CHAPTER 02

Introduction to Fibres, Dyeing & Printing

2.1 INTRODUCTION

India is a country with rich heritage of traditional textiles like Banarasi brocade, Kanjeevaram silk, Baluchari silk, Chanderi, Maheshwari sarees, Jamdani cotton sarees, Kashmiri woollen shawls to name a few. Each type of Indian textile has unique features in terms of the fibres or raw material used for production, weaving and dyeing techniques. Some traditional textiles of India have rich embroidery on it like Kantha stitch, Phulkari work, mirror work, Kutch embroidery etc.

This chapter introduces the reader to different types of natural and manmade fibres, basic concept of yarns, basic weaves, fundamentals of dyeing and printing technology.

2.2 TEXTILE FIBRES

By definition a textile fibre is a unit of matter which is usually at least 100 times longer to its thickness. The basic unit of all textile fibres like cotton, wool and silk is the molecule.

The molecules in a fibre are called polymers as they are a long chain of molecules. The polymeric structure gives the required properties to the fibres. Each fibre has its unique properties which are based on the molecular structure and chemical composition.

2.2.1 Classification of textile fibres

Fibres are classified based on origin into natural and manmade fibres. They are further classified based on chemical composition. The classification of textile fibres is as follows:

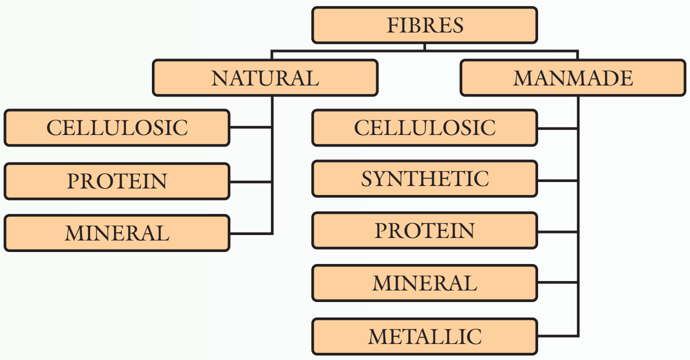

Figure 2.1 Classification of fibres

Table 2.1 Classification of fibres with examples

Fibre type	Composition	Examples of fibres
Natural	Cellulosic	Cotton, Jute, Flax, Hemp, Banana fibre, Pina fibre, etc.
	Protein	Silk, Wool, Camel hair, Agora rabbit hair, Cashmere goat hair, etc.
	Mineral	Asbestos fibre
Manmade	Cellulosic	Viscose rayon, Modal, Tencel, etc
	Synthetic	Polyester, Nylon, Acrylic, Polyethylene, Polypropylene, etc.
	Protein	Soyabean fibre , Polylactic acid fibre, etc.
	Mineral	Glass fibre, Ceramic fibre, etc.
	Metallic	Aluminium fibre , Silver fibre, Tungsten fibre, etc.

2.2.2 Natural fibres

Natural fibres are obtained from the natural resources like plant/ vegetable, animal hair and natural minerals. Fibres from vegetable and plant origin are generally cellulosic in chemical composition. Animal fibres are protein in chemical composition. Natural cellulosic fibres are cotton, flax, jute, coir, hemp, banana fibre, etc. Natural protein fibres are wool, silk and other specialty fibres like camel hair, angora rabbit hair, pashmina goat hair, etc. Natural occurring mineral fibre is asbestos which is based on silicate of calcium and magnesium and is resistant to fire. Asbestos it is not widely used due to its toxic nature.

The following section describes the properties of the most commonly used natural fibres: Cotton, Jute, Flax, Silk and Wool.

COTTON

Cotton fibre is obtained from the seed hair of cotton. It is cellulosic in nature, therefore on burning emits the smell of burning paper. Under the microscope the fine structure of cotton can be observed. The cross section of the cotton fibre is kidney shaped. The length of the fibre ranges from 10 mm to 65 mm depending on the variety of cotton. In India the main cotton producing states are Maharashtra, Andhra Pradesh, Madhya Pradesh and West Bengal.

Cotton fibres are hygroscopic in nature which means that it can absorb around 8.5% of moisture of their dry weight. This gives the fibre the ability to absorb perspiration when made into textiles. Moreover, the hygroscopic nature prevents the cotton fabric to develop static electricity. This makes it is suitable for wearing in hot and humid weather.

Cotton fibres have the ability to conduct heat energy and can withstand high ironing temperatures.

The strength of the cotton fibre is good and the strength increases when the fibre is wet. This makes the clothes made from cotton durable.

Cotton fibres are not affected by alkalis and mild bleaches. This enables the fibre to be laundered at home with detergents.

Cotton fibres can be affected by direct sunlight due to photochemical degradation in the presence of atmospheric oxygen and moisture. This causes the yellowness in undyed cotton/ white fabrics after a period of time.

Cotton fibres, yarns and fabrics can be easily dyed with different classes of dyes like direct, reactive, vat and sulphur dyes.

Figure 2.2 Raw cotton in cotton seed

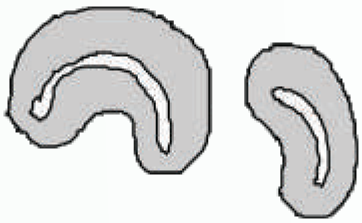

Figure 2.3 Cross-section of cotton fibres

JUTE

Jute fibre is obtained from the stem of the jute plant that grows in the belt of Ganges delta, mainly in the states of West Bengal, Assam and Bihar in India.

Jute fibre is cellulosic in nature and like cotton, can absorb moisture. The jute fibres have excellent strength and low elongation. The strength of jute fibres are higher than cotton and elongate less than cotton on application of weight. This property makes it suitable to be used in bags and sacks to carry heavy weight. But due to roughness and stiff handle of jute fibres is not used for clothing but used for carpets, bags, sacks and in industrial applications.

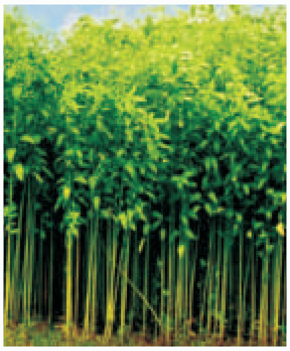

Figure 2.4 Jute plant

Figure 2.5 Jute yarn

FLAX

The flax fibre is thick, regular fibre with a subdued lustre. The colour of the fibre varies from light blonde to greyish blonde. The fibres can be bleached and dyed to any shade like cotton. The length of the fibre ranges from 10 cm to 100 cm. The cross-section of the fibres shows that flax fibres are polygonal in shape. The fabric made from flax is known as linen which is is used for clothing.

Figure 2.6 Cross-section of flax fibres under scanning electron microscope (SEM)

Flax fibres are very strong and stiff in handle. Flax fibres (linen fabric) creases easily due to its stiff nature. This is one major difference from cotton fibre though both are cellulosic in nature.

Like cotton fibres flax can also absorb moisture and is resistant to alkalis.

WOOL

Wool is the fibre obtained from the fleece of domesticated sheep. It is a natural protein fibre. The length of the wool fibres ranges from 5 cm for fine wool to 35 cm for the coarse and long wool. Merino wool is a type of fine Australian wool. The surface of the wool fibre has scales and the cross-section of the wool fibre is oval as shown in the fig 2.7.

The wool fibre is crimped which gives woolen fabric the natural bulkiness and warmth. The crimp in wool provides air space in the woollen fabrics. This warmth in wool is due to the air spaces which trap air and air being an insulator retains the body heat. Wool absorbs moisture more than cotton. Wool also gives off a small steady amount of heat while absorbing moisture. This also makes the wearer feel warm in the cold weather. This property of wool is unique and is not seen in other fibres.

Wool fibres have less strength than cotton, but elongate more than cotton. Wool is more resistant to acid than alkalis. Wool dissolves in alkali and therefore wool cannot be washed with detergents containing alkali. Dry cleaning is recommended for wool.

Exposure to sunlight and weather tends to turn wool yellow, similar to cotton due to photochemical degradation of the wool polymer.

Wool can be easily dyed with acid, reactive and metal-complex dyes.

Figure 2.7 Wool fibres under SEM

Figure 2.8 Natural crimp in wool fibres

SILK

Silk is a natural protein filament obtained from the cocoons of the silk worm. The silk is removed from the cocoon of the silk worm to give continuous length (700-1200 meters) of thread which is known as silk filament. The raw silk strand from the cocoons consists of two silk filaments, triangular in cross-section, held by a protein called sericin. Sericin is also known as the 'silk gum' which gives raw silk a coarse handle. This silk gum can be easily removed by a process called 'degumming' to give silk a smooth handle and bright lustre. It is for this reason that raw silk is coarse in handle and lacks lustre, but degummed silk is soft and lustrous.

Silk filament is very fine, regular in appearance. The triangular cross-section gives silk a smooth lustre as the filament reflects light uniformly.

Silk filament is stronger than wool. Silk is easily degraded by alkalis like wool and cannot be washed by normal detergents. Dry cleaning is recommended for silk fabrics. Sunlight affects silk like wool and cotton.

Silk is generally known as mulberry silk as the cultivated silk worm feeds on mulberry leaves. In India certain different varieties of silk other than mulberry silk which are known as "wild silk" like Tasar silk, Muga silk and Eri silk are available. These silk are cultivated from different type of silk worms. The texture of the wild silk is different from mulberry silk. Tasar silk and Eri silk is coarser in texture and gives a silk fabric which looks different from mulberry silk. Mulberry silk is cultivated mainly in and around Bengaluru in the state of Karnataka,Tasar silk is cultivated in the Bhagalpur region in the state of Bihar and Muga silk in the state of Assam and West Bengal.

Figure 2.9 Silk Cocoons

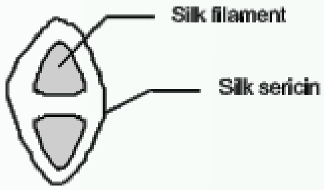

Figure 2.10 Cross-section of silk strand

2.2.3 Manmade fibres

Manmade fibres are not found in nature but are spun from polymers like cellulose, synthetic polymers, metallic compounds, etc by a mechanical spinning process. For cellulosic manmade fibres the cellulose is obtained from wood pulp and fibres like viscose rayon is spun. Textile fibres like polyester, nylon, acrylic polyurethane, polyethylene, polypropylene, etc are composed of synthesized polymers and are commonly known as synthetic fibres. The advantages of manmade fibres are that they can be modified during spinning to incorporate additional properties like antimicrobial activity, flame resistance property etc. In this section the popular manmade fibres like viscose rayon, polyester, nylon and acrylic will be discussed. A brief introduction to high performance manmade fibres is also presented in this section.

VISCOSE RAYON

Viscose rayon is a manmade regenerated cellulosic fibre. The fibres are spun from a viscous solution of alkali-cellulose. The name viscose is derived from the word viscous, which describes the liquid state of the spinning solution used for spinning of the fibre or filament.

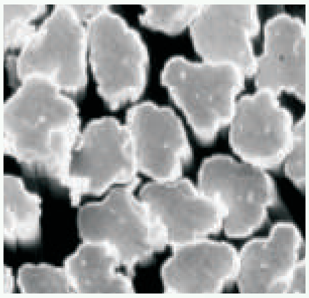

Figure 2.11 Cross-section of viscose rayon fibres under SEM

Viscose rayon is fine, regular or staple fibre. The cross-section is serrated. The composition of viscose rayon is similar to cotton. Therefore, the properties of viscose rayon fibres are also similar to cotton. It is often blended with cotton or polyester and woven into fabrics. Viscose rayon absorbs moisture. Therefore, it can absorb perspiration and is suitable for hot and humid weather. It is resistant to alkalis and can be laundered at home with detergents.

POLYESTER

Polyester is manmade synthetic filament or staple fibre made from reaction between an alcohol and an acid. It is composed of *polyethylene terepthalate* units. The polyester filaments/ fibre are very strong. The strength remains unaltered when wet. This is because of the hydrophobic nature of the polymer. The hydrophobic nature of the polyester enables polyester fabric to dry quickly as the moisture absorption is 0.4% unlike cotton, wool, silk and viscose rayon.

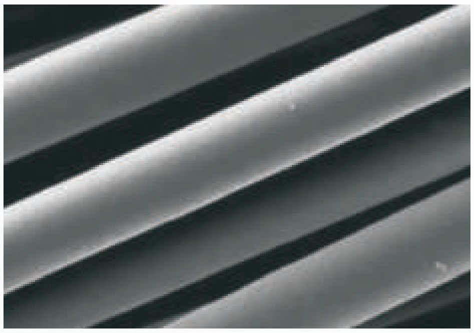

Figure 2.12 SEM image of polyester fibres

The high strength and stiffness of polyester makes it a wrinkle resistant fabric.

Polyester is thermoplastic in nature which means it is capable of being shaped or moulded when heated. It can be heat set. But at the same time on exposure to flame, the polymer catches fire and melts which can be hazardous. Therefore, flame-retardant polyester fibres have also been developed and commercialized.

Polyester is more resistant to acids than alkalis. Polyester is resistant to sunlight more than the natural fibres.

Polyester fibres are blended with cotton/viscose rayon fibres to develop a fabric which would posses the good qualities of both the fibres. Polyester cotton/viscose blended fabrics are stronger than 100 % cotton fabrics, dries faster than 100 % cotton fabrics, more crease resistant than 100% cotton. Polyester cotton/viscose blends are widely used as uniform fabrics and shirting/ suiting material.

NYLON

Nylon is a polyamide manmade filament or fibre. The nylon filament/ fibres are known for its good strength and excellent abrasion resistance. Nylon filaments/ fibres also have elasticity more than polyester. Nylon absorbs around 4% moisture on its dry weight. These properties makes suitable for products like ropes, socks, swim wear, cycling shorts and certain sportswear where high strength, elasticity and abrasion resistance is required.

Nylon like polyester is thermoplastic in nature and melts when heated.

Nylon is less resistant to acids than to alkalis. It has fair resistance to sunlight and weather.

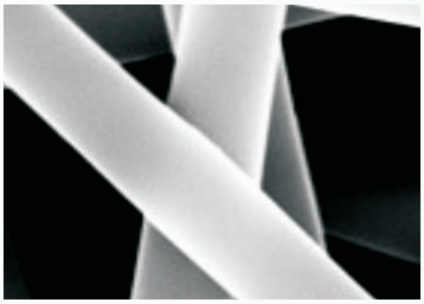

Figure 2.13 SEM image of nylon fibres

ACRYLIC

Acrylic filaments/ fibres are spun from acrylonitrile polymer. In *modacrylic* fibres a copolymer is also used along with acrylonitrile. *Acylonitrile* fibres are slightly wavy and this gives acrylic fibres a bulk like wool. Acrylic fibres are used for knitted sweaters, winter wears, shawls, curtains, imitation fur, pile fabric, upholstery fabrics, etc.

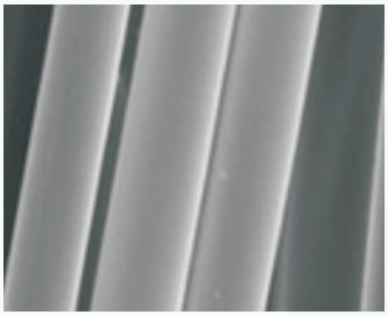

Figure 2.14 SEM image of acrylic fibres

Acrylic fibres have good strength and a soft handle. Acrylic fibres are hydrophobic in nature which results in development of static elasticity.

When exposed to flame acrylic fibres ignite immediately. Acrylic fibres are more resistant to acids than alkalis. Acrylic fibres are also resistant to sunlight and weather.

2.2.4 High Performance Fibres

Apart from the conventional fibres that have been discussed in this chapter, a number of high performance fibres have been developed and commercialized. These fibres have high strength, resistant to chemicals and can withstand high temperature without degradation. They are used for bullet proof vests, fire fighters' uniform and in aerospace engineering including aircrafts and in industrial applications. Some examples are carbon fibres, ultra high molecular weight polyethylene fibres (Dyneema™ and Spectra™), aramid fibres (Kevlar™, Nomex™, Twaron™), etc.

EXERCISE 2.1

PURPOSE: To enable students to understand the source and origin of fibres

1. **Classify the following fibres as natural or manmade fibres:**

   Hemp, Polyester, Acrylic, Mohair, Polypropylene, Glass, Jute, Merino Wool, Pinafibre, Cashmere, Cotton, Angora, Banana, Camel hair, Ceramic, Kevlar.

2. **Match the following:**

PART A	PART B
Kevlar	Manmade cellulosic fibres
Hemp, Jute, Flax	Natural mineral fibre
Viscose rayon, Modal, Tencel	Natural cellulosic fibres
Wool, Angora, Cashmere	Animal protein fibres
Asbestos	High Performance Fibres

ACTIVITY 2.1

Collect 5 different type of fibres and write down their properties and applications. Include new areas of application of the fibres in the field of technical textiles also.

2.3 YARNS

The fibres / filaments are converted to a yarn for weaving or knitting. Individual fibres are made parallel to one another using a series of machines in a spinning unit. Then the parallel strands of fibres are drafted and twisted together to form a yarn. The twist imparts strength and cohesion to the yarn. When yarn is spun from staple fibres it is known "spun" yarn and when yarn is made from twisting of parallel filaments like silk, where the filament runs thoughout the strand of the yarn it is known as "filament yarn". The process of yarn formation is shown in the figure below:

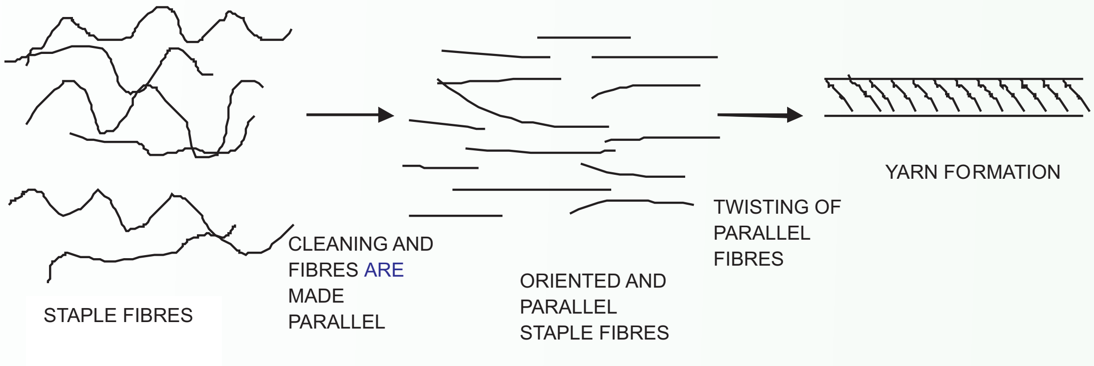

Figure 2.15 Yarn formation

EXERCISE 2.2

PURPOSE: To understand the process of yarns formation

1. Write TRUE/FALSE against each of the following statement

a) Twist imparts strength and cohesion to the yarn.

b) Yarns made from staple fibres are known as filament yarns.

c) Silk is an example of filament yarn.

d) Cotton fibres need to be cleaned, made parallel, drafted and twisted for yarn formation.

e) Yarns are not used for weaving and knitting.

ACTIVITY 2.2

Open any yarn by untwisting it and remove the fibres or the filaments to observe the process of yarn formation.

2.4 WEAVING

Weaving is the process of interlacement of two sets of yarn which are perpendicular to one another. Weaving is done using looms. Looms can be classified as handloom or powerloom. Powerloom can be non-automatic or automatic. Handlooms are operated manually and power looms require electricity. Some traditional Indian fabrics are produced by handlooms in certain clusters in India. The basic components and the fundamental process of weaving is same in all the looms.

In order to interlace warp and weft threads on any type of weaving machine, the three basic operations of shedding, picking and beat up are necessary. The set of thread that run down the fabric in the longitudinal direction is termed as "warp" and the set of threads that is inserted in the fabric in the horizontal direction is termed as the "weft", as shown in the figure 2.16.

The three basic operations during weaving are as follows:

1. **Shedding:** Separating the warp threads into two layers to form a tunnel known as shed.
2. **Picking:** Passing of the weft thread through the shed. The weft threads are the yarn which traverses down the width of the fabric, perpendicular to the warp as shown in the figure.
3. **Beating:** This is pushing the newly inserted length of weft, known as pick to the already woven fabric at a point known as the fell.

The above three operation are known as the primary motions of weaving and occur in a sequence for fabric production.

2.4.1 Weaving process

Yarn from the warp beam passes over the back rest and comes through the drop wires to the healds, which are responsible for separating the warp for the purpose of shed formation. It then passes through the reed, which holds the threads at uniform spacing and is also responsible for beating up action of the weft threads to the fell of the cloth. The pick is inserted in between the reed and cloth roller through a pick insertion mechanism or shuttle. The fabric then gets wound up in the cloth roller with the help of take up roller.

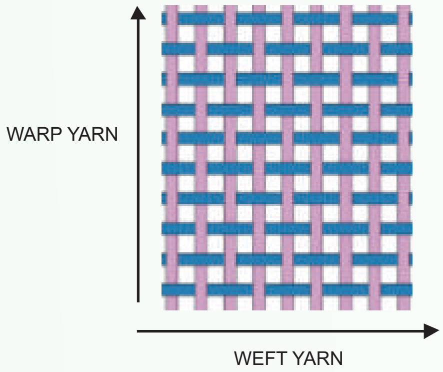

Figure 2.16 Warp and weft yarn in a fabric

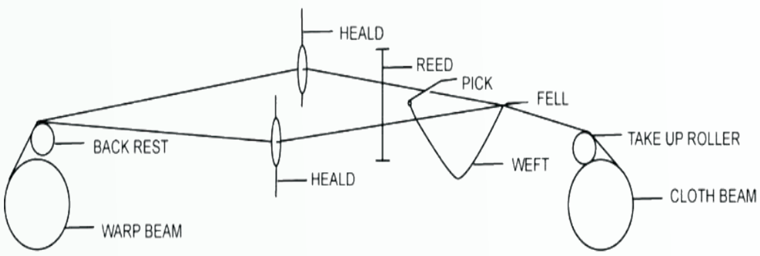

Figure 2.17 Cross-section through the loom showing weaving process

2.4.2 Weave structures

The number of weave structures that can be produced is practically unlimited. In this section the basic structures like plain, twill and sateen weave from which other woven structures are developed are discussed.

PLAIN WEAVE

Plain weave is the simplest interlacing pattern that can be produced. It is produced by alternatively lifting and lowering one warp thread across one weft thread. Figure 2.19 shows the representation of a plain woven fabric. The yarns do not lie straight with the fabric because the warp and weft have to bend round each other when they are interlaced.

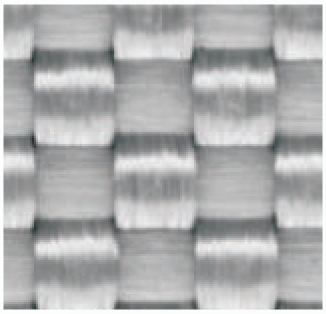

Figure 2.18 Microscopic image of plain woven fabric

	X		X		X
X		X		X	
	X		X		X
X		X		X	
	X		X		X
X		X		X	

X → Warp up

Figure 2.19 Graphical representation of plain weave

TWILL WEAVE

A twill is a weave that repeats on three or more ends and picks and produces diagonal lines on the face of a fabric. The direction of the diagonal lines on the surface of the cloth is generally viewed along the warp direction. Denim and jeans fabrics are common examples of twill weave.

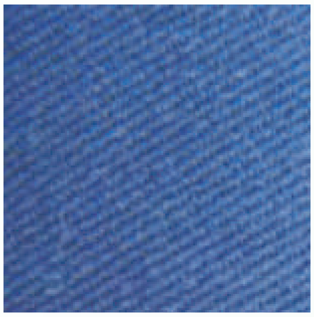

Figure 2.20 Twill woven fabric

	X	X		X	X
X	X		X	X	
X		X	X		X
	X	X		X	X
X	X		X	X	
X		X	X		X

X → Warp up

Figure 2.21 Graphical representation of 2 up 1 down twill weave

SATIN AND SATEEN WEAVE

In Britain a satin is a warp faced weave in which the binding points are arranged to produce a smooth fabric surface free from twill lines. A satin is frequently described as a 'warp satin'. A sateen, frequently referred to as 'weft sateen' is a weft faced weave to give a smooth and shiny appearance.

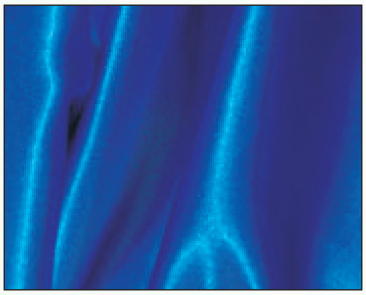

Figure 2.22 Satin woven fabric

X	X	X	.	X
X	.	X	X	X
X	X	X	X	.
X	X	.	X	X
.	X	X	X	X

X → **Warp up**

Figure 2.23 Five- end sateen weave

EXERCISE 2.3

PURPOSE: To understand the process of weaving

1. **Write TRUE/FALSE against each statement**

   a) Shedding is the process of separating the warp threads into two layers to form a tunnel known as shed.

   b) Picking is the process of insertion of the warp thread in the shed.

   c) Shedding, Picking and Beat up are the secondary motions in a loom.

   d) Plain, Twill and Satin weaves are basic weaves.

   e) Plain weave is the simplest form of interlacement that can be produced.

ACTIVITY 2.3

Take any fabric swatch and analyze the movement of the warp and the weft in the fabric sample and illustrate it in a paper.

2.5 DYEING

Dyeing is the process of coloration of textile materials by immersing them in an aqueous solution of dye. Dye molecules are organic molecules. Dye molecules are coloured because they are selectively able to absorb and reflect incident light. The dye molecules are able to react with the functional groups in the fibre in the amorphous regions and form ionic bonds/ van der Waal's forces or covalent bonds and impart colour to the textile fibre. The dye molecules must remain in the fibre after repeated washes in a textile which is colour fast.

2.5.1 Classification of dyes

Dyes can be broadly classified as synthetic dyes and natural dyes based on the source.

2.5.2 Natural dyes

Natural dyes are a class of colorants extracted from vegetative matter (seeds, leaves, roots, and bark) and animal residues. Natural dyes on textiles have been used since ancient times. The earliest written record of the use of natural dyes was found in China dated 2600 BC.

Advantages of Natural Dyes

1. Natural dyestuff can produce a wide range of colours
2. A small variation in the dyeing technique or the use of different mordants(e.g copper sulphate, ferrous sulphate, alum, etc) with the same dye can shift the colours to a wide range or create totally new colours, which are not easily possible with synthetic dyestuffs.
3. Unlike non-renewable basic raw materials for synthetic dyes, the natural dyes are usually renewable, being agro-renewable/vegetable based and at the same time biodegradable.
4. In some cases like harda, indigo etc., the waste in the process becomes an ideal fertilizer for use in agricultural fields. Therefore, no disposal problem of this natural waste.
5. Many plants thrive on wastelands. Thus, wasteland utilization can be an added advantage if natural dyes are extracted from plants in waste lands.

Limitations of Natural Dyes

1. It is difficult to reproduce shades by using natural dyes/colourants, as these are agro products.
2. Colorant varies from one crop season to another crop season, place to place and species to species, maturity period etc.

3. Natural dyeing requires skilled workmanship and is therefore expensive. Low colour yield of source natural dyes thus necessitates the use of more dyestuffs, larger dyeing time and excess cost for mordants and mordanting.
4. Scientific backup is necessary and research and development in this field is still required.
5. Lack of availability of precise technical knowledge on extraction and dyeing techniques.
6. The dyes are sensitive to pH. They change colour if the pH of the water changes.
7. The dyed textile may change colour when exposed to the sun, sweat and air.
8. Nearly all-natural dyes with a few exceptions require the use of mordants to fix them on to the textile substrate. While dyeing, a substantial portion of the mordant remains in the residual dye bath and may pose serious effluent disposal problem.

2.5.3 Synthetic dyes

Synthetic dyes are chemically synthesized organic compounds. They have been classified based on the application. The different classes of dyes have affinity for different fibres. The different classes of synthetic dyes with the fibres that they can dye are given in table 2.2.

Table 2.2 Classes of synthetic dyes

Class of dye	Fibres which can be dyed
Direct dyes	Man-made & natural cellulosic fibres (cotton, flax, viscose rayon)
Acid dyes (anionic dyes)	Natural protein fibres (silk, wool), nylon fibres
Basic dyes (cationic dyes)	Acrylic , modacrylic fibres
Disperse dyes	Polyester, nylon, acrylic, cellulose acetate
Reactive dyes	Cellulosics & protein fibres (Cotton & Silk)
Mordant dyes	Wool, silk (natural protein fibres)
Metal-complex dyes	Wool, silk (natural protein fibres)
Sulphur dyes	Natural & man-made cellulosic fibres
Vat dyes	Cellulosic fibre

Advantages of Synthetic Dyes

- ★ A small quantity of colorant is required to dye large quantity of textile material
- ★ A whole gamut of shade can be achieved with synthetic dyes
- ★ The shades can be easily reproduced so that similar shade is achieved on repeated dyeing
- ★ The dyes like reactive, vat, disperse have excellent fastness properties

Limitations of Synthetic Dyes

- ★ Synthetic dyes also require electrolyte (salt) and auxiliaries for dyeing
- ★ The waste water from the dye house needs to be treated for proper effluent control to reduce water and soil pollution.

2.5.4 General theory of dyeing

Dyeing is the process of coloration of textiles by immersing in an aqueous solution of dye known as dye bath. The dye molecules must diffuse from the dye bath to the fibre. The dye molecules must penetrate inside the fibre structure in the amorphous regions to give the required fastness. To improve the effectiveness of dyeing, electrolyte (e,g salt, soda ash), dye auxiliaries (e.g. levelling agents) and heat is required to assist the process of dye diffusion.

Dyeing can be done in fibre stage, yarn stage, fabric stage or even garment dyeing can be done. In the textile industry dyeing machines are used for dyeing. Modern dyeing machines are sophisticated and computerized for standard dyeing process. In the handloom sector of India manual dyeing is still practised.

EXERCISE 2.4

PURPOSE: To understand the basic theory of dyeing and different classes of dyes

1. Fill in the blanks:

a. …………….. is the process of coloration of textile materials by immersing them in an aqueous solution of dye.

b. The dyes that are extracted from vegetative matter (seeds, leaves, roots, and bark) and animal residues are termed as ……………..

c. Synthetic dyes are .... organic compounds.

d. .... class of dye can dye natural and manmade cellulosic fibres.

e. .... and .... dyes can dye protein fibres like wool and silk.

2. Write TRUE/FALSE against each statement

a. Dyes are soluble in water.

b. Dyes form bonds within the fibre structure.

c. Dyeing can be done on fibres, yarns and fabrics.

d. A large quantity of colorant is used, to dye fabrics with synthetic dyes.

e. Natural dyes are sensitive of pH.

ACTIVITY 2.4

Take 5 samples of fabric 5*5 cm2 and wash them in a solution of detergent for 15-20 minutes. Dry them and check visually if there is any loss of colour during washing. Try to find out why the colour fastness to washing is good or poor.

2.6 PRINTING

Printing is the process of application of colorant to a specific area of the fabric based on the design of the print. It is like localized dyeing of textiles. The process of printing on textiles using wooden bocks was common in India since 12th century. India holds a rich tradition of block printing. Presently, block printing, screen printing, transfer printing and digital printing are done on textiles.

2.6.1 General theory of printing

The printing of textile materials is the process of application of colorant to a predetermined area of the design. For printing dye or pigment is required as the colorant. The printing on textiles is done with the application of print paste that is prepared by using dye/pigment, binder, thickener, water and other print auxiliaries. A print paste limits the colorant to a limited part of the fabric, unlike dyeing where the colorant should be applied uniformly throughout the fabric. This section would discuss the role of the different ingredients used in printing of textiles.

Dye/pigment: The main colouring compound in the printing process.

Water: A small amount of water is required in printing to dissolve the dye into the print paste. Water is a convenient and easily available medium to mix and disperse the dye molecules in the thickener.

Thickener: The purpose of the thickener is to produce a medium for the dye paste. The viscosity of the printing paste is very important as it affects the clarity and depth of the printed pattern. The physical and chemical properties of the thickener should be such that it should not crack immediately after printing. Thickeners can be any of the following:

- ★ Natural gums such as gum Acacia, gum Arabic or gums from starches
- ★ Manmade natural polymer based gums like carboxyl methyl cellulose, sodium alginate, or
- ★ Manmade synthetic compounds such as polyvinyl alcohol.

Steam: After printing the next process is generally steaming. Steaming ensures adequate penetration of the dye molecules in the fibre. This is possible because steaming provides energy for the dye molecules to enter the fibre structure. Steaming also helps in swelling of the fibre so that the dye from the print paste can enter the fibre polymer system.

Dry heating: Thermoplastic fibres tend to be hydrophobic and do not swell sufficiently in water when subjected to steaming. Dry heating softens the fibre and allow the dye molecules to enter into the amorphous region of the fibre structure.

Washing off: Washing is done to remove the thickener and other printing paste from the surface of the fabric after the printing process.

2.6.2 Methods of printing

Printing can be done using different methods. The different methods of printing are presented in this section.

i. Block Printing : Manual method

ii. Screen printing

- ★ Flat bed screen printing (manual/semi-manual/ automatic)
- ★ Rotary screen printing (automatic)

iii. Transfer printing/ sublimation printing

iv. Digital printing

v. Other methods: Flock printing, foil printing, embossing, rubber print, etc.

BLOCK PRINTING

Block printing is one of the traditional styles of printing in which wooden blocks are carved according to the design. Then the blocks are placed on the print paste and stamped on the fabric to be printed. To reduce the size of the print, the size of the block need to be changed. It is a manual method of printing which is still practiced in India mainly in the following states:

Table 2.3 Block printing locations in India

States	Locations
Andhra Pradesh	Hyderabad, Machalipattnam (Kalamkari)
Gujarat	Ahmedabad (Pethapur), Kutch, Porbandar, Rajkot
Rajasthan	Bagru, Chittroli, Sanganer, Jaipur, Jodhpur
Madhya Pradesh	Bagh, Behrongarh, Indore, Mandsar, Burhanpur
Uttar Pradesh	Benares(Block-makers),Farrukabad,Pilakhuan (Blockmakers)
West Bengal	Kolkata and Serampore

Figure 2.24 A wooden block for block printing

Figure 2.25 Block printing process

SCREEN PRINTING

In screen printing a screen is first prepared using a porous mesh. The area through which the print paste has to pass is kept open in the screen and the remaining areas are blocked in the screen as per the print design. Depending on the number of colours that are required for printing, the same number of screens needs to be prepared. The print paste is then applied on the fabric by using a squeegee. Print paste is applied on the screen and the squeegee then moves across the screen, forcing the print paste through the screen and into the fabric. Rotary screen printing is the most popular method of printing and the most economical printing method in the textile printing industry. It has also a high production rate.

TRANSFER PRINTING

Transfer printing is the process of transferring an image to fabric by the process of sublimation transfer, melt transfer or film-release method. In this method the image is generally printed on a paper carrier using volatile dyes. When heat and pressure are applied to this paper the dyes are transferred to the fabric. Volatile disperse dyes are used for transfer printing.

DIGITAL PRINTING

Digital printing is the latest advancement in the method of printing, in which digital inkjet printing machines are used to print the design on the fabric. As the process is computerized, screen or block preparation is not necessary to transfer the design on the fabric. The inks used for digital printing can be based on dyes or pigments. It gives more flexibility to change the design than block or screen printing.

The fabrics are generally pretreated, and placed in the machine for printing, the dyes are fixed usually by steaming in a separate machine, washed off and dried.

EXERCISE 2.5

PURPOSE: To understand the basic process of printing of textiles

1. Fill in the blanks:

a. …………… is like localized dyeing of textiles.

b. …………….. is a traditional method of printing.

c. For printing ……. or ……………. is required as the colorant.

d. Acacia gum, Gum Arabic or gums from starches are used as ………….. in printing.

e. The number of screens required for screen printing of a particular design is equivalent to the number of ………….. in the design.

2. **Differentiate between transfer printing and digital printing.**

Review Questions

1. How can textile fibres be classified?
2. Give 4 examples of cellulosic natural fibres.
3. What are the sources of natural protein fibres?
4. What is the difference in the properties of cotton and jute fibres?
5. What are the differences between the properties of cotton & wool?
6. What are the advantages of polyester over cotton fibres?
7. What are the applications of nylon and acrylic fibres?
8. What are the applications of polyester and viscose?
9. Name 3 high performance fibres.
10. Why is wool warm to wear?
11. What is the reason for the lustre of silk?
12. Name 3 traditional Indian textiles.
13. What are the steps involved in weaving?
14. Name three basic weaves.
15. What is warp and weft in a woven fabric?
16. Graphically represent plain weave.
17. What are the different types of looms?
18. What are the parts of a loom?
19. What are the uses of twill weave?
20. What is the difference between natural and synthetic dyes?
21. What are the advantages of natural dyes?
22. What are the disadvantages of synthetic dyes?
23. Which class of dye can be used for cotton?
24. Briefly explain the process of dyeing.

25. What are the different methods of printing?
26. What is the difference between transfer printing and digital printing?
27. In which regions of India is block printing still practised?
28. What is the function of thickener in printing?
29. Which method of printing is most popular and why?
30. What are the advantages of digital printing?
31. Sketch the cross-section of cotton fibre.
32. Why is rayon called regenerated cellulosic fibre?

ACTIVITY 2.5

Take 5 printed fabric samples 10cm * 10cm. Study the print design. Sketch the print design on paper and write down how many dyes/pigments have been used to print the design.

GLOSSARY

Acid Dye: An anionic dye characterized by its affinity for Protein and Polyamide Fibres usually applied from an acidic dye bath.

Acrylic Fibre: A term used to describe fibres composed of synthetic linear molecules having in the chain at least 85% (by mass) of acrylonitrile groups.

Angora: The hair of the Angora rabbit. Note: The Hair of the Angora Goat is referred to as Mohair.

Aramid Fibre: A term used to describe fibres composed of synthetic linear macromolecules having in the polymeric chain recurring amide groups. These fibres are high permormance fibres.

Basic Dye: A cationic dye characterized by its substantivity for basic-dyeable acrylic and basic-dyeable polyester fibres.

Block Printing: A hand printing method using wood, metal, or linoleum blocks. The design is carved on the blocks, one block for each color. The dye is applied to the block which is pressed against the fabric.

Cashmere: Originally hair from the downy undercoat of the Asiatic Goat. Currently similar hair from animals bred selectively from the feral goat population of Australia, New Zealand and Scotland, is also being regarded as Cashmere provided the fibre diameter is similar.

Cocoon: An egg-shaped casing of silk spun by the silkworm to protect itself.

Continuous-filament Yarn; Filament Yarn: A yarn composed of one or more filaments that run essentially the whole length of the yarn. Yarns of one or more filaments are usually referred to as monofilament or multifilament, respectively.

Cotton: The seed hair of a wide variety of plants of the gossypium family.

Drawing (Synthetic Filaments and Films): Drawing is the process of stretching synthetic filaments to orient the molecular chains in the filament in a particular direction.

Dupion: A type of course and rough silk yarn that is spun from double cocoons. The silk yarn of dupion silk is bulky and course as compared to mulberry silk.

Dye: A colorant that has substantively for a substrate and is soluble in water.

Glass (fibre): A term used to describe fibres made of mixed silicates.

Gum-Sericin: The silk gum that holds the two strands of silk filament together is called sericin. It is protein in nature and soluble in water.

Hydrophilic: Having an affinity for water.

Hydrophobic: Having no affinity for water.

Man-made Fibre: A Fibre manufactured by man and distinct from a fibre that occurs naturally.

Merino: Refers to the wool from the merino sheep that is fine, strong and of a very high quality.

Mordant: A substance, usually a metallic compound, applied to a substrate to form a complex with a dye, which is retained by the substrate more firmly than the dye itself.

Permanent Set: The process of conferring permanent stability, pleats, creases in fibres or fabrics by successive heating and cooling.

Pigment: Pigment is a substance that adds colour to the medium when it is dispersed in the medium. It is insoluble in water.

Polyamide, Natural (fibre): Natural fibres consisting of polymers containing the repeating group -CO-NH-. Examples are silk, wool and other animal hairs.

Polymer: A large molecule built up by the repetition of small, simple, chemical units.

Rotary Screen Printing: In Screen printing a separate screen is created for each color. Rotary cylinders are used for printing. The number of cylinders in Rotary printing is equivalent to the number of colours. It is a faster process than any other method of printing and also economical. The size of the design repeat is limited to the circumference of the cylinders.

Sateen: Sateen is a type of weave that gives a glossy appearance to the fabric. It is generally

Weft: The yarn that run across the width of the fabric.

Yarn: A Product of substantial length and relatively small cross-section consisting of fibres and/or filament(s) used for weaving, knitting, etc.