ability to absorb moisture from the atmosphere. All fibers have this property in varying degrees.

4.12 REVIEW QUESTIONS

1. What do you understand by the comparative characteristics of fabrics?
2. What are the qualities of strength, elasticity and resilience in fabrics?
3. Define the derivability in the fabric yarn.
4. Explain the heat conductivity, absorbency, cleanliness and satability of fabrics.
5. Discuss about the effect of heat and light on the production of fabrics.
6. Write short notes on:
   (a) Effects of mildew
   (b) Resistance to insects in fabrics
   (c) Reaction to alkalis and acids
   (d) Bleaching

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UNIT

5

INSULATION FABRICS

STRUCTURE

5.1 LEARNING OBJECTIVE

After completion of this unit, you should be able to:

- Define the insulation fabrics.
- Describe the production of quitted fabrics.
- Discuss about the composition of quitted fabrics
- Explain the characteristics of imitation fur.
- Learn about knitwear and care of hosiery underwear and outwear.

5.2 INTRODUCTION

The fabrics which help insulate the body are termed as insulation fabrics. There are many methods of insulating the body. Wool and cotton are the most common methods in use today. Wool is better at insulating the body because it retains its insulative properties even when wet. Wool is better at insulating the body due to it allows the skin to evaporate moisture whereas cotton does not". In fact, while both wick moisture away from the skin, wool retains its insulative properties when wet and cotton does not retain such characteristics.

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5.3 INSULATION FABRICS

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There is some evidence that wool actually generates heat when wet (not sure exactly how but sheep have had millions of years of evolution to develop an all-weather insulating pelt). Cotton is much less effective because it wicks moisture (sweat) away from the body, thus cooling you down. It is commonly observed by survival experts that if caught out in the cold and rain in cotton clothing, you are better to strip naked because wet cotton is such an effective conductor of heat you will actually become hypothermic (and dead) quicker in a cotton T-shirt and jeans than you would with no clothes at all. A new product on the market called thinsulate ultra is one of the best.

5.3.1 Types of Fabric Used for Blown Insulation

Blown insulation is a very popular form of home insulation used today. Instead of having large rolls of insulation installed by hand, one by one, insulating materials can be blown into an attic or behind walls much quicker and with the same results. There are different types of fabric (including synthetic and natural products) that can be used in blown insulation.

Cellulose

Blown-in insulation can be made of cellulose plant material, particularly industrial use cotton but also other plant derivatives. It has an R-value, or thermal resistance, slightly lower than fiberglass, but it is easy to install and does not irritate the skin. As an organic material, cellulose is a great option for those who want environmentally green homes.

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Rock Wool

Rock wool is not exactly what it may sound like. There is no actual wool in it at all. Rock wool is fabric manufactured by blowing a very powerful jet stream of air through melted rock or slag. It produces a fibrous material that is great for insulation. It makes an area highly soundproof and has an R-value greater than fiberglass.

Fiberglass

- Traditional fiberglass insulation also comes in a sprayed fiber form. It is just like fiberglass batting (the rolled sheets) and has the same insulating properties, except it has an adhesive mixed in to prevent settling. Like other forms of sprayed or blown-in insulation, it may need an extra vapor barrier.

5.4 QUILTED FABRICS

Quilting is a technique of padding a fabric. It consists of two layers, with batting between the top and the backing fabric. Next it is stitched with decorative designs or threads tied through all thickness inorder to prevent the batting from shifting. The quilting stitches are spaced with regularity. The multiple lines of a running stitch is done by hand or by sewing machine.

Quilting is a sewing method done either by hand, by sewing machine, or by a longarm quilting system. A person who takes on quilting as an occupation is called a **quilter**.

The process of quilting uses a needle and thread to join two or more layers of material together to make a quilt. Typical quilting is done with three layers: the top fabric or quilt top, batting or insulating material and backing material. The quilter's hand or sewing machine passes the needle and thread through all layers and then brings the needle back up. The process is repeated across the entire piece where quilting is wanted. A straight or running stitch is commonly used and these stitches can be purely functional or decorative and elaborate. Quilting is done on bed spreads, art quilt wall hangings, clothing, and a variety of textile products. Quilting can make a project thick, or with dense quilting, can raise one area so that another stands out.

All fabrics used in quilting are pre-washed as well as pressed. The fabrics are easy to needle. They are lightweight and comfortable. Quilting fabrics for pillows and clothing are very luxurious. They drape and wear beautifully.

5.4.1 History

There is a common belief that quilting originated for its utility rather than decoration. The origins of this method of craft are thought to be in the Crusades, when soldiers needed warmth as well as protection from the chafing caused by heavy armor. Additionally, there are ancient Egyptian sculptures showing figures which appear to be wearing clothing which is quilted, possibly for warmth in the chilly desert evenings. In the 14th century, the gambeson was a popular form of armour.

In American Colonial times most women were busy spinning, weaving and making clothing. Meanwhile women of the wealthier classes prided themselves on their fine quilting of wholecloth quilts with fine needlework. Quilts made during the early 1800s were not constructed of pieced blocks but instead whole cloth quilts. Broderie perse quilts and medallion quilts were made. Some antique quilts made in North America have worn-out blankets or older quilts as the internal batting layer, quilted between new layers of fabric and thereby extending the usefulness of old material.

During American pioneer days "paper" quilting became popular. Paper was used as a pattern and each individual piece of cut fabric was basted around the paper pattern. Paper was a scarce commodity in the early American west and women would save letters from home, newspaper clippings, and catalogs to use as patterns. The paper not only served as a pattern but as an insulator. The paper found between the old quilts has become a primary source about pioneer life.

Quilts made without any insulation or batting were referred to as summer quilts. They were not made for warmth, only to keep the chill off on cooler summer evenings.

Harriet Powers, a slave-born African American woman, made two famous story quilts. She was just one of the many African American quilters who contributed to the evolution of quilting.

In modern times, art quilts have started to become popular for their aesthetic and artistic qualities rather than for functionality (they are displayed on a wall rather than spread on a bed).

5.4.2 Types and Equipment

Many types of quilting exist today. The two most widely used are hand-quilting and machine quilting.

Hand Quilting is the process of using a needle and thread to sew a running stitch by hand across the entire area to be quilted. This binds the layers together. A quilting frame or hoop is often used to assist in holding the piece being quilted off the quilter's lap. A quilter can make one running stitch at a time; this is called a stab stitch. Another option is called a rocking stitch, where the quilter has one hand, usually with a finger wearing a thimble, on top of the quilt, while the other hand is located beneath the piece to push the needle back up. The third option is called "loading the needle" and involves doing four or more stitches before pulling the needle through the cloth. Hand quilting is still practiced by the Amish within the United States, and is enjoying a resurgence worldwide.

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Machine Quilting is the process of using a home sewing machine or a Longarm machine to sew the layers together. With the home sewing machine the layers are tacked together before quilting. This involves laying the top, batting and backing out on a flat surface and either pinning (using large safety pins) or tacking the layers together. Longarm Quilting involves placing the layers to be quilted on a special frame. The frame has bars on which the layers are rolled, keeping these together without the need for basting or pinning. These frames are used with a professional sewing machine mounted on a platform. The platform rides along tracks so that the machine can be moved across the layers on the frame. A Longarm machine is moved across the fabric. In contrast, the fabric is moved through a home sewing machine.

Tying is another technique of fastening the three layers together (and is not a form of quilting at all). This is done primarily on quilts that are made to be used and are needed quickly. The process of [http://www.nmia.com/mgdesign/qor/begin/tying.htm tying] the quilt is done with yarns or multiple strands of thread. Square knots are used to finish off the ties so that the quilt may be washed and used without fear of the knots coming undone. This technique is commonly called "tacking". In the mid-west, tacked bed covers are referred to as comforters.

Quilting is now taught at schools in some states.

5.4.3 Processes and Definitions

What is quilting fabric? Well, there are many schools of thought on that subject. You can use many different types of fabrics in quilts, but the primary type is cotton fabric, usually referred to as broadcloth or gingham. Cotton wears very well and tends to hold color and not fade over time, if quality dyes are used in the manufacturing process.

Quilting fabrics are available online at literally thousands of websites. An experienced quilter will do most of their shopping on the Internet, where you can comparison shop from the comfort of your living room, rather than going from store to store! Quilting supply retailers will often extend discounts to their online customers, so pay attention to the sales as you let your fingers do the shopping!

When choosing quilting fabric, be sure to select only one type per quilt, as not all fabrics wear in the same way, and a heavier fabric can stretch or tear a lighter one such as cotton. It is best to use one fabric type, unless you are making a crazy quilt. Broadcloth is probably the most popular type of cotton fabric used today and tends to be relatively inexpensive, with a wide ranging color palette and print availability. Another popular type of quilt fabric is batik, which is cotton that is dyed in the batik style, making for rich, deep true colors that do not run or fade with washing. Batik will generally cost more than plain cotton broadcloth, but makes for a striking addition to any quilt.

You can also use muslin to make quilts, although it is primarily utilized as a backing material. Quilts are composed of three layers: the quilt top, which is what you will see most of time; the batting or wadding, which is what gives the quilt its three dimensional aspect, and finally, the backing material. Quilts are finished by sewing a binding all the way around, generally the same color fabric as the body of the quilt.

Flannel is another popular quilting fabric. It is most commonly used in baby quilts for its soft quality and wearability. Flannel adds a little weight to a quilt, and a great deal of warmth. Whatever type of quilt you choose to make, select one kind of fabric and have fun sewing!

Traditional

Traditional quilting is a six-step process that includes: 1) selecting a pattern, fabrics and batting; 2) measuring and cutting fabrics to the correct size to make blocks from the pattern; 3) piecing (sewing cut pieces of fabric together using a sewing machine or by hand to make blocks) blocks together to make a finished "top"; 4) layering the quilt top with batting and backing, to make a "quilt sandwich"; 5) quilting by hand or machine through all layers of the quilt sandwich; and 6) squaring up and trimming excess batting from the edges, machine sewing the binding to the front edges of the quilt and then hand-stitching the binding to the quilt backing. Note: If the quilt will be hung on the wall, there is an additional step: making and attaching the hanging sleeve.

Piecing: Sewing small pieces of cloth into patterns, called blocks, that are then sewn together to make a finished quilt top. These blocks may be sewn together, edge to edge, or separated by strips of cloth called sashing. Note: Whole cloth quilts typically are not pieced, but are made using a single piece of cloth for the quilt top. Layering: Placing the quilt top right side up atop the batting and the backing, which is right-side out.

Quilting: Sewing the three quilt layers together, using stitches in decorative patterns, called motifs, or in utilitarian patterns, such as straight lines, using bigger stitches. Borders: Typically strips of fabric of various widths added to the perimeter of the pieced blocks to complete the quilt top. Note: borders may also be made up of simple or patterned blocks that are stitched together into a row, before being added to the quilt top. Binding: Fabric strips cut on the bias or straight of the grain, sewn together, making a long strip that will fit the perimeter of the quilt, which is typically machine sewn to the front side of the edge of the quilt, folded over, and hand sewn to the back side of the quilt. Quilting: Stitching through all three layers of the quilt sandwich, typically by hand or machine in decorative patterns, which serves three purposes: 1) to secure all three layers to each other, and 2) to add to the beauty and design of the finished quilt, and 3) to trap air within the quilted sections, making the quilt as a whole much warmer than its parts; for example, a single layer or all three layers used separately. Quilting is usually completed by starting from the middle, and moving outward toward the edges of the quilt. Examples: simple or complex geometric grids, "motifs" traced from published quilting patterns or traced pictures, complex repeated designs called *tessellations,* or stitching within the seam line itself, i.e., stitching in the ditch.

Quilting can be elaborately decorative, comprising stitching fashioned into complex designs and patterns. The quilter may choose to emphasize and add to the richness of the quilting, by using threads that are multicolored and/or metallic, or that contrast highly to the fabric. Conversely, the quilter may choose to make the quilting disappear, using "invisible" nylon or polyester thread, and stitching in the ditch (in the seam line). Some quilters draw the quilting design on the quilt top before stitching, while others stitch "freehand."

While the majority of quilt tops are pieced from many smaller patches of fabric (patchwork quilts), in which the patterns of individual blocks, or the pattern created by combining the blocks is the emphasis, whole cloth quilts typically use a single, non-figural piece of fabric and the elaborate quilting is the emphasis. Polished chintz, sateen or other shiny fabrics are often used in whole cloth quilts to aid in emphasizing the intricately detailed quilting stitches.

Quilting is often combined with embroidery, patchwork, applique and other forms of needlework.

PILE FABRICS

In textiles, **pile** is the raised surface or nap of a fabric, which is made of upright loops or strands of yarn. Examples of pile textiles arecarpets, corduroy, velvet, plush, and Turkish towels. The word is derived from Latin *pilus* for "hair"

The surface and the yarn in these fabrics also called "pile". In particular "pile length" or "pile depth" refer to the length of the yarn strands (half-length of the loops).

The types of pile include

- **Loop pile (uncut pile)**
- **Cut pile**
- **Knotted pile**

- **Tufted pile**
- **Woven pile**
- **Cord pile**
- **Twist pile**

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Pile weave is a form of textile created by weaving. Pilc fabrics used to be made on traditional hand weaving machines. The warp ends that are used for the formation of the pile are woven over metal rods or wires that are inserted in the shed (gap caused by raising alternate threads) during weaving. The pile ends lie in loops over the inserted rods. When a rod is extracted the pile ends remain as loops on top of the base fabric. The pile ends laying over the rod may be left as 'loop pile', or cut to form 'cut pile' or velvet.

On mechanical looms the technology of 'wire weaving' still exists, using modern technology and electronics. This weaving technique allows users to obtain both loop pile and cut pile in the same fabric. Other techniques involve the weaving of two layers of fabric on top of each other, whereby the warp ends used for the pile are inserted in such a way that they form a vertical connection between the two layers of fabric. By cutting the pile ends in between the two layers one obtains two separate pile fabrics. With this technique only the cut pile effect can be obtained. This is known as 'face-to-face weaving'. Both 'wire weaving' and 'face-to-face' weaving are used for the manufacturing of upholstery and furnishing fabrics as well as in rug making. Pile weave or knotted weave is the method of weaving used in most rugs. In this technique the rug is woven by creation of knots. A short piece of yarn is tied by hand around two neighboring warp strands creating a knot on the surface of the rug. After each row of knots is created, one or more strands of weft are passed through a complete set of warp strands. Then the knots and the weft strands are beaten with a comb securing the knots in place. A rug can consist of 25 to over 1,000 knots per square inch.

Warp Pile Weave

Velvet: Velvet is a type of woven tufted fabric in which the cut threads are evenly distributed, with a short dense pile, giving it a distinctive feel. Velvet can be made from many different kinds of fibres. It is woven on a special loom that weaves two pieces of velvet at the same time. The two pieces are then cut apart and the two lengths of fabric are wound on separate take-up rolls.

Velvet was expensive to make before industrial power looms became available. Velvet is difficult to clean because of its pile, but modern dry cleaning methods make cleaning more feasible.Velvet pile is created by warp or vertical yarns and velveteen pile is created by weft or fill yarns.

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Velvet is often made from silk. Velvet made entirely from silk has market prices of several hundred US dollars per yard.

Types of Velvet

Plain - Commonly made of cotton, this type of velvet has a firm hand and can be used for many purposes.

Silk - More expensive than plain velvet, this type is usually shinier and softer than the cotton variety.

Viscose - In terms of quality, this type is more similar to silk velvet than cotton velvet.

Hammered - This type is extremely lustrous, appears dappled, and somewhat crushed.

Embossed - A metal roller is used to heat-stamp the fabric, producing a pattern.

Crushed - This type of velvet can be produced by pressing the fabric down in different directions. Also , it can be produced by mechanically twisting the fabric while wet. The result is patterned appearance that is very lustrous.

Panne - Also a type of crushed velvet, panné is produced by forcing the pile in a single direction by applying heavy pressure.

Devore - This variety is produced with a caustic solution. This dissolves part of the velvet leaving sheer areas of fabric. Usually a definite pattern is produced.

Velveteen is a type of imitation velvet. It is normally made of cotton, or cotton/silk. It has a pile that is short (never more than 3mm deep), and is closely set. It has a firm hand, and a slightly sloping pile. Unlike true velvet, this type has greater body, does not drape as easily, and has less sheen.

Cotton can also be used, though this often results in a slightly less luxurious fabric. More recently, synthetic velvets have been developed, mostly polyester, nylon, viscose, acetate, and mixtures of different synthetics, or synthetics and natural fibers (e.g., viscose and silk). Velvet can also be made from fibers such as linen, mohair, and wool. A cloth made by the Kuba people of the Democratic Republic of Congo from raffia is often referred to as "Kuba velvet".

A small percentage of lycra is used sometimes to give stretch.

Frieze

Terrycloth, a pile fabric (usually cotton) with uncut loops on both sides. The pile in terrycloth is formed by a special weaving arrangement in which three picks or fillings are inserted and beaten up with one motion of the reed. Common varieties include two-pick and three-pick terries with three-pick one being the highest quality, it has two picks under the pile loop and one pick between loops. Each loop acts as a tiny sponge.

Terrycloth is used to make bath towels and bath robes due to its ability of absorbing large amounts of water.

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History of Frieze: In the history of textiles, **frieze** (French: *frisé*) is a Middle English term for a coarse woollen, plain weave cloth with a nap on one side. The nap was raised by scrubbing it to raise curls of fibre, and was not shorn after being raised, leaving an uneven surface. *Panni frisi*, "Frisian cloths", appear in medieval inventories and other documents. Frieze was woven in the English Midlands and Wales, and in Ireland from the fourteenth century, and later in Holland as well. A similar textile is baize. In Old Norse, such cloth was called *vaðmál* (wadmal), and lengths of wadmal were a medium of exchange, especially for the poor who had neither cattle nor silver. Wadmal could be used to pay property tax.In the seventeenth century *Frieze* was applied to linen cloth, apparently as from Frisia, an unconnected usage.

Coarse frieze was manufactured in England for export to Ireland in the nineteenth century. "Frieze cloth,.a mixed and for the most part an unraised fabric, has been manufactured for a series of years, and continues so to be, probably, in increasing quantity", wrote Samuel Jubb in 1860. "This cloth is heavy and sound, rather than fine in quality. It is made... almost entirely for the Irish trade" Frieze was to be seen Jubb noted impassively, worn so threadbare it was reduced to "the merest expression of threads crossing each other at right angles... on the back of an Irish pig-jobber or that of an Irish reaper." The Ulster, a long loose overcoat as worn in Ulster, was made of frieze. Irish frieze found its way to North America: a stock of hooded coats that was brought to Detroit in 1701 included twenty-three made of *frise d'Irlande.*

The term frieze can also be used for the curly nap frieze fabrics have, as well as the action of raising the nap, which differs from standard methods. Today, *frieze* is also a term applied to a textile technique used in modern machine-loomed carpeting, as well as the textile produced. Carpets made with this technique are known for their resilience, due to a high twist rate, outperforming standard cut or loop pile carpets.

Filling Pile Weave

Corduroy, is a texmtile composed of twisted fibers that, when woven, lie parallel (similar to twill) to one another to form the cloth's distinct pattern, a "cord." Modern corduroy is most commonly composed of tufted cords, sometimes exhibiting a channel (bare to the base fabric) between the tufts. Corduroy is, in essence, a ridged form of velvet.

Velveteen: Another form of velvet distinguished by their fiber length and pile yarn position. A velveteen is made of staple fibers and the pile yarn is in filling direction, where velveteen is made of filament fiber and the pile yarn is in warp direction.

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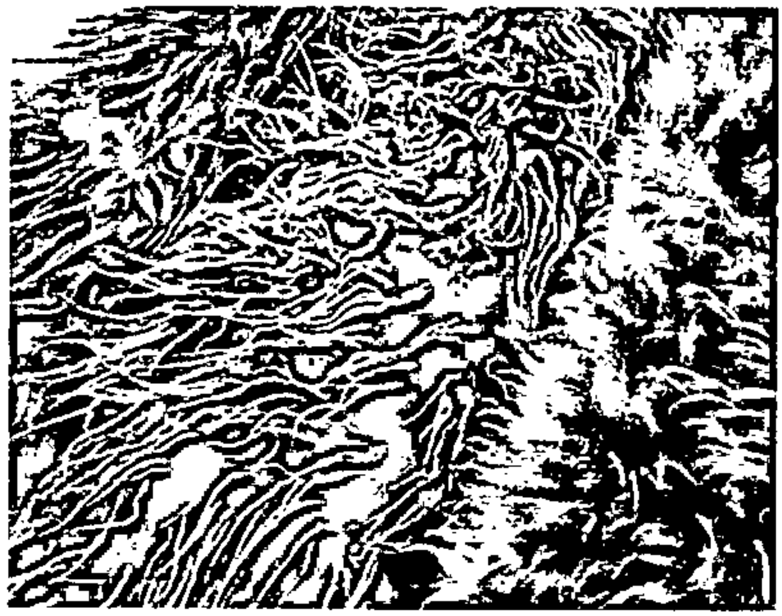

Figure 5.1: Hi-Pile Fabric

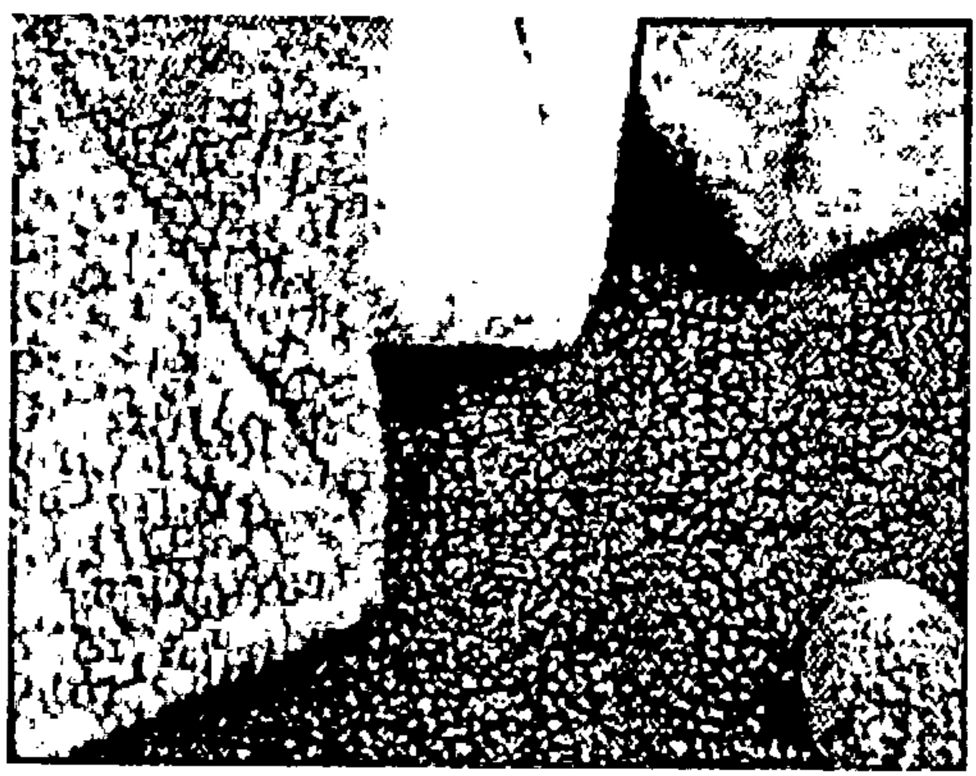

Figure 5.2: Sherpa Fabric

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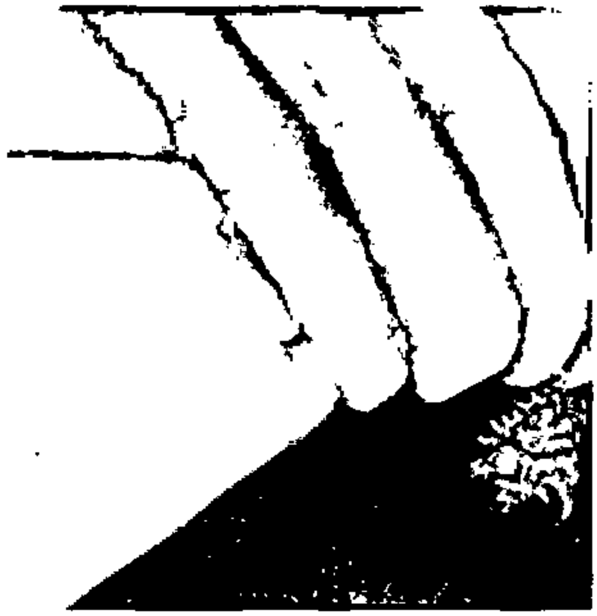

Figure 5.3: Boa Fabric

Figure 5.4: Bonded Fabric

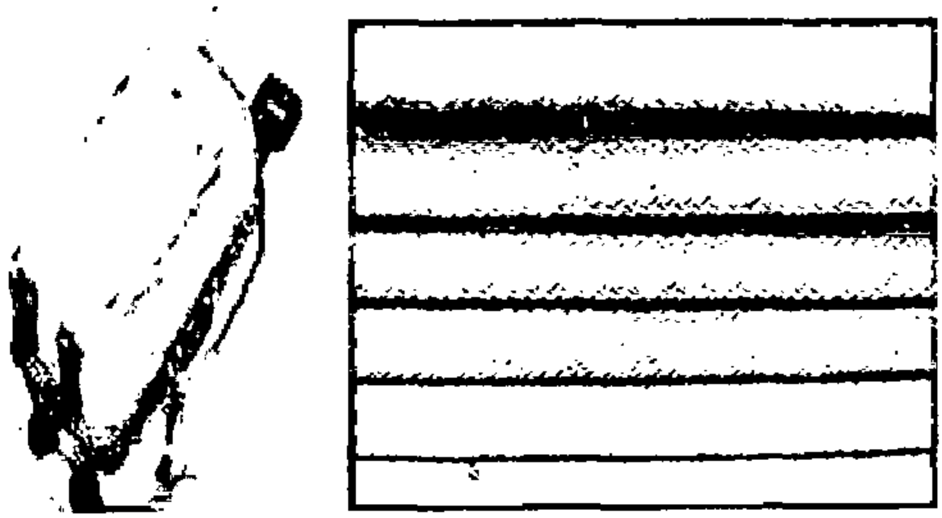

Figure 5.5: Suede Fabric

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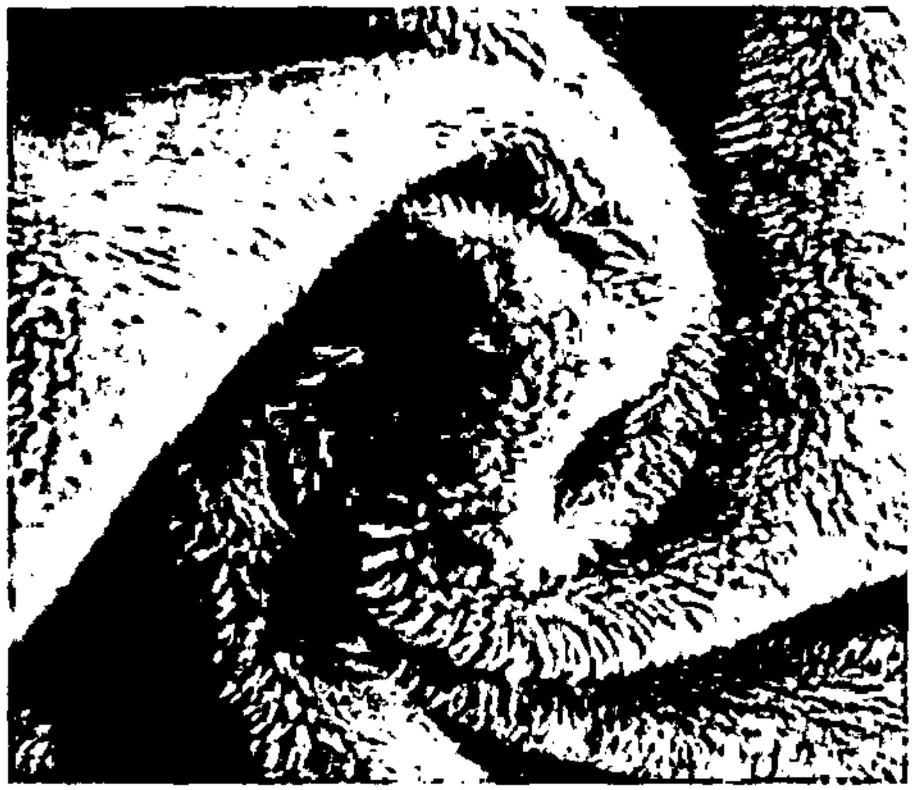

Figure 5.6: Velboa Fabric

5.5 CHARACTERISTICS OF IMITATION FUR

5.5.1 Imitation Fur

Imitation fur or artificial furs or imitation furs are known as pile fabrics, which are engineered to have the appearance and warmth of animal furs. They are attached to a backing using various techniques. Although they can never match the characteristics of natural furs, imitation furs do have certain advantages over their natural counterparts. Unlike natural furs, imitation furs can be colored almost any shade, allowing for more dramatic color combinations. Additionally, imitation furs are more durable and resistant to environmental assaults. In fact, some are even labeled hand washable. With concerns over the environment and animal rights, more and more fashion designers are developing garments using imitation fur. Lastly, imitation furs are much less expensive than natural furs, making them an attractive option for many people.

Fur is one of the oldest known forms of clothing, and has been worn by men and women for a variety of reasons throughout history. While quite desirable, real fur had the disadvantage of being expe®nsive and in short supply. For this reason, imitation furs were introduced on the market in 1929. These early attempts at imitation fur were made using hair from the alpaca, a South American mammal. From a fashion standpoint, they were of low quality, typically colored gray or tan, and could not compare to exquisite furs like mink or beaver. But the fabric was inexpensive and warm, so manufacturers continued to develop improved versions of the imitation fur, trying to give it a denser look, better abrasion resistance, and more interesting colors.

In the 1940s, the quality of imitation furs was vastly improved by advances in textile manufacture technology. However, the true modern imitation furs were not developed until the mid 1950s, with the introduction of acrylic polymers as replacements for alpaca hair. These polymers were particularly important because they could provide the bulk required to imitate real fur without the weight associated with other imitation fur fabrics. They were also easier to color and texture than alpaca fibers. Later in the decade, polymer producers found that acrylic polymers could be made even more fur-like and fire resistant by mixing them with other polymers. These new fabrics, called modacrylics, are now the primary polymer used in imitation fur manufacture.

Figure 5.7: Artificial Fur or Imitation Fur

5.6 RAW MATERIALS USED IN MAKING ARTIFICIAL / IMITATION FURS

Imitation furs are made with a variety of materials. The bulk fibers are typically composed of polymers, including acrylics, modacrylics, or appropriate blends of these polymers. Acrylic polymers are made from chemicals derived from coal, air, water, petroleum, and limestone. They are the result of a chemical reaction of an acrylonitrile monomer under conditions of elevated pressure and heat. For imitation furs, secondary monomers are also added to improve the ability of the acrylic fibers to absorb dyes. Modacrylic polymers are copolymers made by the reaction of acrylonitrile and vinyl chloride monomers. These fibers are particularly useful for imitation furs because they can be easily dyed with animal-like colors and

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have a natural fire retardance.

Modacrylic and acrylic polymers have other characteristics that make them useful in imitation fur manufacture. They are light-weight and springy, imparting a fluffy quality to the garment. They are also highly resistant to heat, sunlight, soot, and smoke, are strong and resilient, and show good stability during laundering. Since they are thermoplastic polymers, they can be heatset. They resist mildew and are not susceptible to attack from insects. These polymers also have very low moisture absorbency and will dry quickly.

Other naturally occurring fabrics are also used to make imitation furs and improve the look and feel of the overall garment. These include materials such as silk, wool, and mohair. Cotton or wool, along with polypropylene, are typically used to make the backings to which the fibers are attached. Rayon, a semisynthetic fiber made from cellulose and cottonlinters, is used to supplement acrylic and modacrylic fibers on the garment, as are polyester and nylon. Materials such as silicones and various resins are used to improve the smoothness and luster of imitation furs. To complete the look of a imitation fur, dyes and colorants are used. If a true imitation is desired, designers match the color with natural fur. However, fashion designers have found that the imitation fur fabric has merits of its own and have started using colors and styles that give it its own new, unique look.

5.6.1 The Manufacturing Process

The production of a imitation fur can be a mostly automated process. The manufacturing steps involved include production of the synthetic fibers, construction of the garment, and modification of the garment.

Chemical synthesis of fibers

- Making a imitation fur begins with the production of the synthetic fibers. While different types of polymers are used, modacrylic polymers provide a good illustration of the fiber manufacturing process. First, the acrylonitrile and vinyl chloride monomers are mixed together in a large stainless steel container. They are forced into a chamber in which the pressure and temperature is increased. Mixing blades are constantly in motion and the polymerization process begins. A white powdery resin is produced, which is then converted into a thick liquid by dissolving it in acetone.
- The liquid polymer mixture is then pumped through a filter to remove undissolved particles. From the filter, the material is pumped through spinnerets, which are submerged in a water bath. The spinnerets look similar to shower heads, and when the polymer is extruded through, it emerges as a group of continuous fibers called a tow.
- The tow is then pulled along a conveyor belt and stretched through a

series of pulleys. As the tow is stretched, it is also washed and dried. As it dries, the acetone is driven off, leaving only the polymer. The continuous fibers are then annealed, making them stronger, and are sent to a machine that cuts them to appropriate sizes.

- After various quality control checks are performed on the fibers, they are moved to the next phase of processing. Here, the polymers are soaked in dye solutions and colored. While this is not the only phase of manufacture in which the fibers are colored, this is usually the point where solid background colors are obtained.

Producing the fur

- 5 While the fibers provide the primary texture and look for imitation fur, the backing provides most of the structure. Working off a specific garment design, the backing, which is made out of cotton or wool, is sent through a machine to be appropriately cut. It is then transferred to the next phase of production, in which the fibers will be attached.
- To convert the fibers into a garment, four different techniques can be employed. The most basic method is the weaving process. In this process, the fibers are looped through and interlaced with the backing fabric. While this technique is fairly slow, it can produce a large range of cloth shapes. Another method of imitation fur production is called tufting. It is similar to weaving; however, it produces garments at a much higher rate of speed. Circular loop knitting and sliver knitting are other methods of imitation fur garment production. Sliver knitting utilizes the same equipment used in jersey knitting. This makes it the fastest and most economical of all the imitation fur garment production techniques, and it is also the one most used by manufacturers.

Finishing touches

- To simulate a natural fur, the garments are treated in various ways. First, to ensure that the imitation fur will remain unchanged after it is produced, the fabric is heated. This heat setting process preshrinks the fabric, giving it improved stability and expanded fiber diameters. Next, to remove loose fibers from the fabric, wire brushes are passed through the fabric. This process is known as tigering. Rough shearing of the fibers by cutting them with a set of helical knives gives them a uniform length. The luster of the fabric can be improved through a method known as electrofying. This is a polishing technique that involves combing the fabric with a heated, grooved cylinder in both directions. The next treatment is the application of chemicals such as resins and silicones, which improves the feel and look of the fiber. Coloring to simulate specific animals can also be enhanced at this staged. Another round of electrofying can be done, as well as a finishing shearing to remove any remaining loose fibers. Depending on the type of imitation fur, embossing to simulate curls can also be done during this stage of manufacture.

- After the imitation fur has been produced, the government requires that they are labeled as imitation fur fabrics. These labels are typically sewn in the inside of the garment and must be legible throughout the life of the product. In the final steps of imitation fur manufacturing, the garment is put in the appropriate packaging and shipped to distributors.

5.6.2 Quality Control

To ensure the quality of imitation fur, manufacturers monitor the product during each phase of production. This process begins with an inspection of the incoming raw materials and continues with the finished fibers that are produced in the polymerization reactions. These fibers are subjected to a battery of physical and chemical tests to show that they meet the specifications previously developed. Some of the characteristics that are tested include pH, appearance, density, and melting point. Other things such as fiber elasticity, resilience, and absorbency can also be tested.

As the garments are being produced, line inspectors take random samples at certain time intervals and check to ensure that they meet set requirements for things such as appearance, sewing quality, fiber strength, size, and shape. The primary testing method is visual inspection, although more rigorous tests can also be performed. In addition to the manufacturer's own standards, the industry and government also set requirements. A set of governmental standards, known as L-22, has been voluntarily adopted by the industry. These tests outline minimum performance standards for things such as shrinkage, pilling, snagging, and wear.

5.6.3 The Future

The technology of producing imitation furs has improved greatly since the early twentieth century. Future research will focus on developing new fibers and finishes. These polymeric fibers will have improved feel, look, and a lower cost. Additionally, quicker and more efficient methods of production are also being investigated. Special animal simulation techniques have recently been developed. One method simulates the long and short hair sections of mink or river otter fur by mixing shrinkable and non-shrinkable fibers. Another method simulates the feel of beaver fur by mixing certain fine and coarse fibers. Finally, manufacturers will strive to produce ever higher quality products at the lowest possible cost.

5.7 METALIZED FABRICS

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Metalized fabric is a yarn or fiber made of or containing metal. It is a fabric, typically shiny or iridescent, made of such yarn or fiber. There are many types of conductive fabric (metallized fabric) available in the market. Usually metallic fibers are used in the production of metalized fabrics.

Metallic fibers are manufactured fibers composed of metal, plastic-coated metal, metal-coated plastic, or a core completely covered by metal. Gold and silver have been used since ancient times as yarns for fabric decoration. More recently, aluminum yarns, aluminized plastic yarns, and aluminized nylon yarns have replaced gold and silver. Metallic filaments can be coated with transparent films to minimize tarnishing. A common film is Lurex polyester.

Metal fiber may also be shaved from wire (steel wool), bundle drawn from larger diameter wire, cast from molten metal, or grown around a seed (often carbon).

5.7.1 History of Metal Fibers

Gold and silver have been used since ancient times as decoration in the clothing and textiles of kings, leaders, nobility and people of status. Many of these elegant textiles can be found in museums around the world. Historically, the metallic thread was constructed by wrapping a metal strip around a fiber core (cotton or silk), often in such a way as to reveal the color of the fiber core to enhance visual quality of the decoration. Ancient textiles and clothing woven from wholly or partly gold threads is sometimes referred to as *Cloth of Gold.* They have been woven on Byzantine looms from the 7th to 9th Centuries, and after that in Sicily, Cyprus, Lucca, and Venice. Weaving also flourished in the 12th Century during the legacy of Genghis Khan when art and trade flourished under Mongol rule in China and some Middle Eastern areas. The Dobeckmum Company produced the first modern metallic fiber in 1946. In the past, aluminum was usually the base in a metallic fiber. More recently stainless steel has become a base as well. It is more difficult to work with but provides properties to the yarn that allows it to be used in more high tech applications.

5.7.2 Fiber Properties

Coated metallic filaments help to minimize tarnishing. When suitable adhesives and films are used, they are not affected by salt water, chlorinated water in swimming pools or climatic conditions.[7] If possible anything made with metallic fibers should be dry-cleaned, if there is no care label. Ironing can be problematic because the heat from the iron, especially at high temperatures, can melt the fibers.

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5.7.3 Production Method

There are two basic processes that are used in manufacturing metallic fibers. The most common is the *laminating process*, which seals a layer of aluminum between two layers of acetate or polyester film. These fibers are then cut into lengthwise strips for yarns and wound onto bobbins. The metal can be colored and sealed in a clear film, the adhesive can be colored, or the film can be colored before laminating. There are many different variations of color and effect that can be made in metallic fibers, producing a wide range of looks.

Metallic fibers can also be made by using the *metalizing process*. This process involves heating the metal until it vaporizes then depositing it at a high pressure onto the polyester film . This process produces thinner, more flexible, more durable, and more comfortable fibers.

Metal fiber may also be shaved from wire (steel wool), bundle drawn from larger diameter wire (smallest fiber is produced by this method), cast from molten metal, or grown around a seed (often carbon). Bundle drawn metal fiber can be produced to sizes smaller than one micron in diameter.

5.7.4 Producers

Currently metallic fibers are manufactured primarily in Europe with only three manufacturers still producing metallic yarn in the United States. Metlon Corporation is one of the remaining manufacturers in the U.S. that stocks a wide variety of laminated and non-laminated metallic yarns.

5.7.5 Trademarks

The Lurex Company has manufactured metallic fibers in Europe for over fifty years. They produce a wide variety of metallic fiber products including fibers used in apparel fabric, embroidery, braids, knitting, military regalia, trimmings, ropes, cords, and lace surface decoration. The majority of Lurex fibers have a polyamdie film covering the metal strand but polyester and viscose are also used. The fibers are also treated with a lubricant called P.W., a mineral-based oil, which helps provide ease of use.

Metlon Corporation is a trademark of Metallic Yarns in the United States and has been producing metallic yarns for over sixty years. Metlon produces their metallic yarn by wrapping single slit yarns with two ends of nylon. One end of nylon is wrapped clockwise and the other end is wrapped counterclockwise around the metallic yarn. The most commonly used nylon is either 15 denier or 20 denier, but heavier deniers are used for special purposes.

5.7.6 Uses

The most common uses for metallic fibers is upholstery fabric and textiles

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such as lamé and brocade. Many people also use metallic fibers in weaving and needlepoint. Increasingly common today are metaillic fibers in clothing, anything from party and evening wear to club clothing, cold weather and survival clothing, and everyday wear. Metallic yarns are woven, braided, and knit into many fashionable fabrics and trims. For additional variety, metallic yarns are twisted with other fibers such as wool, nylon, cotton, and synthetic blends to produce yarns which add novelty effects to the end cloth or trim. Stainless steel and other metal fibers are used in communication lines such asphone lines and cable television lines. Stainless steel fibers are also used in carpets. They are dispersed throughout the carpet with other fibers so they are not detected. The presence of the fibers helps to conduct electricity so that the static shock is reduced. These types of carpets are often used in computer-use areas where the chance of producing static is much greater. Other uses include tire cord, missilenose cones, work clothing such as protective suits, space suits, and cut resistant gloves for butchers and other people working near bladed or dangerous machinery.

Metalized fabric materials are available with and without adhesive, with and without protective urethane coating that prevents finger prints, moisture and discoloration.

5.7.8 Applicaton Examples

- Mânufacturing EMI shielding tapes
- Manufacturing EMI shielding gaskets (We can supply with hot-melt adhesive)
- Making protective clothing against surrounding RF noise (ex. for pace-maker users)
- Shielding *against magnetic field interference*
- Signal or low voltage electric current carrier

5.7.9 Gold-Plated Conductive Fabric

Surface plating is 99.9% pure gold, with Ni + Cu + Ni under-plating, and has excellent shielding effectiveness. As an option, we can provide Anti-Tarnish Urethane coating to prevent finger prints.

After the conductive fabric in general usually use nickel-plated copper form, for example some standard companies use 99.9% pure gold, there are multiple options, including the substrate, gold-plated components, etc., gold and antibacterial properties inherent in the human body without an allergic reaction, gold Guangcan, for use in exposed places there are very good decorative effect.

Gold-plated conductive fabric according to customers need to develop many new varieties. Gold-plated conductive fabric not only has the best performance and good looks, but for different occasions, on the rational allocation of finished gold-plated components, making the cost of greatly

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reduced, the current form by the thickness of the base material, according to the different gold-plated components series products: the order of 24K gold, 18K gold, 16K gold, 14K gold, DTY-multi-strand filament yarn woven fabric as the substrate, cut flat on the reduction of batch front glitch particularly effective.

5.8 KNITWEAR

History of Knitwear

Coco Chanel's 1916 use of jersey in her hugely influential suits was a turning point for knitwear, which became associated with the liberated woman. Shortly afterwards, Jean Patou's cubist-inspired, color-blocked knits were the sportswear of choice.

In the 1940s came the iconic wearing of body-skimming sweaters by sex symbols like Lana Turner and Jane Russell, though the 1950s were dominated by conservative popcorn knits. The swinging 1960s were famously manifested in Missoni's colorful zigzag knitwear. This era also saw the rise both of Sonia Rykiel, dubbed the "Queen of Knitwear" for her vibrant striped sweaters and her clingy dresses, and of Kennedy-inspired preppy sweaters. In the 1980s, knitwear emerged from the realm of sportswear to dominate high fashion; notable designs included Romeo Gigli's "haute-bohemian cocoon coats" and Ralph Lauren's floor-length cashmere turtlenecks.

Structure of Knitted Fabrics

Knitted fabrics are divided into two basic types: warp-knit fabrics such as tricot and weft-knit fabrics such as a hand-knit sweater. Weft-knit items have the drawback that they *run* when cut. Warp-knit fabrics are often used in lingerie.

- knits can shrink but can also extend if a rib construction
- knits have nap
- ribs/wales versus courses
- generally more elasticity along the course than along the wale

Knitting Stitches

Over the long history of knitting across the world, hundreds of different knitting stitches have been created.

The basic building blocks of all hand knitting are the following stitches: knit, purl, cast on, cast off, increase and decrease stitches. Use of a combination of these methods can provide a vast number of different textures to knitted fabrics.

In order to save space in knitting patterns, the names of stitches are normally abbreviated.

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5.8.1 Composition of Knitted Fabrics

The most common fibres used for knitted fabrics are cotton & viscose with or without elastane, these tend to be single jersey construction and are used for most t-shirt style tops.

Types of knitted fabrics

- Double knits
- Four-way stretch knits
- Interlock
- Single Jersey
- Milanese
- Power mesh
- Raschel lace
- Ponti Roma
- Rib knits
- Velour
- *Loopback & Brush back fleece* i.e. sweatshirt fabric
- Tricot
- Two-way stretch knits
- Fleece knits - including micro fleece, sherpa fleece etc
- Terry knit
- Pointelle

Methods of Knitting

A method of constructing fabric by interlocking series of loops of one or more yarns. The two major classes of knitting are warp knitting and weft knitting, as follows:

Warp Knitting: A type of knitting in which the yarns generally run lengthwise in the fabric. The yarns are prepared as warps on beams with one or more yarns for each needle. Examples of this type of knitting are tricot, milanese, and raschel knitting.

Milanese Knitting: A type of run-resistant warp knitting with a diagonal rib effect using several sets of yarns.

Raschel Knitting: A versatile type of warp knitting made in plain and jacquard patterns; the latter can be made with intricate eyelet and lacy patterns and is often used for underwear fabrics. Raschel fabrics are coarser than other warp knit fabrics, but a wide range of fabrics can be made. Raschel knitting machines have one or two sets of latch needles and up to thirty sets of guides.

Tricot Knitting: A run-resistant type of warp knitting in which either single

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or double sets of yarn are used. (Also see TRICOT).

Weft Knitting: A common type of knitting, in which one continuous thread runs crosswise in the fabric making all of the loops in one course. Weft knitting types are circular and flat knitting.. Circular Knitting: The fabric is produced on the knitting machine in the form of a tube, the threads running continuously around the fabric. Most hosiery machines are in this category. . Flat Knitting: The fabric is produced on the knitting machine in flat form, the threads alternating back and forth across the fabric. The fabric can be given shape in the knitting process by increasing or decreasing loops. Full-fashioned garments are made on a flat knitting machine.

5.8.2 Elasticity, Thickness and Warmth

Compared to the other two classes, knitted fabrics are much more elastic, which accounts for their historical use in stockings and other clothing that requires changes in shape. Hence, dresses and lingerie made from knitted fabrics can be more form-fitting than counterparts made from a woven fabric. Knitted fabrics can stretch, depending on their material and knitting pattern, up to 500 percent of their original size. Lace knitting generally produces the most flexible fabric, since it has large holes that can deform in shape; by contrast, cable knitting generally produces the least flexible fabric, since the stitches are crossed under tension, which inhibits deformation. Knitted fabrics that do not deform much are called *stable knits*. For comparison, woven fabrics typically deform only along their bias direction–i.e., at 45° to the warp and weft directions–and only by a small amount; however, a woven fabric made with an elastane fibre may deform more than a stable knit.

The elasticity of knitted fabrics gives them an excellent drape, but this is opposed somewhat by their generally greater thickness compared to wovens. Thus, the *turn of the cloth* (i.e., the maximum curvature of a fold of the fabric) is generally finer in woven fabrics than in knitted fabrics. For this reason, knitted fabrics resist wrinkles better than wovens, but do not generally take a crease.

Knitted fabrics are generally warmer and more comfortable than woven fabrics, which is why they are worn closer to the body. Moreover, knitted fabrics are often made from wool, which stays warm even when wet; wool is preferred since it is more elastic than most fibers and produces more even, beautiful knits. In general, elasticity and warmth are opposing qualities in a knitted fabric, since the most elastic knitted fabrics, such as lace, have the largest holes and are thus less insulating.

5.9 CARE OF HOSIERY UNDERWEAR

Hosiery, also referred to as legwear, describes garments worn directly on the feet and legs. The term originated as the collective term for products of which a maker or seller is termed a hosier; and those products are also known

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generically as hose. The term is also used for all types of knitted fabric, and its thickness and weight is defined in terms of denier or opacity. Lower denier measurements of 5 to 15 describe a hose which may be sheer in appearance, whereas styles of 40 and above are dense, with little to no light able to come through on 100 denier items.

The first references to hosiery can be found in works of Hesiod, where Romans are said to have used leather or cloth in forms of strips to cover their lower body parts. Even the Egyptians are speculated to have used hosiery as socks have been found in certain tombs.

Most hosiery garments are made by knitting methods. Modern hosiery is usually tight-fitting by virtue of stretchy fabrics and meshes. Older forms include binding to achieve a tight fit. Due to its close fit, most hosiery can be worn as an undergarment, but it is more commonly worn as a combined under/outer garment

Underwear

Undergarments or underwear are clothes worn under other clothes, often next to the skin. They keep outer garments from being soiled by bodily secretions and discharges, shape the body, and provide support for parts of it. In cold weather, long underwear sometimes is worn to provide additional warmth. Some undergarments are intended for erotic effect. Special types of undergarments have religious significance. Some items of clothing are designed as underwear, while others, such as T-shirts and certain types of shorts, are appropriate both as undergarments and as outer clothing. If made of suitable material, some undergarments can serve as nightwearor swimsuits.

Undergarments commonly worn by women today include include brassieres and knickers (known in the United States as panties), while men often wear briefs, boxer briefs or boxer shorts. Items commonly worn by both sexes include T-shirts, sleeveless shirts (also called singlets), bikini underwear, thongs, and G-strings.

Hosiery Care Bag

The ideal way to extend the life of your Omero hosiery. Machine wash your hosiery (or any other lingerie or delicate items) in this fabulous mesh bag. Zipper closure has tuck-in cover so it won't open during the wash or snag other items.

5.10 CARE OF HOSIERY OUTWEAR

The hosiery industry must confront the problems all textile mills face in producing a fabric. In particular, hosiery mills must treat the wastewater generated during the dyeing phase to prevent contamination. Many of the dyes used to tint pantyhose contain toxic substances such as ammonium sulfate. To minimize harmful wastewater, manufacturers must adhere to guidelines set by the U.S. government's Environmental Protection Agency (EPA). Treating the water before it is dumped into rivers has alleviated some of the wastewater concerns. Another approach has been to control the amounts of various chemicals used during the manufacturing process. Failure to measure chemicals properly can create an over-abundance of some of the materials, thereby causing harmful waste. A third idea has been to substitute less harmful chemicals when possible.

The hosiery industry currently produces almost 2 billion pairs of women's sheer hose annually. Industry analysts predict that consumers will continue to demand high-quality nylons in a variety of shades, styles, and degrees of sheerness. Manufacturers will strive to meet the consumer's need by experimenting with hybrid fabrics that combine synthetic fibers with natural fibers such as cotton.

Prevent Wrinkles in Cotton

Wrinkled clothes can appear sloppy and distract from your look. With these tricks, your outfits will be smooth and stylish.

Packing Seasonal Clothing

Make room in your closet by rotating and packing seasonal items. Keep clothes fresh and tidy until their next wear.

Get Grease Out of Clothing

Grease is a stubborn stain to remove. Pre-treating can help prevent permanent damage to the garment.

5.11 STUDENT ACTIVITY

- Write a note on the insulation fabrics.
- Write a note on the artificial/imitation fabrics.

5.12 SUMMARY

The insulation fabric such as made of wool is used for both thermal and acoustic insulating applications. Sheep wool is a natural, sustainable, renewable, recyclable material that does not endanger the health of people or the environment. Wool is a highly effective insulating material that has been used for years insulating people in the form of clothing. Mongolian nomads also used felted and woven sheep wool pads as an insulating layer on the walls and floors of their dwellings called, ger or yurts. Presently the use of wool for insulation is starting to rise in popularity.

Quilting is usually completed by starting from the middle, and moving outward toward the edges of the quilt. Examples: simple or complex geometric grids, "motifs" traced from published quilting patterns or traced pictures, complex repeated designs called *tessellations*, or stitching within the seam line itself, i.e., stitching in the ditch.

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Metalized fabric is a yarn or fiber made of or containing metal. It is a fabric, typically shiny or iridescent, made of such yarn or fiber. There are many types of conductive fabric (metallized fabric) available in the market. These materials are available with and without adhesive, with and without protective urethane coating that prevents finger prints, moisture and discoloration.

Hosiery, also referred to as legwear, describes garments worn directly on the feet and legs. The term originated as the collective term for products of which a maker or seller is termed a hosier; and those products are also known generically as hose.

Inline is a method of hosiery display used in mass-merchandising outlets where national brands and private label merchandise are displayed along the same wall. Many mass-merchants now use an in-line system, as opposed to free-standing "boutique" displays.

5.13 GLOSSARY

- **Plain** - Commonly made of cotton, this type of velvet has a firm hand and can be used for many purposes.
- **Silk** - More expensive than plain velvet, this type is usually shinier and softer than the cotton variety.
- **Viscose** - In terms of quality, this type is more similar to silk velvet than cotton velvet.
- **Hammered** - This type is extremely lustrous, appears dappled, and somewhat crushed.
- **Embossed** - A metal roller is used to heat-stamp the fabric, producing a pattern.
- **Crushed** - This type of velvet can be produced by pressing the fabric down in different directions. Also , it can be produced by mechanically twisting the fabric while wet. The result is patterned appearance that is very lustrous.
- **Panné** - Also a type of crushed velvet, panné is produced by forcing the pile in a single direction by applying heavy pressure.
- **Devore** - This variety is produced with a caustic solution. This dissolves part of the velvet leaving sheer areas of fabric. Usually a definite pattern is produced.
- ***Velveteen*** is a type of imitation velvet. It is normally made of cotton, or cotton/silk. It has a pile that is short (never more than 3mm deep), and is closely set.
- **In-Line:** Method of hosiery display used in mass-merchandising outlets

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where national brands and private label merchandise are displayed along the same wall. Many mass-merchants now use an in-line system, as opposed to free-standing "boutique" displays.

5.14 REVIEW QUESTIONS

1. What do you mean by the insulation fabrics?
2. Describe the production of quitted fabrics.
3. Discuss about the composition of quitted fabrics
4. Explain the characteristics of imitation fur.
5. Write a note on:

(a) Knitwear

(b) Care of hosiery underwear

(c) Care of hosiery outwear.

(d) Imitation fur