LESSON 4  YARN MANUFACTURE FROM STAPLE FIBRES

STRUCTURE

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4. **Yarn Manufacture from Staple Fibres**

Woven and knitted fabrics use a yarn as the starting material. Yarns are also used for sewing, packaging etc. In this lesson, we will learn how yarns are manufactured from staple fibres. In the two subsequent lessons of this unit, the manufacture of yarns from continuous filaments and the production of fancy yarns will be described.

4.0 Objectives

After going through this lesson, you will be able to:

- Understand what is a yarn.
- Understand how yarns are manufactured from staple fibres.
- Understand the role of twist in determining the properties of a yarn.
- Identify the direction of twist in a yarn.

4.1 Introduction

A yarn is a continuous strand of short discontinuous textile fibres twisted together or of continuous filaments. Out of the three major natural fibres, cotton and wool fibres are short (usually between 1 cm. to 10 cm. long) while silk filament is around 1 km. long. Man-made fibres are generally produced in the form of continuous filaments but may be used as staple- this is achieved by cutting the long filaments into short staple fibres. A considerable amount of these staple fibres are blended with natural fibres and then the blend is converted into yarns for fabric manufacture. The staple fibres or their blends are converted to yarns by first making a web in a carding machine. The webs are collected in the form of slivers which contain the parallelized short fibres held together by cohesion between the fibres. They are then subjected to drafting and twisting to yield yarns.

Yarns may also be made from continuous filaments by collecting a number of them in parallel configuration and introducing twist to improve cohesion. As shown in Fig. 4.1, the filaments may be used as mono-filament, multi-filament yarn without twist, twisted multi-filament yarn and twisted yarn made from short, staple fibres.
In this lesson we will describe the manufacture of yarns from staple fibres. Yarns composed of staple fibres are also called "spun yarns". These spun yarns are generally manufactured either on the cotton system or the woollen system or the worsted system. In this lesson, we will describe the cotton system of yarn formation. The texture of the spun yarn makes it more comfortable than the filament yarn.

4.2 Historical Background

Cotton fibres have been used by mankind for over 5000 years. Much before mechanized spinning became possible; yarns were made from cotton by hand. The high spinnability of cotton can be demonstrated by taking a small bunch of fibres and then rolling them in one direction in the palms of your hands when it gets converted into a coarse cotton yarn.

Since the texture and appearance of a fabric is considerably influenced by the type of yarn used, the study of the yarn is of considerable importance.

People still use their fingers and a spindle with a tiny hook attached at the top and a disc at the bottom to spin coarse yarns from cotton. The same principle formed the basis of the Indian spinning wheel or "charkha" (Fig 4.2) which came up sometime between 500-1000 AD and is still used to spin cotton. The mechanized version of the charkha, called Ambar charkha, has been developed and is quite extensively used to make hand-spun cotton yarn for making khadi fabric.
The machines used for spinning perform the same action as the fingers and the spindle of the hand spinner. Machines work at much higher speed but divide the yarn making process into a number of operations which will be described in the next section.

**Self-check Questions**

1. What is the difference between a staple fibre and a staple fibre yarn?

2. How can yarn be spun by hand?

### 4.3 Yarn Manufacture from Cotton Fibres

Mechanical spinning is carried out mainly for cotton, wool and their blends with other fibres like polyesters. The natural fibres contain dirt and other impurities which need to be removed first. The staple fibres have to undergo various processes of mixing/blending, opening, cleaning, drawing etc before the final yarn of desired thickness is obtained.

The cotton fibre has to pass through the following stages during its spinning.

#### 4.3.1 Opening (Blow room)

The cotton arrives in the mill in large bales weighing about 180 kg each, from where it is brought to the blow room. The compressed mass of raw fibre in the bales is removed and then it is mixed, opened and cleaned.

Mixing is necessary to obtain uniformity of fibre quality. Opening is necessary in order to loosen hard lumps of fibre and disentangle them. Cleaning is required to remove trash—such as dirt, leaves, burrs and any remaining seeds. These functions are carried out through a continuous series of machines in the blow room as described below.

- a) Hopper Bale Breaker
- b) Hopper Bale Opener
- c) Hopper Feeder
- d) Various Types of Beaters – Harsh and Soft.

The number and types of beaters used depends upon the type of cotton that is being processed.
The blending feeder (Fig. 4.3) has a spiked apron that raises cotton until part of it is knocked off by roll. The churning of cotton mixes it.

4.3.2 Picking

This fluffy mass of fibres then moves to picking machine called “scutcher” (Fig. 4.4). The loosening and cleaning of the fibres continues and it is then formed into a continuous white sheet called “lap” which resembles a compressed cotton layer. As can be seen, a considerable amount of impurities are removed during this process.

4.3.3 Carding (Card room)

The cotton laps from the blow room are then fed to the carding machine (Fig. 4.5) where the remaining impurities (trash) are removed and the cotton is opened into individual fibres. In this machine the lap passes between two cylinders covered with specially bent wires. Here the individual fibres are straightened and made somewhat parallel. This process of cleaning and opening the cotton into individual fibres is known as “Carding”. The fibres emerge from the carding roll as a thin, uniform web which is drawn in a funnel shaped device where it gathers into a soft mass of a rope of fibres, about ¾ inch in diameter. It is called “sliver”. The sliver is collected into the containers called cans. Card slivers are used for coarse and medium count yarns.
4.3.4 Combing

This is an optional process. When the fibre is intended for fine or superfine yarns, the carded sliver is fed through the ‘Comber’. Here fibres are combed by the fine toothed combs. The fibres are thus made perfectly parallel and fully straightened. The short fibres are removed. These combed fibres are formed into sliver called “combed sliver” and collected in cans.

The combed sliver made of the longest fibres produces a smoother and more even yarn of fine and superfine quality. Combing is an expensive process and adds considerably to the cost of the fabric. Combed fibres lead to formation of better fabric, because of higher fineness, strength, uniformity, smoothness and luster.

4.3.5 Drawing

In the drawing operation (Fig. 4.6) several slivers are fed into the drawing rollers at the same time. The drawing frame consists of four steps of rolls each of which travels at a faster speed than the previous set of rollers. The difference in speed causes the elongation of the sliver and draws it into a new sliver which is without any twist. This makes the sliver even and the fibres become fully parallel and straightened.
4.3.6 Roving

After the single or several stages of drawing (as the case may be for combed sliver), the sliver is taken to a “slubber” where it is drawn out further to the desired shape, twisted and then wound on bobbins. These bobbins are then placed on the intermediate frame, where further drawing and twisting takes place. In the case of fine and superfine cottons, the yarn passes through roving frame and then is further placed onto jack frames. The operations of intermediate and jack frames are identical, but each machine yields a finer product. The four machines viz, slubbing frame, intermediate frame, roving frame (Fig. 4.7) and jack frame are together called “fly frame”. Roving is thus the final product of the several drawing out operations in the fly frames preparatory to final spinning of the yarn. At this point, up to roving, fibres are only partially twisted and have low tensile strength. They may break with a slight pull.

![Fig. 4.7 Roving Frames (Taken from Reference 1)](image)

4.3.7 Spinning

Next the yarn is placed on the ring spinning frame (Fig. 4.8), where it passes through several sets of rollers running at successively higher speeds and is finally drawn out or drafted by introducing twist and winding operations.

The yarn here passes through a traveller to a spindle which revolves and puts in an exact number of twists as the yarn is wound up on a desired bobbin. The ring spinning frame completes the manufacture of yarn by drawing out, inserting twist, winding the yarn, all in one operation.

![Fig. 4.8 The Ring Spinning Frame (Taken from Reference 1)](image)
The bobbins filled with yarn are then removed from ring frames for processing as may be desired; for example, the yarn may be formed into hanks or skeins for bleaching or may be wound on spools, for weaving. They are then marked and labeled as desired. A summary of the operations is given in Table 4.1.

Table 4.1 Summary of the Spinning Process

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Process</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Opening</td>
<td>Loosens blends and fluffs fibres.</td>
</tr>
<tr>
<td>2</td>
<td>Picking</td>
<td>Loosens, cleans, and forms into “lap”.</td>
</tr>
<tr>
<td>3</td>
<td>Carding</td>
<td>Straightens and forms the card sliver.</td>
</tr>
<tr>
<td>4</td>
<td>Combing</td>
<td>Straightens, removes short fibres and forms combed sliver.</td>
</tr>
<tr>
<td>5</td>
<td>Drawing</td>
<td>Parallelizes blends and reduces the size of strands.</td>
</tr>
<tr>
<td>6</td>
<td>Roving</td>
<td>Reduces the size further with a slight twist.</td>
</tr>
<tr>
<td>7</td>
<td>Spinning</td>
<td>Twists and winds the final yarn.</td>
</tr>
</tbody>
</table>

Self-check Questions

3. Explain the process of drawing.

4. At which stage of yarn manufacture is twist introduced in cotton?

4.4 Yarn Manufacture from Blend of Two Different Fibres

The production of staple or spun yarn is not limited to yarns from one kind of fibre alone. Blends of cotton with polyester and of wool with polyester are well known. Polyester is also blended with other fibres in varying proportions. The main reasons for the increasing use of polyester blend with cotton fibres are the easy care and wash and wear characteristics imparted by the polyester component. In addition, it also imparts durability, strength, wrinkle resistance and elastic recovery to the composite yarn. For carpets, blend of wool with acrylic fibres is quite popular.

Man-made fibres may be processed on any of the spinning systems which were mentioned earlier. The cut length of the staple man-made fibre determines the system used. If the cut length is compatible with that of cotton, the spinning is done on a cotton system. If the cut length is large and compatible with that of wool, then it is spun on a woollen or worsted system.

Unlike natural fibres, polyester (and nylon) fibre has a smooth surface without any crimp and it is rather difficult to process those fibres into yarn either in
pure form or as blends with cotton (or wool or viscose rayon). Un-crimped fibres will slip past each other and cannot be easily carded or drafted. Crimping helps in achieving good fibre to fibre cohesion. The average crimp frequency is 5 to 6.5 crimps per cm. The crimped fibres are supplied in bales.

Blending must be done at any one of the fibre processing stages discussed earlier. During the initial opening stage, appropriate amount of each fibre can be weighed and a layer of this sandwiched between cotton fibre laps for feeding to the blending feeder (Fig 4.2) for onward transmission to a mechanical mixer.

Blending may be commenced at other stages of spun yarn manufacture, or in spinning stage also and for details references 1 and 2 may be seen. It must be emphasized that unlike natural fibres, the polyester fibres are clean and do not need to be subjected to the cleaning operations. Also they are all of the same length and therefore combing action is not required.

Self-check Questions

5. Why is polyester used for blending?
6. At which stage can blending be done?

4.5 Twist and its Effect on Properties of Spun Yarns

Twist binds the staple fibres together into a yarn. It plays a vital role in yarn properties and performance. Twist is a spiral turn given along the length of yarn. All staple yarns are twisted to hold the fibres together. In twisting fibres together to form yarns, the fibres can be twisted in either of the two directions shown in Fig. 4.9 and are called “S” twist or the “Z” twist. The majority of single yarns are made with a Z twist. However in certain fabric constructions, special effects can be achieved by combining yarns in which the fibres have been twisted in either the same or opposite directions. Twist is specified by the number of turns per unit length: turns per inch (tpi) or turns per meter (tpm).

In many instances the direction of twist of the yarn has little effect on the fabric appearance, but the direction of inclination of the fibre can accentuate some weave effects.
The amount of twist to be given to a yarn varies with the length of fibres, the size of the yarn and the desired end product. Up to a certain level, twist increases strength of a yarn while excessive twist leads to form a weaker yarn. This is because; the initial twist brings the fibre cluster together and binds them, thus increasing the strength. However, at high level of twist, the inclination of the fibre to the yarn axis becomes rather large and thus the strength along the yarn begins to decrease. Increasing the amount of twist also affects the yarn hairiness, comfort, cost and linting. Yarn with less twist tends to be more hairy, soft and more comfortable. Finer yarns require more twist than coarse yarns. Also knitting yarns have less twist than yarns used in weaving. In better quality yarns, twist is evenly distributed throughout the yarn and is towards the higher side.

Self-check Questions

7. What is the importance of twist for a yarn?

8. How many types of yarn twist are you aware of?

9. What is the measure of yarn twist?

10. How does twist affect the fabric properties?

Activity

1. Take 10 fabrics with different appearances and softness. Remove individual warp and weft yarns from the fabric and observe the yarns by putting them independently on a flat surface. What do you notice? Untwist these warp and weft yarns. What is your observation?

2. Fill in the blocks given below by indicating the sequence of operations for making yarn from cotton fibre.

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[Block Diagram]
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4.6 Assignments
4.6.1 Class Assignments

i) How is cotton yarn manufactured? Explain the purpose of each process briefly.

4.6.2 Home Assignment

ii) Why does the yarn strength first increase with twist level and after reaching a maximum, begins to decrease with increasing twist?

4.7 Summing Up

In this lesson the conversion of staple fibres to yarns has been described. After giving a brief history of the spinning process and a detailed description of the process of manufacture of cotton yarn, the importance of twist in determining yarn properties has been considered.

4.8 Possible Answers to Self-check Questions

1. A staple fibre is a short thin fibre, while a yarn is a continuous strand of short textile fibres twisted together.

2. Yarn can be spun by hand by rolling a bunch of fibres in one direction in between the two palms.

3. In the drawing operation several slivers are fed into the drawing rollers at the same time. The drawing frame consists of four steps of rolls each of which travels at a faster speed than the previous set of rollers. The difference in speed causes the elongation of the sliver and draws it into a new sliver which is without any twist. This makes the sliver even and the fibres become fully parallel and straightened.

4. Twist is introduced in the roving and the spinning stages of yarn manufacture.

5. Polyester is blended with other fibres because of its easy care and wash and wear characteristics. In addition, it also imparts durability, strength, wrinkle resistance and elastic recovery to the composite yarn.

6. Blending may be done at any one of the fibre processing stages.

7. Twist holds the short fibres together to form yarn. Twist gives strength and uniformity to a yarn.

8. There are two types of twist in yarns. The S twist and the Z twist.

9. Yarn twist is measured by the number of turns per unit length. This length may be specified in meter or in inches and thus twist is given as turns per meter (tpm) or turns per inch (tpi).
10. Twist affects the strength of yarn, hairiness, comfort and cost of yarn.

4.9 Terminal Questions

1. Describe in detail the process of conversion of cotton fibre to yarn.

2. Why is cotton blended with polyester for dress making material?

4.10 References and Suggested Further Reading


4.11 Glossary

1. Fabric  A manufactured assembly of fibres and yarns that has substantial surface area in relation to its thickness and sufficient cohesion to give the assembly useful mechanical strength.

2. Fibre  Hair-like textile material, generally characterized by flexibility, fineness and high ratio of length to thickness.

3. Filament  A fibre of indefinite length.

4. Continuous filament yarn  A yarn composed of one or more filaments that are essentially the whole length of the yarn.

5. Thread  A multi-ply textile yarn in general, two or more yarns twisted together.

6. Spindle  A long, slender stick used in spinning to provide the necessary twist to fibres being formed into a yarn. Spindles may be hand devices or part of a spinning wheel.