Compiled Study Material for Diploma Course in Haryana

Branch

Textile Technology

(Semester-IV)

Subject

Textile Testing-I

Maharishi Kashyap Government Polytechnic,
Jattal, Panipat

TEXTILE TESTING - I

SYLLABUS

UNIT I

Importance of Textile Testing and Quality Control

Introduction to textile testing (aim and Scope). Importance and objectives of textile testing. Sampling techniques. Random and biased samples. Zoning techniques for raw cotton. Yarn sampling methods.

UNIT II

Fibre dimension

Mean length, staple length, effective length, Span length, 2.5% span length, 50% span length, short fiber percentage. Analysis of Baer sorter diagram. Definition of fibre fineness. Importance of fibre fineness. Principle of air flow machines for measurement of fineness. Fiber strength, fibre maturity, maturity percentage and maturity ratio. Definition of moisture content and moisture regain of textiles. Relative and absolute humidity. Standard Atmospheric conditions. Wet and dry bulb hygrometer. Humidity and its importance to textile material. Estimation of foreign matter. Trash percent in cotton.

UNIT III

Fiber testing instruments

HVI instrument, principle, uses and advantages. AFIS yarn analysis. Bundle Fiber strength tester. Maturity of cotton fibre by Caustic Soda Method, Differential Dyeing Method and Polarised Light Method. Measurement of moisture regain by Oven dry method. Trash analysis in cotton by Shirley trash analyser.

UNIT IV

Yarn Testing-I

Twist and its importance. Its effects on yarn properties. Twist factor, single and ply yarn. Twist Testers. Twist by direct count method, single yarn twist tester, ply yarn twist tester, twist untwist method. Yarn numbering systems. Direct, Indirect and Universal systems of yarn numbering. Conversion factors for various numbering systems in detail. Determination of count of yarn by simple weighing method and from small length by Bessley's yarn balance.

UNIT V

Yarn Testing-II

Yarn strength- Single yarn and lea strength tester. Elongation- Breaking elongation. Elongation at break. Count strength product. CRE, CRL, CRT type. Factor affecting the tensile property of yarn. Principle of tensile testing machine. Tensile strength Testing of Yarn. Single and lea strength tester. Evenness of yarn. Principle, working and advantage and disadvantage of uster eveness tester. Classification of Yarn Faults and Its Removal. Classimate yarn fault analysis.

UNIT I

Importance of Textile Testing and Quality Control

Contents: *Introduction to textile testing (aim and Scope). Importance and objectives of textile testing. Sampling techniques. Random and biased samples. Zoning techniques for raw cotton. Yarn sampling methods.*

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1. Introduction

The testing of textile products is an expensive business. A laboratory has to be set up and furnished with a range of test equipment. Trained operatives have to be employed whose salaries have to be paid throughout the year, not just when results are required. Moreover all these costs are nonproductive and therefore add to the final cost of the product. Therefore it is important that testing is not undertaken without adding some benefit to the final product. There are a number of points in the production cycle where testing may be carried out to improve the product or to prevent sub-standard merchandise progressing further in the cycle

1.1. Aim of Testing

- Checking the quality and suitability of raw material and selection of material.
- Monitoring of production i.e. process control.
- Assessment of final product, whether the quality is acceptable or not, (how will be the yarn performance in weaving? etc).
- Investigation of faulty materials (analysis of customer complaint, identification of fault in machine etc.).
- Product development and research.
- Specification testing: Specifications are formed, and the materials are tested to prove whether they fall within the limits allowed in the specification (e.g. specified by a customer).

2. Importance and objectives of textile testing

The importance and objectives of textile testing are closely interlinked, emphasizing the critical role of this process in the textile industry.

2.1. Importance of Textile Testing

1. **Ensuring Quality:** Textile testing is key in maintaining high standards of quality in fabrics and garments. It helps in identifying defects and ensuring that the final product meets both industry standards and consumer expectations.

2. **Consumer Safety:** It ensures that textiles are safe for consumer use. Testing for harmful chemicals and irritants is crucial to avoid skin allergies, toxic reactions, and other health hazards.

3. **Performance Verification:** Testing verifies that textiles perform as expected under various conditions, like exposure to sunlight, washing, and regular wear and tear, which is vital for consumer satisfaction and product longevity.

4. **Compliance with Regulations:** Textile testing is essential for compliance with national and international safety and quality standards. This is especially important for companies that export their products.

5. **Innovation and Development:** It supports research and development within the textile industry, aiding in the creation of new materials and processes that are more efficient, sustainable, or have improved properties.

6. **Environmental Considerations:** It helps in assessing the environmental impact of textiles, ensuring sustainable production practices and the use of eco-friendly materials.

3. Sampling Techniques

Sampling:

It is not possible or desirable to test all the raw material or all the final output from a production process because of time and cost constraints.

Many tests are destructive so that there would not be any material left after it had been tested. Because of this, representative samples of the material are tested.

Terms used in sampling:

➥ **Consignment:**

This is the quantity of material delivered at the same time. Each consignment may consist of one or several lots.

➥ **Test lot or batch:**

This consists of all the containers of a textile material of one defined type and quality, delivered to one customer according to one dispatch note. The material is presumed to be uniform so that this is the whole of the material whose properties are to be characterised by one set of tests. It can be considered to be equivalent to the statistical population.

➥ **Laboratory sample:**

This is the material that will be used as a basis for carrying out the measurement in the laboratory. This is derived by appropriate random sampling methods from the test lot.

➥ **Test specimen:**

This is the one that is actually used for the individual measurement and is derived from the laboratory sample. Normally, measurements are made from several test specimens.

➥ **Package:**

Elementary units (which can be unwound) within each container in the consignment. They might be bump top, hanks, skeins, bobbins, cones or other support on to which have been wound tow, top, sliver, roving or yarn.

Container or case:

A shipping unit identified on the dispatch note, usually a carton, box, bale or other container which may or may not contain packages.

3.1. Types of samples

There are two types of samples.

1. Random sample
2. Biased sample

3.1.1 Random sample

In selecting a random sample, every effort is made to ensure that every individual in the population has an equal chance of being included in it. The number in the sample must be large enough to include all the variations of the individuals in the population. The characteristics of random sample should represent the characteristics of the population or bulk material from which it was selected.

3.1.2 Biased sample

It may sometimes happen that the selection of a sample is influenced by factors other than chance, i.e. the sample is not a random sample. In such cases the sample may not be entirely representative of the bulk. This kind of sample is called a biased sample.

1.4 Methods Used in the Sampling of Fibres, Yarns and Fabrics

1.4.1 Methods Used for Sampling Fibres

It was mentioned earlier that sampling techniques have to consider the form of the material available for test e.g. fibre, yarn or fabric. Going a step further, the sampling method used for selecting a fibre sample for testing depends upon the form in which the fibre is available. Thus, fibres in bales or sliver or card web or yarn will demand different techniques.

Some sampling techniques used for the determination of fibre properties are discussed in what follows.

1.4.1.1 The Squaring Technique → used for sliver.

This technique is used for the selection of a random sample from a sliver. In using this technique, the sliver is first opened out into the form of a web and placed on a black velvet pad. The end of the sliver is then 'squared off'. This is achieved by placing a glass plate over the fibres to act as a control, allowing only a small fringe to project beyond the leading edge of the plate, as shown in Figure 1.2.

Next, all the protruding fibres are removed and discarded. The plate is moved back a little and a second fringe is removed. These last two steps eliminate the extent-bias since all the ends of the fibres have terminated in a given volume of the fibre web.

The above operation is repeated until the final position of the plate edge is at least a distance equal to the length, from its original position, of the longest fibre present. This step is essential because whenever a sliver is broken there is a bias of long fibres at each broken fringe.

The plate is then moved back a millimetre or so one last time and all the fibres protruding from the leading edge of the plate are removed and taken as the numerical or representative sample for a test, e.g. a length test on a comb sorter.

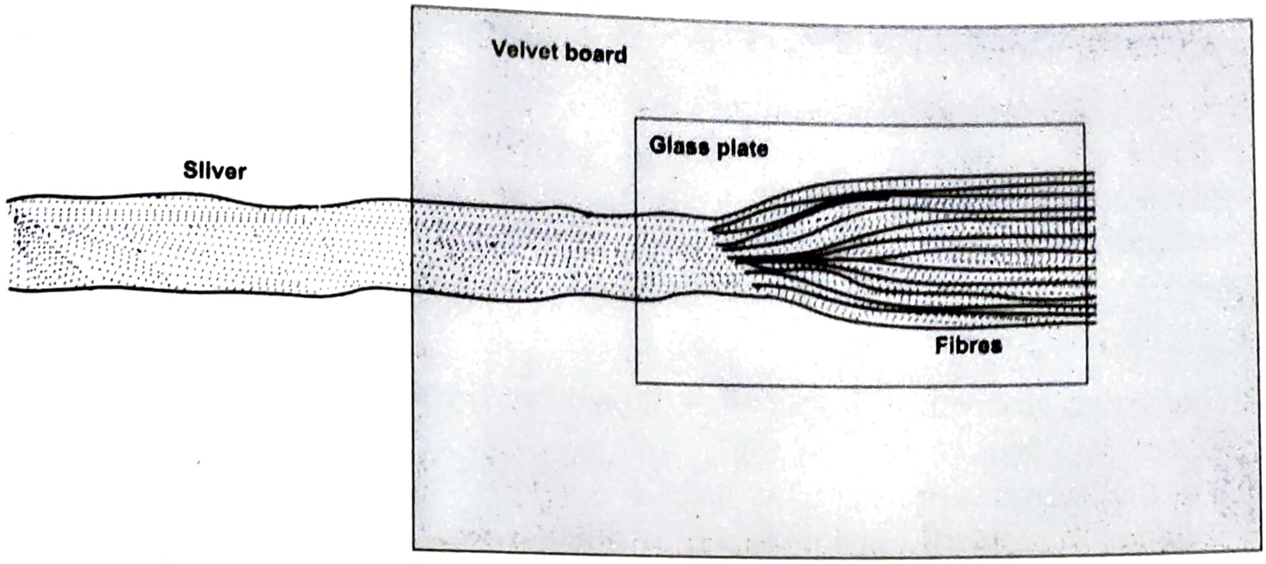

Figure 1.2 Squaring technique of sampling

1.4.1.2 The Cut-squaring Method → sliver, Roving, yarn.

When the material is composed of fibres in parallel order, e.g. drawframe sliver, rove and yarn, a modified squaring technique, called the cut-squaring technique, may be used.

First of all any twists in the material are removed. The material is then gently opened out a little, and laid parallel on a black velvet pad. A glass plate is placed over the fibres with its leading edge at right angles to the strand axis. This arrangement is depicted in Figure 1.3.

* Glass Plate shifted one milimeter back

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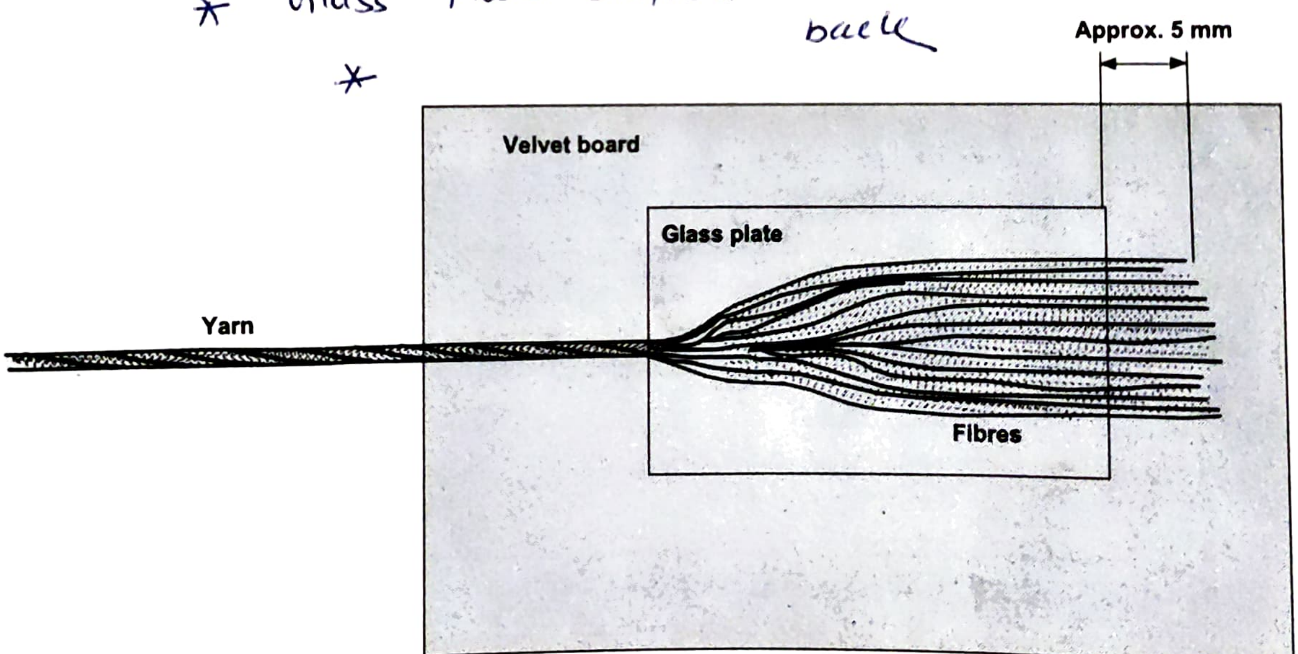


Figure 1.3 Cut-squaring method of sampling

The protruding fringe of fibres is cut across with scissors as close to the glass plate as possible and the fibres whose cut ends project are removed by forceps and discarded. The glass plate is then shifted back about one millimetre and again the projecting fibres are removed and discarded. This operation is repeated. Finally, after a third movement of the glass plate, the whole fringe is pulled out and used as the test sample.

1.4.1.3 Zoning Technique → fibre -

The selection of representative samples from a large lot of material presents special problems. In a bale of cotton, for example, the fibres may not form a homogenous mixture and small tufts of fibre have to be pulled out from as many places in the bale as is practically possible. Further, if the fibres form a highly heterogeneous mass, a very large number of tufts would need to be selected from the bale at random so that all its parts have been represented.

In such cases, an elaborate system called the **zoning technique** is used. This technique too involves selection of tufts of fibre from all possible parts of the bulk. But it is reliable in that samples prepared by different persons show results between which the differences are statistically insignificant. In other words, sampling on a given bulk of material by the zoning method gives samples that are similar in characteristics, and therefore representative of the bulk. The zoning technique is thus one recommended first by the British Standards. A brief account of the use of the technique in preparing a sample for evaluating the length characteristics by means of a comb sorter it is given in the following. Figure 1.4 represents a pictorial representation of the method used.

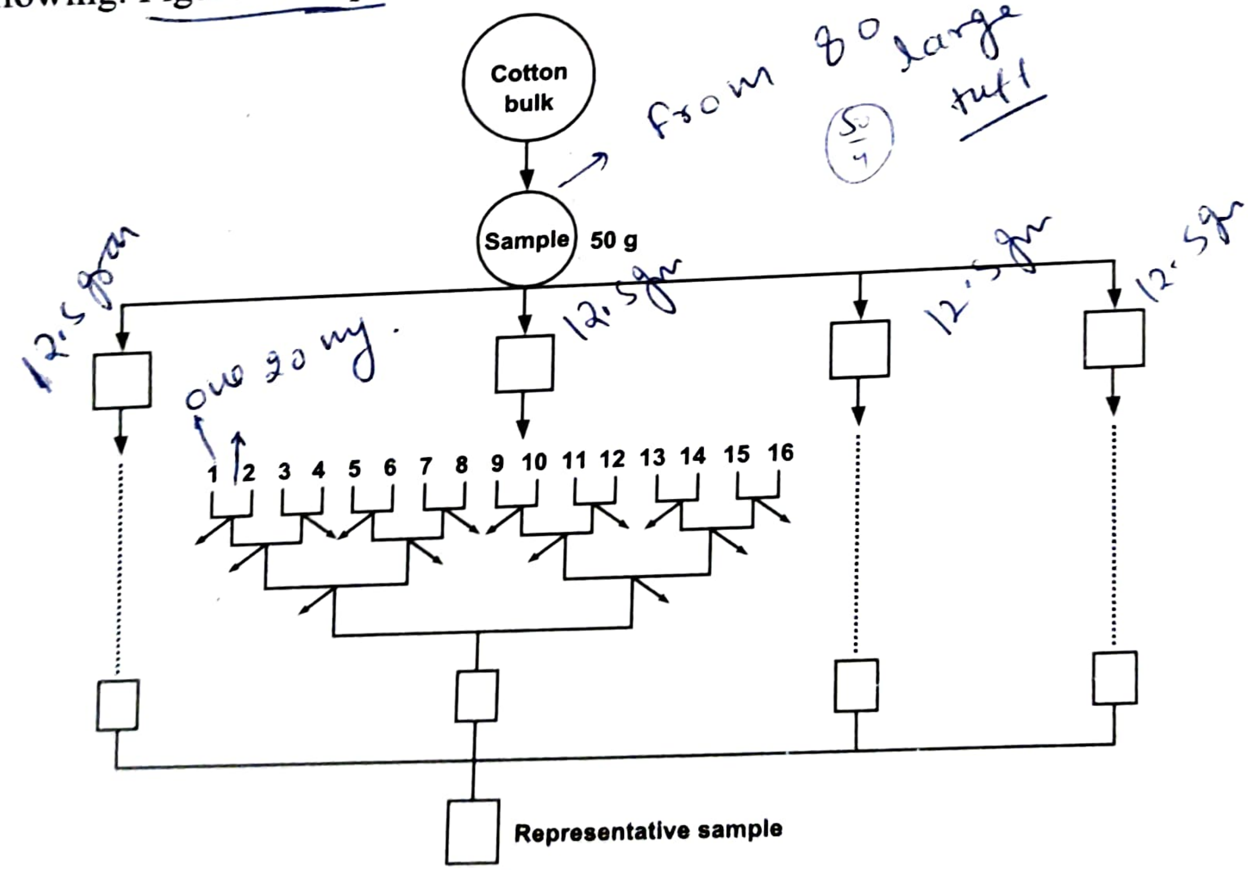


Figure 1.4 Zoning technique In the CD-ROM, watch Animation No. TT - I 1.1

1. A sample of about 50 grams is prepared from the bulk material by selecting about 80 large tufts chosen, as practicably as is possible, from all portions of the bulk.
2. The sample is then divided into four quarters.
3. Next, 16 small tufts of about 20 mg each are selected at random from each quarter.

4. a) One of the small tufts is taken and divided into two nearly equal parts by hand. The half in the right hand is discarded and the one in the left is turned through a right angle.

   b) This tuft is then split into two nearly equal parts by hand; the half in the left hand is now discarded and the remaining portion turned through a right angle.

   c) A third halving is then carried out on the portion that remains in the hand. The right hand portion is discarded this time and the remaining portion is turned through a right angle.

   d) Now a fourth halving is done on the remaining portion of the fibre. The left hand half is discarded and the small tuft ('wisp') that remains is preserved.

   The remaining 15 tufts of Step 3 are halved four times in exactly the same manner as above to give 15 small tufts, or wisps, that are preserved. 16 wisps are similarly separated from each of the other quarters of Step 2. Now we have selected 16 wisps from each quarter of the original sample.

5. The set of 16 wisps from each quarter is combined into a tuft. This gives us four tufts.
6. Each of the four tufts is thoroughly mixed by hand by drawing and doubling between the fingers.
7. Each of these mixed tufts is then divided into four parts, splitting the tuft in a direction perpendicular to the fibre length. Splitting in a lengthwise direction could result in two parts of differing in length characteristics. Hence this precaution is important. Care is also taken to see that the parts are as nearly equal to each other as possible.
8. One part is taken respectively from each of the tufts and combined to give a new tuft. This is repeated with the remaining parts of each tuft. We now have four new tufts, each containing a part of the previous four tufts (Step 6).
9. Each of the new tufts is thoroughly mixed again by manual drawing and doubling.
10. A quarter portion is then taken from each of the four new tufts to make the final sample, again taking care to split the tuft in a direction perpendicular to the fibre length.

This sample can now be regarded as a representative sample possessing all the length characteristics of the bulk material from which it was taken.

1.4.2 Methods Used for Sampling Yarns

Yarn samples are selected according to the type of test and the form in which the yarn is available. The yarn could be a ring bobbin, a double-flanged bobbin, a bundle of hanks and so on. The question is one of selecting a small number of individual packages from a large number. Some sampling methods used in the preparation of samples for the determination of yarn count, twist and strength are discussed below.

1. Sampling for the determination of the count of yarn in package form

Sixteen packages are selected from the concerned machine for spun yarns in the form of cops, ring-frame bobbins, tubes or other forms of primary package. Skeins are then wound from the top portions of eight of these packages. Next, skeins are wound from about the middle portions of the remaining eight packages.

With large packages such as cones and cheeses, take eight packages. Prepare two skeins from each; it is preferable to take one skein from the outer portion and another from a part near the middle. For continuous Þlament yarns, only one skein is taken from the outside of each of sixteen cones or cheeses.

2. Sampling for the determination of count of yarn removed from fabric

From the conditioned fabric, cut at least two rectangular strips, about 20 inches long, containing different warp ends for determining the count of warp yarns. Similarly, take at least Þve rectangular 20-inch strips representing different weft packages for determining the count of weft yarns. The strip width should be such as to contain at least Þfty lengths of either warp or weft yarn.

3. Sampling for the determination of twist in yarn in package form

Take test specimens in equal numbers from ten packages, taking care that no specimen is taken from within one yard of the end of the package. Discard a length of about one yard of yarn between consecutive specimens.

4. Sampling for the determination of the lea strength of spun yarns

A lea of yarn is taken from each of twenty packages. If only a smaller number of packages is available, withdraw leas from a smaller multiple of four packages such that a total of twenty leas are obtained. For example, two leas can be taken from each of ten packages. If only eight packages are available, three leas are taken from four of the packages and two each from the remaining four, to give twenty leas.

5. Sampling for the determination of single thread tensile strength

If single yarns and two ply yarns of medium to fine count are being evaluated, not less than 50 test specimens are taken from the available material. The yarn may be from a package, or from a warp, or from a woven or knitted fabric.

In the case of coarse two-ply yarns and for cabled yarns, the number of test specimens may be reduced to thirty.

In either case, the test specimens shall be selected so as to be representative of the sample.

EXERCISE

Multiple choice questions

1. The popular technique for cotton sampling is:

a. Cut squaring technique b. Zoning Technique

c. Squaring technique d. All of the above

2. Cut squaring technique is used for …….

a. Sliver b. Yarn

c. Roving d. All of the above

3. Which sampling technique used for sliver?

a. Cut squaring technique b. Zoning Technique

c. Squaring technique d. All of the above

Very short answer type of question

1. Define sample.
2. Define random sample.
3. Define biased sample.
4. What is textile testing?
5. Write the name of sampling techniques.
6. Write the name of yarn sampling techniques.

Short answer type questions

1. Discuss the importance of textile testing.
2. Write the aim and scope of textile testing.
3. Write the objective of textile testing.
4. Define the random and biased sample.
5. Why sampling is important for textile industry.
6. Differentiate random and biased sampling.

Long answer type question

1. Write the importance and objective of textile testing.
2. Discuss the zoning techniques for raw cotton.

UNIT II

FIBRE DIMESNION

Mean length, staple length, effective length, Span length, 2.5% span length, 50% span length, short fiber percentage. Analysis of Baer sorter diagram. Definition of fibre fineness. Importance of fibre fineness. Principle of air flow machines for measurement of fineness. Fiber strength, fibre maturity, maturity percentage and maturity ratio. Definition of moisture content and moisture regain of textiles. Relative and absolute humidity. Standard Atmospheric conditions. Wet and dry bulb hygrometer. Humidity and its importance to textile material. Estimation of foreign matter. Trash percent in cotton.

1. Fibre length

1.1. Introduction

An important fibre characteristic that influences the process of converting staple fibre to yarn, that is spinning, is length. The natural fibres, such as cotton, wool, flax etc., are available only in staple fibre form; this means that they have limited length. These fibres, especially cotton and wool, are available in a good number of varieties. Each of these verities has characteristics mean length. Both cotton and wool are therefore classified according to their length as long, medium, or short fibres. This section introduces the importance of fibre length in some detail and then discusses the methods of determining fibre length used in practice for cotton, as it is used on a much wider scale than any other fibre.

1.2. Importance of fibre length

Length of staple fibre is one of the most important characteristics. In general, a longer average fibre length is to be preferred because it confers a number of advantages. Firstly, longer fibres are easier to process. Secondly, more even yarns can be produced from them because there are less fibre ends in each length of yarn. Thirdly, a higher strength yarn can be produced from them for the same level of twist.

The cut length of man-made fibres is often influenced by the fibre length of natural fibres.

The measurement of natural fibres is a task as there is a greater variation in the length of different types of same material and even within the same type.

The properties of cotton fibre vary

- for different varieties of cotton.

- for different growth areas.
- for different climatic conditions.
- from year to year.

1.3. Definition of fibre length parameters

1.3.1. Fibre length:

This is the general term describing the longitudinal dimension of fa fibre.

- **Staple length**

Many definitions of staple length can be found in the literature. Two of them are given below.

J.E. BOOTH defines staple length has a quantity estimated by personal judgment by which a *sample of a fibres raw material is characteristics has regards as a technically most important fibre length.*

The handbook of textile testing published by BIS defines staple length has follows:

A measure of fibre length of a typical and representative sample from a bulk.

- **Means length**

This is the average length of all the fibres in sample. The average value is based on the weight length or the relative number-length distribution.

- **Effective length**

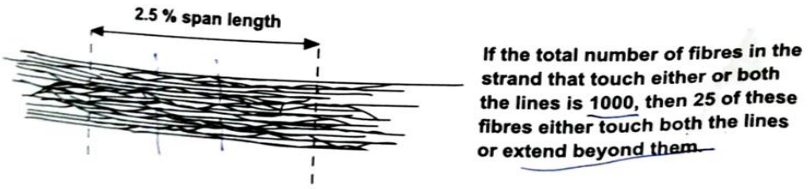
The effective length of fibre is the length of the bulk of the longer fibre in the sample.

- **Span length**

If a strand of parallel fibre is caught by two nips has in a set of successive pair of drafting rollers not all the fibre in the strand will be cause in both the nips. Some will caught at one of the nips some at the other and some at both the nips. Considering all the three categories of fibre if a certain percentage of the fibre are caught at both nips, some of these fibres will be equal to the distance between the nips and the other longer than this distance. If the percentage of such fibre is said x then the distance between the nips is called the x % span length. Another way of saying this that at x% span length, x% of the total number of fibres have length that are either equal to or greater than the span length.

➢ **2.5 % span length**

From the above explanation, if 2.5% of the total number of fibres are either caught at both the nips or extend beyond the distance between the two nips, then the inter-nip distance is called the 2.5% span length. Another way of defining the 2.5% span length is say that it is the distance from a line where the fibres in a strand are randomly caught, to a point where only 2.5% of fibres touch the point or extend beyond it. This is illustrated in Figure 3.1.



➢ **50 % span length**

Similarly the 50% span length is defined as the distance from a line where the fibres in a strand are randomly caught to a point where only 50% of fibres either touch the point or extend beyond it. It is obvious from this and the above definitions that for a given strand of fibres, the 50% span length will be less than the 2.5% span length. As the span length increases, fibres that are equal in length to or longer than the span length will decrease.

10. Uniformity ratio

The uniformity ratio is the ratio between 50% span length and 2.5% span length expressed as a percentage. Thus,

$$\text{Uniformity ratio} = \frac{\text{50\% span length}}{\text{2.5\% span length}} \times 100$$

➢ **Short fibre percentage**

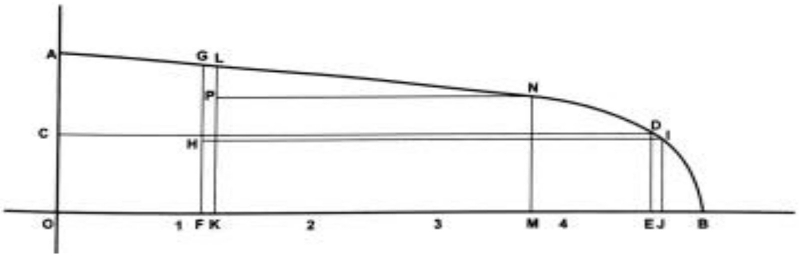
This is the percentage of fibre that is equal to or less than half the effective length.

➢ **Analysis of Baer sorter diagram**

The statistical analysis of a sorter diagram is done by means of a geometrical construction called Clegg's construction. This is explained in the following with reference to Figure 3.5.

- Let OAB be the trace of the sorter diagram i.e. the array of fibres arranged vertically in decreasing order of length.
- Let the mid-point of OA be C.
- From C, draw a line parallel to OB. Let this line cut the curve at D.
- Drop a perpendicular from D to OB. Let it cut OB at E.
- Mark a point F on OB such that OF = ¼ OE.
- From F, draw a line perpendicular to OB to cut the curve at G.
- Let the mid-point of FG be H.
- From H, draw a line parallel to OB. Let this line cut the curve at I.
- From I, draw a line perpendicular to OB. Let the perpendicular cut OB at J.
- Mark a point K on OB so that OK = ¼ OJ.
- From K, draw a line perpendicular to OB. Let the perpendicular cut the curve at L.
- Mark a point M on OB so that OM = ¾ OJ.
- From M, draw a line perpendicular to OB. Let the perpendicular cut the curve at N.
- From N, draw a line parallel to OB. Let this line cut KL at P.

From the construction described above, the values of the following fibre parameters are calculated.



1. Effective length

In the sorter diagram shown in Figure 3.5, KL is the effective length of the fibre sample. It may be observed that KL is also the upper quartile of the length distribution curve extending from OA to DE. The lower quartile is MN. It may also be noticed that this region of the curve ignores the short fibres represented by the portion DEB. Thus the effective length is clearly "the length of the main bulk of the longer fibres".

It is the effective length that is used for making settings between successive pairs of drafting rollers in spinning.

2. Mean length

This is the average length of the fibres in the sample. This is obtained from Figure 3.5 by dividing the base line readings by the base line length. Thus,

$$\text{Mean length} = \frac{\text{area under the curve OAB}}{\text{OB}}$$

In practice, as the diagram is drawn on graph paper, the area OAB is easily computed by counting all the squares in the area and multiplying the total by the unit square area of the graph paper used.

Two points may be noted with regard to the comb sorter method of cotton fibre length

a) The sorter diagram represents a cumulative frequency curve of fibre length. A normal frequency curve depicting variation in length of the sample can also be drawn and this will be the typical bell-shaped curve usually obtained.

b) The estimation of length by this method involves the use of the area of the fibre array. It is for this reason that care must be taken to ensure that the fibre tufts are laid down on the velvet pad as evenly as possible, so that distances measured along the base line are proportional to the number of fibres.

   In comparison, the single-fibre method, described earlier, involves the direct measurement of only one dimension of the fibre, namely its length.

3. Percentage of short fibre

The percentage of short fibre is defined as the number of fibres that are equal to or shorter than half the effective length expressed as a percentage of the total number of fibres. In the diagram, JIB represents the number of fibres that are equal to or less than half the effective length, the longest of these being equal to JI. The percentage of short fibres can be estimated as follows.

$$\text{Percentage of short fibre} = \frac{\text{area JIB}}{\text{area OAB}} \times 100 = \frac{\text{JB}}{\text{OB}} \times 100$$

4. Modal length

This is defined as the length of fibres that occurs most frequently in the bulk of fibres present. In other words, this is the length present in the maximum number of fibres in the sample.

5. Dispersion

Dispersion is defined as the variation in length of the fibres, excluding the short fibre as defined above. It is estimated from Figure 3.5 by expressing the inter-quartile range as a percentage of the effective length. In the figure, KL is upper quartile and MN is the lower quartile. The difference between these quartiles is KL – MN = PL, which is the inter-quartile range. So dispersion may be calculated as follows.

$$\text{Dispersion} = \frac{\text{PL}}{\text{KL}} \times 100$$

It can be seen from the above discussion that the steeper the curve, the greater the value of KL and therefore greater will be the variation in length in the sample. Conversely, the flatter the curve, the lower the value of KL and lower will be the variation in length.

In the ideal case, when all the fibres would be of the same length, the dispersion would be zero and the portion AOJI in the diagram would be a rectangle.

Man-made staple fibres are not as variable as cotton or wool and are rarely measured for length in a Baer Sorter type instrument. If, however, a sample of a man-made fibre were evaluated for its mean length in a Baer sorter, the fibre array diagram would be nearly rectangular in shape.

- ## Fibe Fineness

The fineness of textile fibres is another important property that affects their properties and influences their behaviour and processing. If fibre length concerns the longitudinal dimension of a fibre, fineness concerns its transverse dimension or the cross-sectional dimension like diameter, width etc. The fineness determines how many fibres are present in the cross-section of a yarn of given thickness. Additional fibres in the cross-section provide not only additional strength, but also a better distribution in the yarn. Thirty fibres are needed at the minimum in the yarn cross-section, but there are usually over 100.

Influences:

Fibre fineness influences primarily:

- Spinning limit
- Yarn strength
- Yarn evenness
- Yarn fullness
- Drape of the fabric product
- Lustre
- Handle
- Productivity of the process.

Why Fiber Fineness is so important:

It has been known since long that fibre fineness plays an important role in determining the quality of resultant yarn and hence that of the resultant fabrics. In general fiber fineness is important due to the following factors:

1. It affects Stiffness of the Fabric

- As the fiber fineness increases, resistance to bending decreases.

It means the fabric made from yarn of finer fiber is less stiff in feel.

It also drapes better.

2. It affects Torsional Rigidity of the Yarn

Torsional rigidity means ability to twist.

As fiber fineness increases, torsional rigidity of the yarn reduces proportionally.

Thus fibers can be twisted easily during spinning operation.

Also there will be less snarling and kink formation in the yarn when the fine fibers are used.

3. Reflection of Light

Finer fibers also determine the luster of the fabric.

Because there are so many number of fibers per unit area that they produce a soft sheen.

This is different from hard glitter produced by the coarser fibers.

Also the apparent depth of the shade will be lighter in case of fabrics made with finer fibers than in case of coarser fibers.

4. Absorption of Dyes

The amount of dye absorbed depends upon the amount of surface area accessible for dye out of a given volume of fibers. Thus a finer fiber leads to quicker exhaustion of dyes than coarser fibres.

5. Ease in Spinning Process

A finer fiber leads to more fibre cohesion because the numbers of surfaces are more so cohesion due to friction is higher.

- Also finer fibers lead to less amount of twist because of the same increased force of friction.

- This means yarns can be spun finer with the same amount of twist as compared to coarser fibers,

6. Uniformity of Yarn and Hence Uniformity in the Fabric

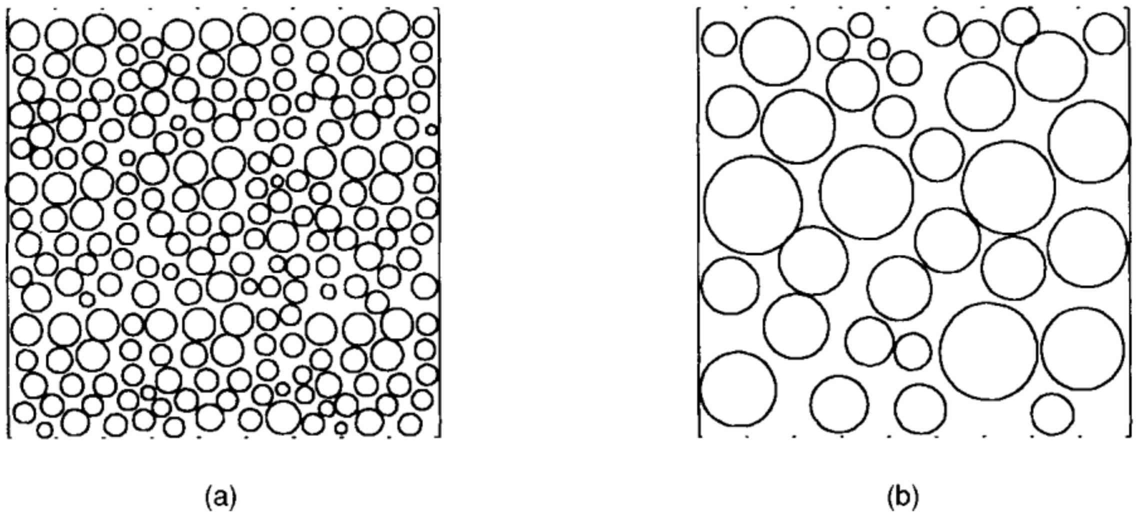
- Uniformity of yarn is directly proportional to the number of fibres in the yarn cross section.

- Hence finer the fiber, the more uniform is the yarn. When the yarn is uniform it leads to other desirable properties such as better tensile strength, extensibility and luster.

- It also leads to fewer breakages in spinning and weaving.

Fibre fineness measurement by airflow method

This is an indirect method of measuring fibre fineness which is based on the fact that the airflow at a given pressure difference through a uniformly distributed mass of fibres is determined by the total surface area of the fibres. The surface area of a fibre (length X circumference) is proportional to its diameter but for a given weight of sample the number of fibres increases with the fibre fineness so that the specific surface area (area per unit weight) is inversely proportional to fibre diameter; below Figure shows this diagrammatically. Because the airflow varies with pressure difference it is the ratio of airflow to differential pressure that is determined by the fibre diameter. Therefore, the method can be used to measure either

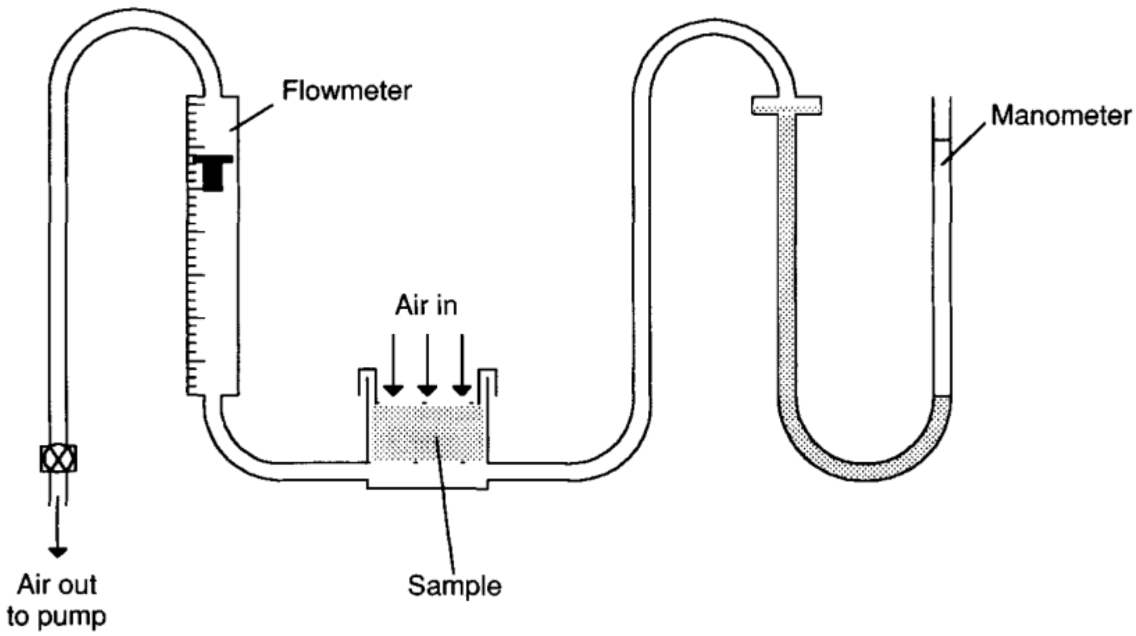


Airflow through coarse and fine fibres.

the airflow at constant pressure or the pressure drop at constant airflow. The measurement of airflow at constant pressure is the more usual form of apparatus with wool. For fibres of approximately circular cross-section and constant overall density such as unmedullated wool, the estimate of fineness corresponds to the average fibre diameter as determined by the projection microscope with a good degree of accuracy.

Method of test for clean wool sliver

A random and representative sample of fibre is taken from the bulk and conditioned for 24 h in a standard testing atmosphere. Three 2.5 g samples (2.5 ± 0.004 g) are prepared by cutting the sliver obliquely. Each sample in turn is evenly packed into the cylinder of the measuring instrument shown in Figure. The cylinder is of a fixed size with a perforated base to allow the air to pass through. The wool is packed into the cylinder using a rod of a specified length so that the wool is not compressed to a greater density than specified. The perforated retaining cap is then screwed into position. A pump is used to suck air through the sample and the pressure drop across the sample is monitored with a manometer. The manometer has a lower engraved mark to which the pressure is adjusted by a valve so that the airflow is measured at a fixed pressure drop. The volume of air flowing through the sample is then measured with a flowmeter. Each sample is removed and retested four times and a mean is taken of the 12 readings. The airflow is measured in arbitrary units which are then converted to micrometres using tables supplied with the instrument. These tables are specific for different types of wool such as oil or dry combed tops because the surface condition of the fibres affects the airflow over them. The machine is calibrated with a set of reference wools which have been measured by the projection microscope method.



Fibre diameter measurement by airflow.

Fibre Strength:

Fibre strength is generally considered to be next to fibre length and fineness in the order of importance amongst fibre properties.

Fibre strength denotes the maximum tension the fibre is able to sustain before breaking.

It can be expressed as breaking strength or load, tenacity etc.

Fibre Maturity:

- Cotton fiber consists of cell wall and lumen.

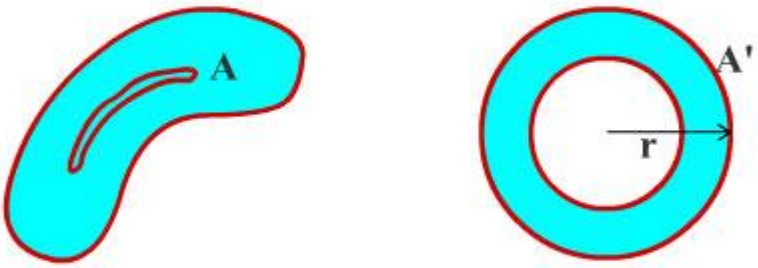
- The maturity index depends upon the thickness of the cell wall.

The fibers are considered ripe if they have maturity index between 50-80%, unripe if they have MI between 30 to 45% and dead when they have it less than 25%.

Unripe fibers have neither adequate strength nor adequate longitudinal thickness. They lead to loss of yarn strength, neppiness, high proportion of short fibers, varying dyeability, processing difficulties mainly at the card.

Measurement of fiber maturity:

To measure maturity some method of measurement is required. The degree of cell wall thickening may be expressed as the ratio of the actual cross-sectional area of the wall to the area of the circle with same perimeter (see figure)



The 'degree of thickening', θ, $= A / A'$

$$A' = \pi r^2 = (4\pi^2 r^2 / 4\pi)$$

Multiplying by 4π,

$$= p^2 / 4\pi$$

Because $p^2 = \text{perimeter}^2 = (2\pi r)^2$

Therefore,

$$\Theta = A / A' = 4\pi A / p^2$$

The direct method for fiber maturity is not practicable routine test. So indirect method can be used for the same.

After sorter diagram test tufts of cotton are left on the velvet pad. Each tuft is laid on a microscope slide. the fibres are parellel but separated, and a cover slip put over the middle.

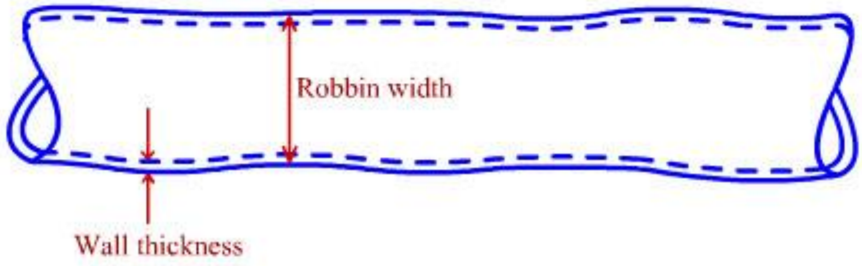
The fibres are then irrigated with a small amount of 18% caustic soda solution which has the effect of swelling them. After the fibers should be observed under projection microscope. This enables the fibers to be classified into three groups:

(1) Normal fibers (N): mature fibres with a well-developed cell wall cotton fibre become rod-like after swelling. These fibres are classed as 'normal'.

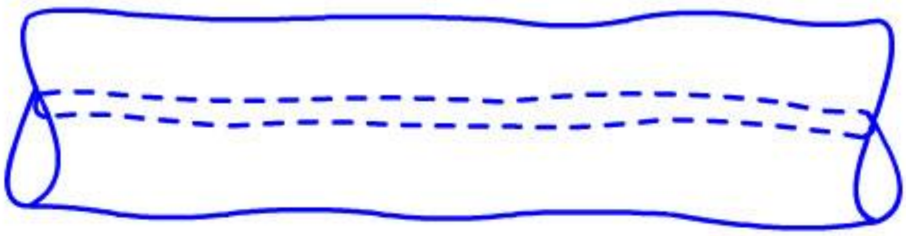
(2) Thin-walled fibres: these category fibres lying between the other two classes.

(3) Dead fibres (D): if the wall is less than one-fifth of the total width the fibre is classed as dead (see figure).

A 'Dead'



B 'Thin-walled'



- It is desirable to express the results as a single figure which would give actual maturity.
- From a sample of 100 fibres it would be abnormal to find that all the fibres could be classed as 'normal' fibres
- The standard chosen was

$$N - D = 67 - 7 = 60$$

- It is also desirable that the result should be proportional to the 'degree of thickening'.
- Assuming a constant specific volume, and a perimeter, p, constant for a pure strain of cotton, then

$A \infty H$ (hair or fibre weight per centimeter)

- Therefore,

$$\theta \infty H$$

- The maturity ratio to be derived from these conclusions is the ratio which expresses the actual fibre weight pe cm, *H*, in relation to a standard fibre weight per cm *H s.* Thus,

  Maturity ratio $M = H / Hs$

- By definition, the standard fibre weight per cm, *H s*, is that which the fibre would have if it were fully maturec the arbitrary sense of having an *N-D* of 60.

The relation between the immaturity count and fibre weight.

- A linear relationship found between *H* and *N-D*:

  $H = 0.937\ (N\text{-}D) + 135.2$

  Hence,

  $H/H\ s = [0.937\ (N\text{-}D) + 135.2] / [0.937\ (67 - 7) + 135.2]$

  $= 0.0049\ (N\text{-}D) + 0.706$

  To round the figures,

  Maturity ratio $M = [(N\text{-}D)/200] + 0.7$

- The maturity ratio is therefore directly proportional to the degree of thickening of the cell wall.

- The relationship between *M* and θ

  $$\theta = 0.577\ M$$

- The theoretical range for the value of M will be from 0.2, all dead, to 1.2, all mature or normal.

MOISTURE & TEXTILES

Atmospheric Conditions and Relative Humidity:

The dampness of the atmosphere can be calculated in terms of humidity

Absolute humidity:

The weight of water present in a unit volume of moist air, i.e. grams/m^3

Relative Humidity:

The ratio of the absolute humidity of the air to that of air saturated with water vapo ır at the same temperature and pressure, expressed as a percentage.

$$RH\% = \frac{\text{Absolute humidity of air}}{\text{Absolute humidity of air saturated with water}} \times 100$$

Std. Testing Atmosphere:

R. H. % : 65% ± 2%

Temp.: 20° C ± 2° C (cold countries)

27° C ± 2° C (tropical & subtropical countries)

Definition of moisture content (M) and moisture regain (R)

These two terms are related to the amount of moisture present in a fibre. It may be noted that the amount of moisture in a fibre is constant for any given condition of humidity, but that it can be expressed in two different ways, one with respect to the as is weight of fibre and the other with respect to the oven dry weight of fibre.

Moisture content of fibre (M)

This is defined as the ration between the weight of water in the fibre and total weight of the material expressed as a percentage as a percentage.

Fibre moisture content, $M = \frac{Weight\ of\ water\ in\ the\ fibre}{Total\ weight\ of\ fibre} \times 100$

Moisture regains of fibre (R)

The term moisture regain is used to describe the moisture that a dry fibre would absorb from the surrounding air when placed in an atmosphere of definite RH. The greater RH the greater would be the regain and vice versa.

Moisture regain is defined as the ratio between the weight of water in the fibre and oven-dry weight of the fibre expressed as a percentage.

$$Fibre\ moisture\ regain\ (R) = \frac{Weight\ of\ water\ in\ the\ fibre}{Oven\ dry\ weight\ of\ the\ fibre} \times 100$$

Relation between M and R

$$M = \frac{100R}{100+R}$$

Importance of humidity in Textile industry

Humidity plays a significant role in the textile industry, impacting both the production process and the quality of the final textile materials. Here are some key aspects of how humidity is important for textile materials:

Fiber Properties: Natural fibers like cotton, wool, and silk absorb moisture from the air, which can affect their strength, elasticity, and durability. The amount of moisture these fibers can absorb depends largely on the relative humidity of their environment.

Spinning and Weaving: During the spinning and weaving processes, the presence of moisture can influence the strength and consistency of the yarn. High humidity can prevent static electricity build-up, which is beneficial because static can cause fibers to repel each other, leading to breakages and uneven yarn.

Dimensional Stability: Textile materials can shrink or expand depending on the moisture content in the air. This is particularly important for the dimensional stability of the final product. Controlled humidity is essential to ensure that the dimensions of the textile remain consistent.

Comfort and Performance: For end-users, the moisture-absorbing properties of textiles, influenced by humidity, are important for comfort and performance. For example, sportswear often requires materials that can effectively wick moisture away from the skin.

Quality Control: In textile manufacturing, maintaining a consistent level of humidity is crucial for quality control. Fluctuations in humidity can lead to inconsistent quality in the final product, affecting both texture and appearance humidity and its importance to textile material.

2.10.2.1 Wet and Dry Bulb Hygrometer

Principle

If it can be so arranged that a thin film of moisture (water) always surrounds the bulb of a thermometer, the temperature indicated by the thermometer would depend upon the humidity of the surrounding atmosphere. If the surrounding air is not saturated with moisture, water evaporates from the bulb into the air at a rate that is proportional to the difference between the actual humidity and 100% humidity. Since cooling takes place with evaporation, the temperature indicated by the thermometer will be less than the room temperature.

The drier the atmosphere the greater the amount of moisture evaporating from the bulb, and the greater will be the cooling. The thermometer will thus show a much lower temperature than the actual room temperature. The opposite will be the effect if the atmosphere were relatively humid. It is this principle of gauging the humidity of a given atmosphere that is used in the design and working of a wet and dry bulb hygrometer.

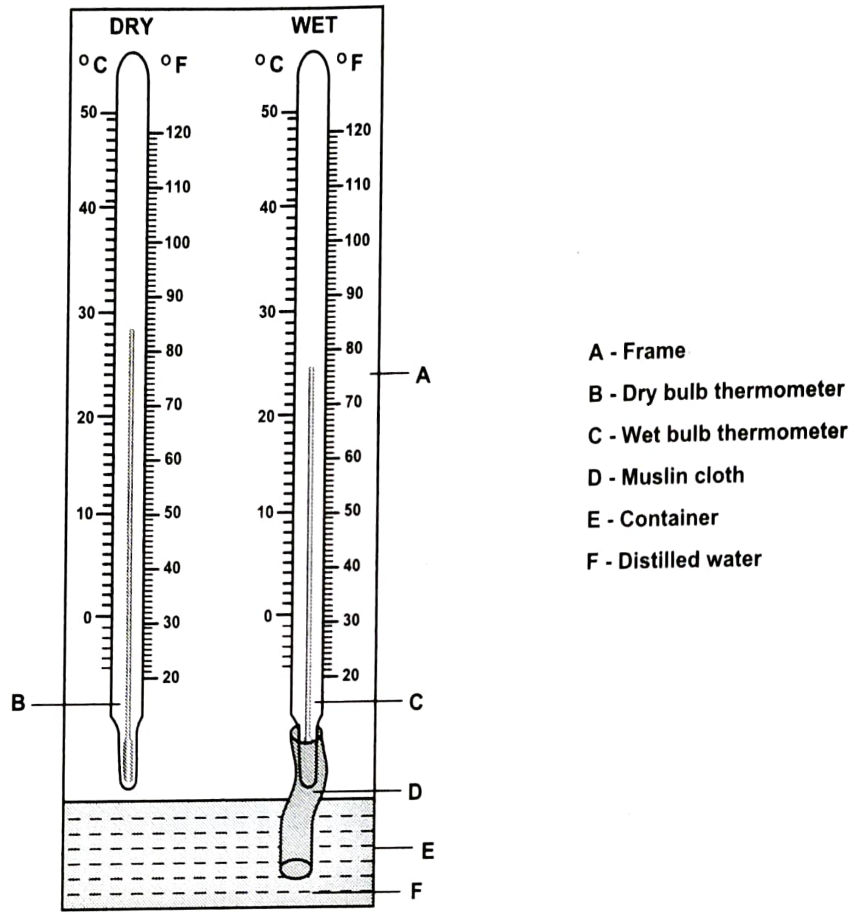


Figure 2.6 Wet and dry bulb hygrometer

In the CD-ROM, watch Animation No. TT - I 2.1

Description

A wet and dry bulb hygrometer is shown in Figure 2.6. It consists of a frame A on which two identical thermometers, B and C, are mounted. A muslin (thin absorbent fabric) sleeve D, which is dipped into a container E containing distilled water F, covers the bulb of thermometer C. This thermometer is therefore called the 'wet bulb thermometer'. The bulb of the other thermometer B is left open to the atmosphere. This thermometer is thus called the 'dry bulb thermometer' and the temperature it shows is referred to as the dry bulb temperature, which is of course the room temperature. The wet bulb temperature is on most occasions lower than the dry bulb temperature. In an atmosphere of 100% RH, both the thermometers would indicate the same temperature.

The instrument comes with an RH table that displays a series of values of the dry bulb temperatures in the extreme left column and increasing values of the difference between the wet and dry bulb temperatures along the top row.

Determination of relative humidity

A wet and dry bulb hygrometer is usually mounted on the wall of a testing room or any place where the relative humidity is to be monitored.

The procedure of determining the RH of an atmosphere is simple. The wet bulb and dry bulb thermometer is placed in the atmosphere until the mercury levels in both of them attain constant positions. The wet bulb and dry bulb temperatures are then noted. The difference between these two temperatures is worked out.

The RH table is then used to read out the RH of the atmosphere being evaluated. This is done by locating the dry bulb temperature in the left-most column and then moving rightward along the row till the column corresponding to the difference between the dry and wet bulb temperatures is reached. The RH value at the meeting point is the RH of the atmosphere.

An example

Dry bulb temperature	=	87°F (30.6°C)
Wet bulb temperature	=	72°F (22.2°C)
Difference	=	15°F (8.4°C)
RH% read from the table	=	43%

EXERCISE

Multiple choice questions

1. Standard moisture regain of cotton fibre is

a. 8.5 b. 9

c. 7 d.11.5

2. Which of the following is used to determine the humidity:

a. Vibroscope b. Wet and dry bulb hygrometer

c. Sheffield micronair d. Shirley trash analyser

3. Which of the following is not measured by the Baer sorter diagram:

a. Mean length d. Effective length

c. Upper quartile length d. Span length

4. Fibre fineness is measured by

a. Airflow method b. Tensile machine

c. Baer sorter d. Wet and dry bult hygrometer

5. Maturity ratio of cotton fibre is

a. 1.8-2 b. 0.2-1.2

c. 2-4 d. 0.5-1

6. The relation between moisture regain (R) and moisture content (M) is:

a. M=$\frac{100}{100}$ b. R=$\frac{100M}{100+R}$

c. M=$\frac{100R}{100+R}$ d. R=$\frac{1000M}{100+R}$

Very short answer type questions

1. Define mean length.

2. Define effective length.

3. Define 2.5% span length.

5. Define 50% span length.

6. What is staple length?

7. What is maturity of fibre?

8. Define moisture regain.

9. Define moisture content.

10. What is relative humidity?

11. What absolute humidity?

Short answer type questions

1. Define the moisture regain and moisture content and write relation between them.

2. What are the standard atmospheric condition in textile testing lab?

3. Explain the oven dry method to measure moisture regain.

4. Write short note on effective and span length.

5. Write short note on airflow method to measure the fineness of fibre.

6.Write short note on measurement of relative humidity with wet-dry bulb hygrometer.

7. Write the importance of humidity for textile materials.

Long answer type question

1. Describe the test procedure of comb sorter for the measurement of different length with combs sorter diagrams.

2. What is the importance of fibre maturity? Explain the method of measuring the fibre maturity.

3. Write the importance of fibre fineness for textile materials. Explain the principle of airflow method to measure the fineness with neat sketch diagram.

UNIT III

Fiber testing instruments

HVI instrument, principle, uses and advantages. AFIS yarn analysis. Bundle Fiber strength tester. Maturity of cotton fibre by Caustic Soda Method, Differential Dyeing Method and Polarised Light Method. Measurement of moisture regain by Oven dry method. Trash analysis in cotton by Shirley trash analyser.

The High-Volume Instruments (HVI)

The Uster HVI 900 system measures the seven physical characteristics defined by the United States Department of Agriculture (USDA) in its cotton marketing system.

1. Fibre length

2. Fibre strength

3.Length uniformity

4. Elongation

5.Micronair

6.color

7.Trash

-All these properties are important in fiber research,

-In the development of improved fiber blends, and

-In verifying that purchased fiber meets specifications

The HVI 900 fiber testing system offers precise and reliable automated operation with computer-controlled calibration and diagnostics.

The HVI system has the following measuring modules (Principle)

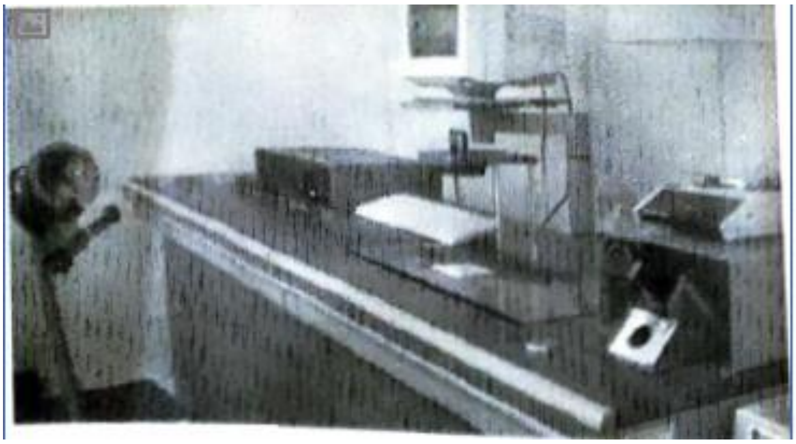
1. Length/strength

2. Micronair module

3. Colour/Trash

The modules are housed in two separate cabinets. The larger cabinet includes the Length/Strength module and the smaller one contains the Micronaire, Colour/Trash and NlR modules. The instrument comes with a standard keyboard, a monitor-to display menu selections, operating instructions and test options-a precision balance, a printer and a relative humidity/temperature probe. As and when a round of tests is completed for a cotton sample the results are transmitted to the printer or an external computer system.

The HVI 900 model comes as a semi-automatic version and as an automatic version. The sample preparation is the same in principle in both of these versions, but in the former it is done manually by means of a fibro sampler, while in the latter it i done automatically, to minimise operator variations.



Advantages of HVI

-The results are practically independent of the operator.

-The results are based on large volume samples and are therefore more significant.

-The respective fibre data are immediately available.

-The data are clearly arranged in summarised reports.

-They make possible the best utilisation of raw material data.

-Problems due to the fibre material can be predicted by using the test results.

Advanced Fibre Information System or the 'AFIS'

The advanced fibre information system (AFIS) was developed by the Uster Company in 1986. It provides the following information about cotton fibres.

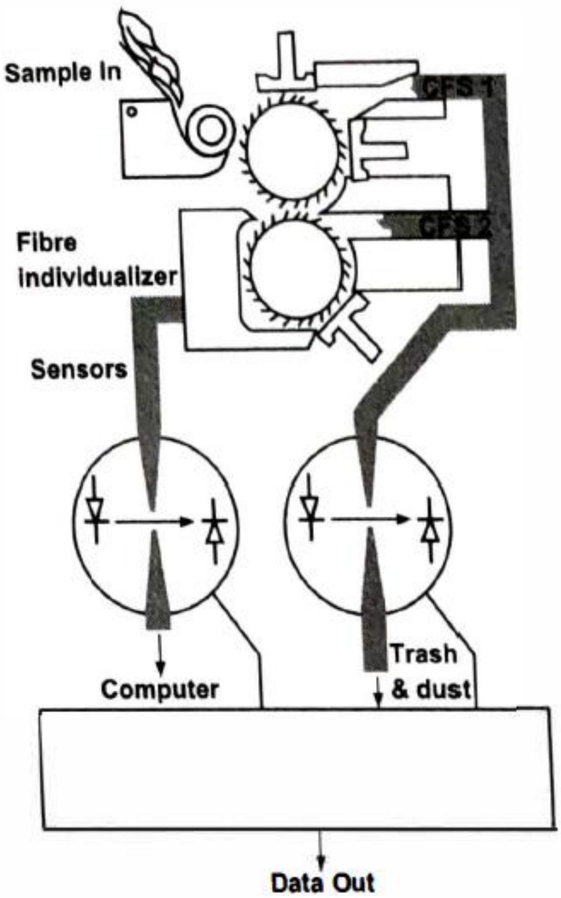
1. Length

2. Neps

3. Trash

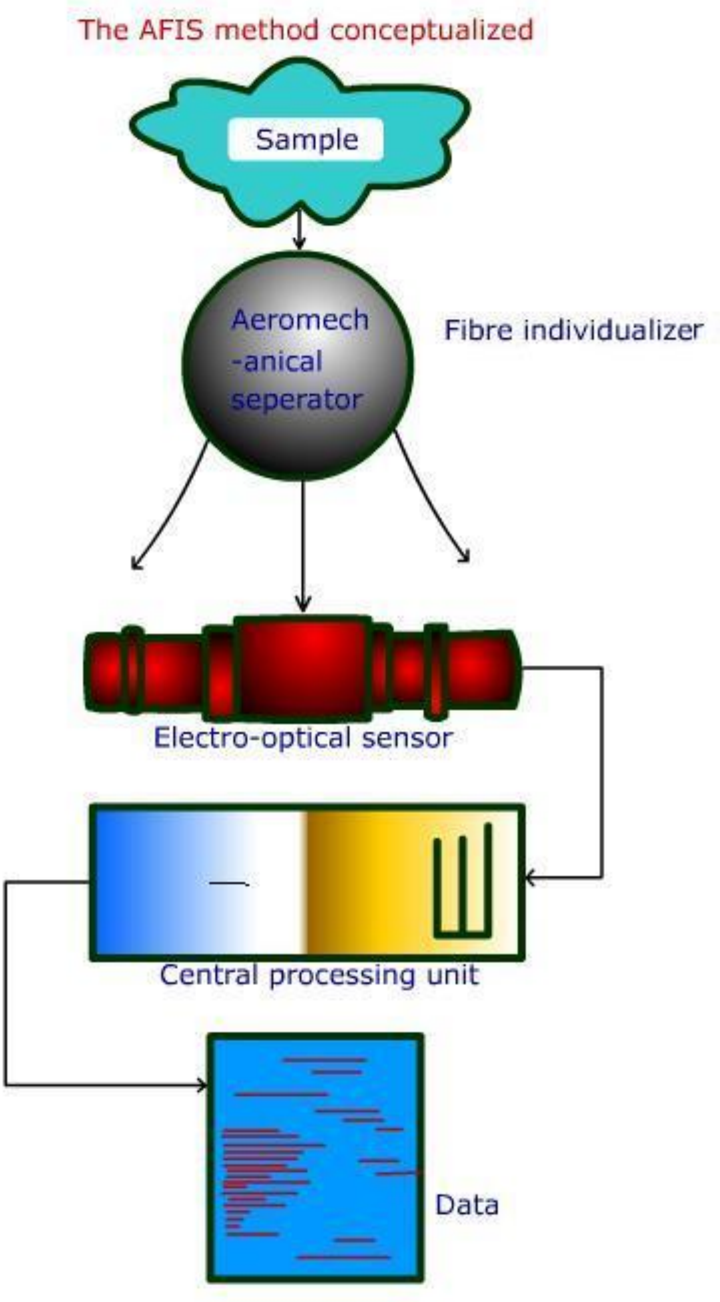
4. Maturity and Fineness

An AFIS instrument is shown in figure.


Sample In
CFS 1
CFS 2
Fibre
individualizer
Sensors
Computer
Trash
& dust
Data Out

BASICS PRINCIPLE:

The AFIS method is based on aeromechanical fibre processing, similar to opening and carding, followed by electro-optical sensing and then by high speed microprocessor based computing and data reporting as shown in Figure.



Basic AFIS schematic

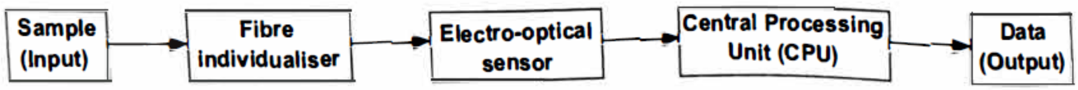
- A fibre sample is introduced into the system and is processed through a fibre individualizer, which aero mechanically separates the sample into three components consisting of cleaned fibre, micro dust, and trash.
- Each of these components is transported in a separate pneumatic path and may be analysed electro-optically or by other means.

- The data processing and reporting are handled by an industrialized PC.

AFIS provides basic single fibre information and is distinguished from earlier and existing methods by providing distributions of the basic fibre properties. These distribution measurements provide more accurate, precise, and basic information about fibre.

Working of AFIS

The testing of fibres by means of the AFIS is given in the following flow chart.



Modules in AFIS

The AFIS instruments consist of the following modules.

1. Fibre length module
2. Maturity and fineness module
3. Nep classification module
4. Trash module

ADVANTAGES:

- High degree of accuracy, which gives precise results.
- Testing speed is high.
- It avoids laborious time work needed for measurement of nep count.
- The results are free from human and machine error.
- It can analyse process performance.

Methods used to determine the maturity

The following method have been commonly used for determining the maturity of cotton:

a. Causticare method

b. Differential dyeing techniques

c. Polarised light method

1. Differential dyeing method

This is an old technique that was used several years ago. A brief description of the method is included here merely for historical interest, as it has no practical value in today's context.

Principle

Mature and immature cotton fibres differ in their behaviour with regard to the uptake of certain dyes. This approach is based on the premise that mature fibres are thick-walled and have material substance on to which dyes can be taken up to produce fairly dark shades with specific dyes that dye only the secondary wall of the fibre. The thin-walled, immature fibres, on the other hand, have a very thin cell wall and so they only take up little dye. The technique uses two direct dyes, one that dyes only the secondary wall (of the mature fibres) and the other of a contrasting colour that merely stains the immature fibres and helps to identify them visually. A visual assessment of the extent of the immature fibre in the sample enables the assessment of its immaturity. Alternatively, the dyed fibre is compared with similarly dyed standard fibre of known maturity and its maturity arrived at.

Procedure

In a method that has been used, a 3-g sample of cotton is spread out evenly and stitched loosely into a piece of cotton gauze to form a thin flat bed. The composite specimen is thoroughly wetted in boiling distilled water and transferred to a boiling dye bath containing 180 g of water, 1 g of Diphenyl Fast Red Supra and 2 g of Chlorantine Fast Green BLL.

60% sodium chloride on the weight of fibre is added twice after every 15 minutes of dyeing at the boil to exhaust the dye bath. Then, after a final 15-minute dyeing of the sample, it is removed from the bath, drained of excess dye liquor and washed well in cold water. A final wash in boiling water follows this. The sample is then washed in cold water and dried.

The maturity of the sample is assessed in one of two ways

a) The estimate of the average maturity of the sample is assessed visually by manually separating the red and green fibre and computing the amount of the green fibres as a percentage of the total amount of fibres in the dyed sample.
b) A comparison of the dyed sample under test with a set of previously-prepared standard dyeings of fibres of known different maturity is done visually and the maturity of the sample is identified accordingly.

Dyeing methods are not satisfactory methods as the process of dye absorption is influenced by various factors other than maturity alone. Moreover, the assessment of maturity itself is subjective and this could lead to differences between the results of different operators.

Hence these methods are not generally used or recommended for accurate work.

2. Causticaire method

Principle

This method is based on the flow of air through a plug of cotton fibres and it therefore uses an airflow instrument. The resistance offered by a plug of cotton is dependent not only on fibre fineness but also on the maturity of the fibres.

When cotton is treated with caustic soda, the fibres swell. The swelling will be greater in the case of mature fibres and hardly any in the case of immature fibres. The dimensions of the mature fibres will be significantly altered. This is so because mature fibres have a fairly thick cell wall and the caustic soda enters the fibre structure and swells the fibre causing it to untwist and assume a rounded, cylindrical appearance.

The immature fibres will continue to have their flat, ribbon-like, convoluted appearances. There is virtually no secondary thickening present in these fibres and caustic soda produces no visible swelling of the fibre; the convolutions too remain as they were before the treatment.

Two fibre samples are taken; one is treated with 18% caustic soda and the other is left untreated. The "causticaire" readings of these specimens are determined in a Sheffield-type airflow instrument and used to compute the maturity of the sample in question.

Procedure

In this method, the Sheffield-type micronaire instrument is fitted with a special scale called the causticaire scale.

Two specimens of mass 3.24 grams each are taken and tested on the instrument as usual. The average causticaire reading is determined from two readings for each of them. The specimens are then treated with 18% caustic soda and 1½% wetting agent till sufficient saturation is obtained. Next they are washed well and dried in a hot-air oven. The dried samples are blended thoroughly by manual opening and mixing and then conditioned for a sufficient period of time in standard atmosphere.

Two specimens each of 3.24 grams are then weighed out from the treated and conditioned material. They are then tested again in the same micronaire instrument and their average causticaire reading is noted. The maturity index of the sample under test is then calculated using the following formula.

$$\text{Maturity index} = \frac{\text{Causticaire reading for the untreated sample}}{\text{Causticaire reading for the treated sample}} \times 100$$

Finally, on the basis of the causticaire maturity index, the fibre is classified according to the maturity categories shown below.

Causticaire maturity index	Maturity
Below 70	Very immature
70 - 75	Immature
76 - 81	Average mature
82	Mature

The causticaire technique is prone to a number of practical errors that make it unsuitable for routine testing. For example, the caustic soda treatment cannot be standardised due to the fact that some manual pressing of the sample is involved in ensuring complete wetting of the fibres with the chemical. Further, fibre moisture content before and after the treatment may be different and this would affect the results. Working with oven-dry samples before and after the treatment might overcome this problem, but this would also unduly lengthen the procedure.

3. Polarised light method

This method is based on the colour displayed by mature and immature fibres when observed under "crossed polars" in a polarising microscope. A polarising microscope is a microscope that is equipped with a polariser and an analyser, in addition to the other essential parts of a common microscope like the eyepiece, objective, rotating stage fitted with a device for moving the microscopic glass slide, etc. Figure 3.18 shows the salient features of a polarising microscope. Note that the polariser is located under the stage holding the specimen slide while the analyser is above it.

The reader may remember from previous learning the essential parts of a polarising microscope. In any case the terms associated with the polarised light method are explained briefly in the following.

i) Polariser: A polariser is a thin plastic material in which special crystals are embedded precisely and uniformly. When a polariser is placed in the path of ordinary light, it permits normal light waves vibrating only in one particular plane to pass through it, cutting off light waves in all the other planes. A mark present on the polariser indicates the direction (the plane) in which it will permit the light to pass through.

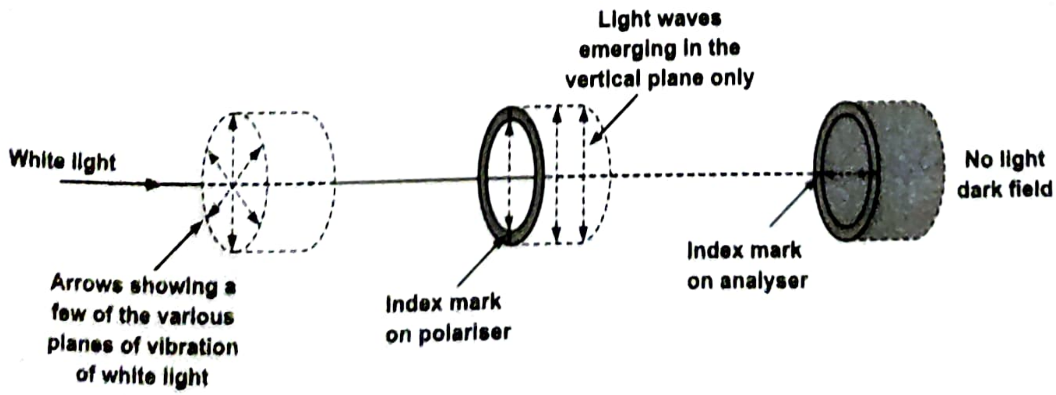


Figure 3.18 Schematic of the working of a polariser and an analyser and the situation of 'crossed polars'

ii) **Polarised light:** Unpolarised light consists of waves of electromagnetic radiation vibrating in several planes perpendicular to the direction of propagation of the light, as shown in Figure 3.19. When unpolarised light, from any given source, is passed through a 'polariser' or Nicol prism, it comes out as 'polarised light', or *light that is vibrating only in one plane.* Changing the direction of the polariser can alter the plane of vibration of the polarised light. Thus polarised light can be adjusted to vibrate parallel or perpendicular to the axis of a fibre under investigation. Since the polariser cuts off all the light waves reaching it except the one parallel to its direction, the emerging polarised light will be lower in intensity compared with the original 'unpolarised' source of light.

iii) **Polarising microscope:** A polarising microscope is one that has all the usual parts of an ordinary microscope, like the eyepiece, the magnification system, the telescopic traverse of the objective, the rotating stage for placing the glass-slide with fibre sample, the mechanical traversing device for the slide, the condenser to control the light, and so on. It also has a polariser that enables a study of fibres in polarised light. (See Figure 3.19).

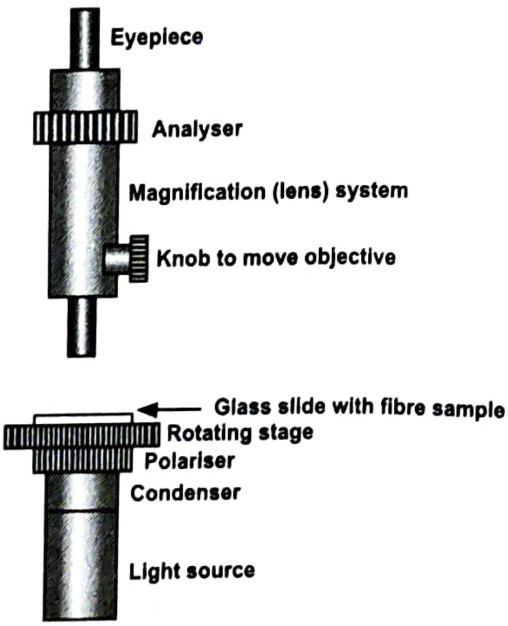


Figure 3.19 Parts of a polarizing microscope

In a polarising microscope, it is possible to have the plane of vibration of the polarised light adjusted to any chosen direction, parallel or perpendicular to the fibre axis.

It is also usual in such microscopes to have a second polariser called the 'analyser', to enable a study of fibres under 'crossed polars', i.e. with the direction of the analyser perpendicular to that of the polariser, so that a dark field is obtained, as shown schematically in Figure 3.19 above.

When the polariser and analyser are parallel to each other, the light emerging from the polariser is not cut off by the analyser and a 'bright' field of view results.

However, under crossed polars, the fibre will display one or a greater number of interference colours that are characteristic of the fibre being observed, only if the fibre is rotated to be at an angle of 45° to the direction of polariser or analyser.

When a fibre is rotated in a cross polars situation such that it is parallel to either the polariser or the analyser, only a dark field is seen and the fibre will be invisible.

iv) **Immersion liquid:** A fibre under study in a microscope must be properly immersed in a suitable liquid medium. The immersion liquid completely surrounds the fibre without any trapped air or air bubbles, so that a clear image of the fibre is obtained without any distortion. The liquid chosen for immersing the fibre must be stable, non-volatile, miscible with any other liquids it may be mixed with, and inert to the fibre and to the liquid it is mixed with.

In this context, it is important to remember that the refractive index of the immersion liquid determines the clarity of the image of the fibre. If the refractive index is too close to that of the fibre, the fibre will not be clearly visible. If it is quite different from that of the fibre, the fibres will be clearly seen and its edges will be sharp and distinct.

This behaviour is based on the principle that the image of the fibre will disappear, i.e. it will not be seen at all if the immersion liquid has the same refractive index as that of the fibre.

v) **Microscopic glass slide and cover slips:** Fibres under microscopic study are mounted on 'microscopic glass slides', which are rectangular pieces of clear glass, about 3″ × 1″ in dimensions. The fibres are usually mounted parallel to the long side of the slide, a drop of the immersion liquid is gently placed on them and then a 'cover slip', which is a very thin square piece of glass, is placed on the wet fibres.

vi) **First order red selenite plate:** This is a special plate that is introduced after the analyser to enhance or intensify the brightness of the interference colours of a fibre viewed between crossed polars. This plate is inserted such that its slow vibration direction (indicated by an arrow on it) is parallel to the fibre.

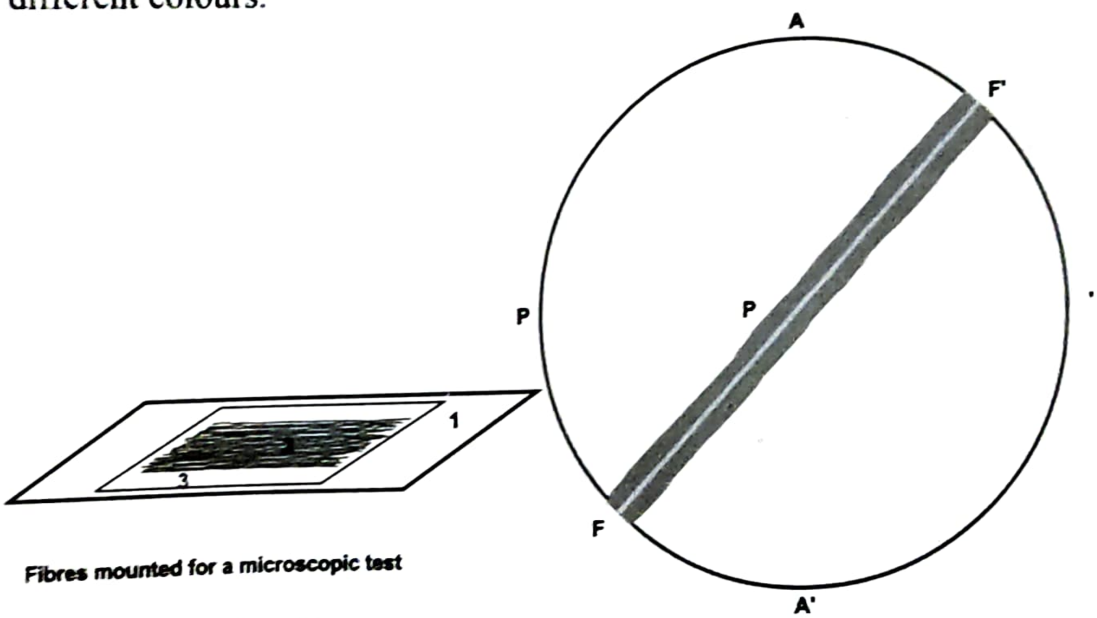
Procedure

About 50 fibres from a random sample of the test fibre are placed on a microscopic glass slide with their axes as parallel to the long axis of the slide as possible. The fibres are then gently straightened and parallelised. A drop of a suitable immersion liquid is placed gently on the fibres and a clean, dry cover slip is placed over the fibres and lightly pressed to remove any air bubbles. Care is taken to see that there are no finger marks on the glass slide or cover slip.

A typical appearance of a microscopic slide ready for viewing is shown in Figure 3.20 (a). The slide is traversed slowly so that each fibre can be counted as it comes under view and the total number of fibres is thus noted.

The slide is placed on the rotating stage of a polarising microscope and the fibres are brought into sharp focus. The polariser and the analyser are then adjusted such that they are at 90° to each other, i.e. the setting is a 'cross-polars' setting. The stage of the microscope is then rotated so that it is at 45° to the crossed polars position, as shown in Figure 3.20 (b).

Note the dark field and the coloured fibre. The interference colour, or sometimes colours, shown by a fibre under crossed polars is characteristic of the fibre itself. The observation of the interference colours is a good technique for distinguishing between some fibres. It is also very useful for differentiating between mature and immature fibres as they display different colours.



Fibres mounted for a microscopic test

1 - Microscopic glass slide

2 - Fibres

3 - Cover slip

View of a fibre under crossed polars

PP' - Polariser

AA' - Analyser

FF' - Fibre

(a) (b)

Figure 3.20 Fibres mounted for a microscopic test (b) View of a fibre under crossed polars

In the CD-ROM, watch Animation No. TT - I 3.9

A 1st Order Red Selenite plate is now inserted into the appropriate slot near and above the analyser. The interference colours of the fibres will now be intensified. Each fibre is then viewed for its interference colours and identified as mature, half-mature of immature fibre on the basis of the following colour scheme.

a) If the colour of a fibre is **yellow or yellow green or combination of both**, the fibre is noted as a **mature fibre**.

b) If the colour is **blue or blue green or combination of both**, the fibre is noted as a **half- mature fibre**.

c) Lastly, If the colour is **purple or deep blue or combination of both**, the fibre is regarded as an **immature fibre**.

2.10.3.1 Moisture Measuring Oven

This is a direct method of assessing the amount of moisture in textile materials.

Principle

A sample of known weight is heated in a special oven at a temperature of 105 ± 3°C for 1½ to 2 hours to constant weight or oven-dry weight. The difference between the original weight and the oven-dry weight of the sample gives the weight of moisture present in the sample.

The moisture in the sample is expressed as a percentage of its original weight to get the moisture content of the sample. Similarly, expressing the moisture in the sample as a percentage of the oven-dry weight of the sample gives its moisture regain.

Description

Figure 2.10 shows a moisture-testing oven. It consists of a double-walled chamber A, the walls of which are packed with an insulating material like glass wool to minimise the loss of heat. Two portions can be identified with regard to the chamber, the upper portion C and lower portion D.

The lower portion houses the heating elements, a temperature-set knob E and a thermostatic control. The thermostat consists of the typical bimetallic rod which senses and controls the temperature inside the chamber. It is connected both to a red light G and a green light H. A main switch I is connected to the power supply. A blower fan F is provided inside the instrument at the right-hand side of the chamber for circulating the hot air inside. The middle portion of the chamber has sufficient space for accommodating a cage J that carries the sample under test.

The upper portion of the chamber has a balance K; the right-hand side pan L of this balance carries a standard weight of 50 grams (M). The left-hand side pan N is connected to the cage. Weights corresponding to the loss in weight of the sample as it dries can be put in this pan to counterpoise pan L. This arrangement helps to determine the weight of water inside the chamber without disturbing the sample.

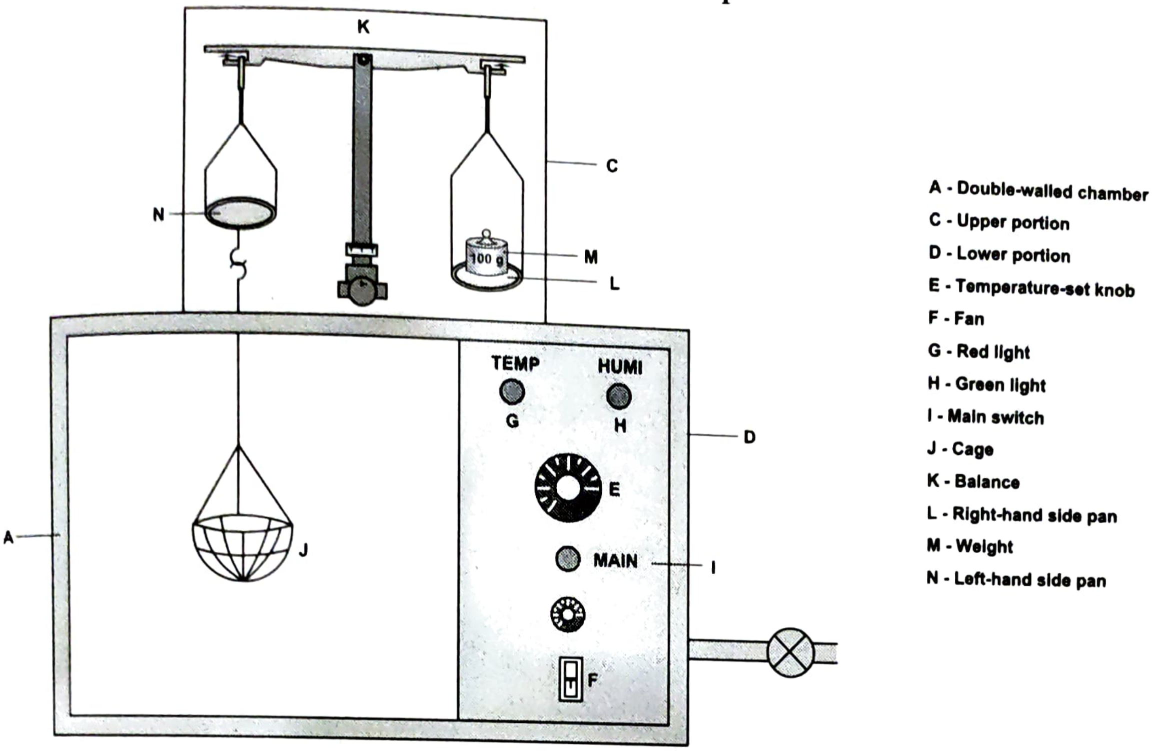


Figure 2.10 Moisture measuring oven   In the CD-ROM, watch Animation No. TT - I 2.5

Procedure to determine fibre moisture content and moisture regain

50 grams of the sample are placed in the cage inside the chamber, so as to balance the 50-g weight in the right-hand pan. The oven is switched on and the heating elements are turned on. A continual flow of air at the correct RH (ideally air at standard RH and temperature) is passed through the oven. The thermostatic control is set at 105°C.

The air flowing into the chamber starts getting heated and when the temperature is sufficiently high the moisture in the fibre sample will start evaporating. Care is taken that the thermostatic arrangement maintains the temperature inside the chamber within ± 2°C of the set temperature of 105°C.

After about 1½ hours of heating, the weight of material will have reduced due to the moisture being evaporated from it. A suitable weight is now placed in the left-hand side pan such that it exactly balances the other pan. Weighing is done at every 10 minutes until a constant weight is obtained. This means that all the moisture from the sample has been removed. The total of the weights in the left-hand pan is the amount of moisture present in 50 grams of the sample.

The oven-dry weight of the sample is calculated as the difference between the original weight of the sample and the weight of the moisture present in it.

If the original weight of the sample is W_1 and its oven-dry weight is W_2 then the moisture content can be calculated using the following formula:

$$\text{Moisture content (M)} = \frac{\text{weight of moisture in the sample}}{\text{original weight of the sample}} \times 100$$

$$= \frac{W_1 - W_2}{W_1} \times 100$$

Similarly the fibre moisture regain can be calculated using the following formula:

$$\text{Moisture regain (R)} = \frac{\text{weight of moisture}}{\text{oven weight of the sample}} \times 100$$

$$= \frac{W_1 - W_2}{W_2} \times 100$$

The main advantage of a regain-testing oven is that all the weighing is carried out inside the oven. This means that the instrument avoids the need to carry the sample to a separate balance, in which case it could gain in moisture and lead to erroneous results. Further large samples can be tested. In fact this is by far the most accurate method for estimating regain of a large sample. It serves as a benchmark for accurate testing of fibre regain and other methods can be checked against it for accuracy.

It must be noted that the method is based on the assumption that the air drawn into the oven is at the standard atmosphere conditions. If not, corrections would have to be made depending upon the actual temperature and RH of the test atmosphere.

3.4.3.2 Assessment of Trash Content in Cotton

The most common instrument used to separate and quantify the amount of lint and trash in cotton is called the "Shirley trash analyser".

Working principle of the equipment

The Shirley trash analyser uses the simple principle of buoyancy to separate the lint from the trash. A weighed sample of cotton is opened up and the mixture of lint and trash particles is introduced into the path of a steady stream of air. The air carries away the cotton fibres into a container; trash particles that are too heavy to be carried by the air stream fall down under gravity into another container. The lint and trash are weighed separately and the trash percentage is computed. As the light lint 'floats' away with the air stream, this technique is also called the 'air floatation' principle.

3.4.3.3 Shirley Analyser Terminology

1. Lint content

This is defined as the amount of fibres in the given cotton sample that is free from trash.

2. Trash content

This is defined as the amount of extraneous material, i.e. other than cotton fibres, in the given cotton sample.

3. Invisible loss

The invisible loss is the amount of the sample that is not accounted for in a test. It is calculated by subtracting the sum of the experimentally determined masses of the lint and the trash in the given cotton sample from the original mass of the sample.

Sampling

As for all tests, the sample taken for a trash content test must be representative of the lot or one that is agreed to between the buyer and the seller. A specimen of mass 100 grams is usually taken for the test. Special care should be taken to ensure that no trash particles are lost in handling, or else an erroneous value may result.

3.4.3.4 Description of the Shirley Analyser

Figure 3.41 represents a line diagram of the salient parts of a Shirley analyser machine. Essentially, it is like a mini-card with appropriate modifications suitable to this test.

1. **The opener unit:** The feed table A, the feed roller B and the taker-in C are together designed to open up the test specimen N and introduce the resulting mixture into the path of the air stream. D is a streamer plate located above the taker-in roll.
2. **Lint collection:** E is a stripper knife fixed at the right-hand top, in between the taker-in and cage or perforated drum F. A delivery box, L, located below the cage, is used to collect the trash-free, clean cotton, M.
3. **Trash collection:** Below the feed plate is a trash tray, G, placed close to the hinged door H.
4. **The air-stream:** A fan, I, below the cage sucks in air into the machine just below the feed plate. The air passes through the fan and then back into the outside air via the delivery pipe J. The air stream can be controlled by means of the air control valve K.

3.4.3.5 Working of the Machine

The well-opened cotton sample is laid out on the feed plate and fed into the machine at the feed roller. The high surface speed of the taker-in cylinder and the large number of teeth on it causes the cotton to be opened up virtually to individual fibre state. The individualised fibres and the associated trash particles move tangentially away from the zone of action of the taker-in in a downward direction and enter the air stream, that moves from the left to the right

As stated above, the air stream carries away the individualised fibres and light dust, beyond the streamer plate, to the perforated drum. The thick layer of fibre web settling on the cage inches forward on the cage as more and more fibre settles on it at the back. When the fibre layer finally turns around the top of the cage, it is stripped off. The stripped mass falls into the container L, at the far right. The dust is sucked into the cage and is extracted away.

The particles of trash that are separated from the lint are not much affected by the air stream and simply fall down vertically under gravity in the settling chamber on to the tray G.

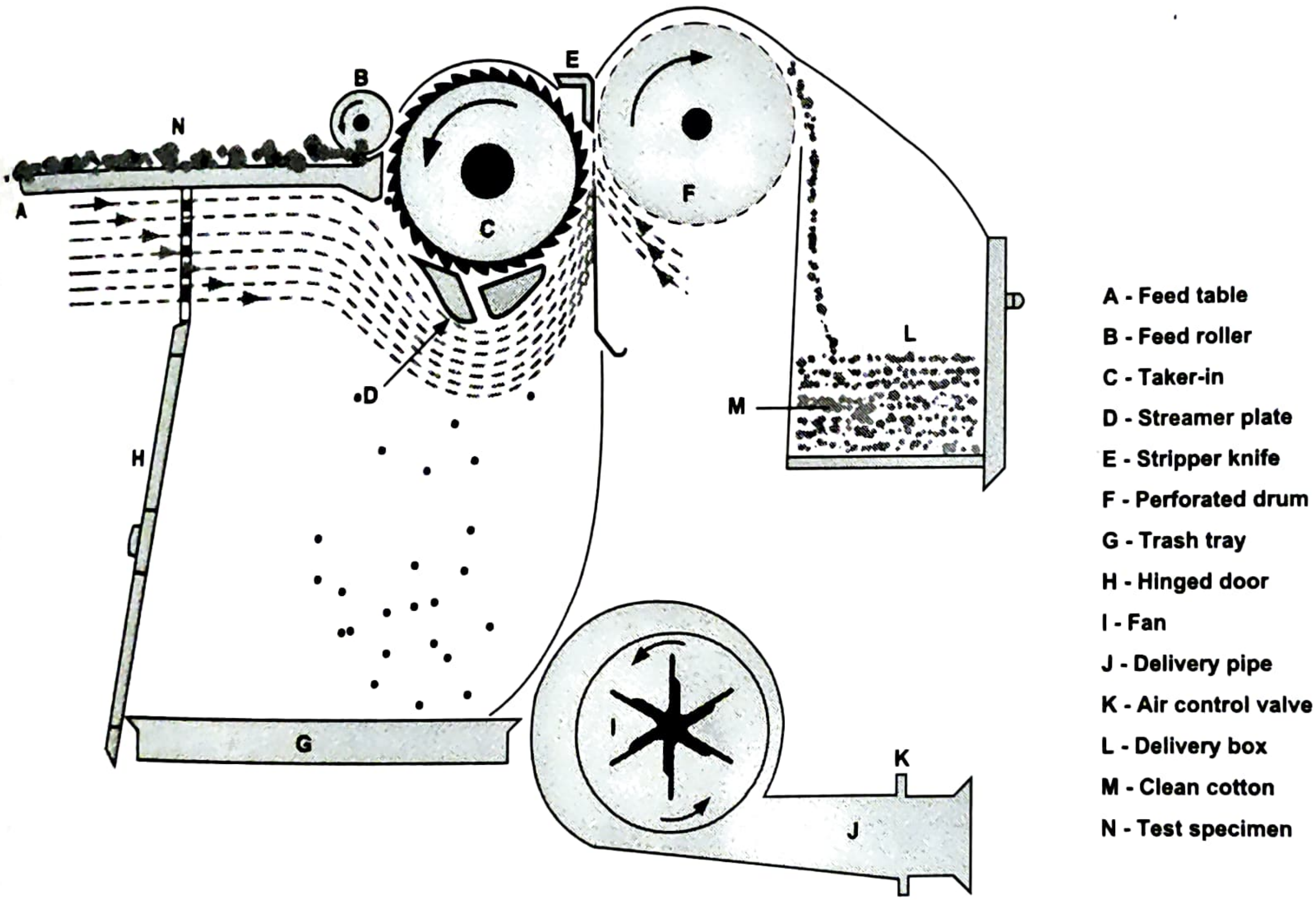


Figure 3.41 Shirley analyser In the CD-ROM, watch Animation No. TT - I 3.7

EXERCISE

Multiple choice questions

1. How many physical characteristics of fibre measured by High-Volume Instruments (HVI)?

a. 5 b. 6

c. 7 c. 8

2. Maturity and Neps are measured by the instruments?

a. AFIS b. HVI

c. Both a and b d. None of the above

3. Which Methods are used to determine the maturity of fibre?

a. Causticare method b. Differential dyeing techniques

c. Polarised light method d. All of the above

4. What is the full form of AFIS?

a. Advanced Fibre Information System b. Automatic fibre information system

b. Advanced Fibre Instrument System d. Advanced Fabric Information System

Very short answer type questions

1. Write the full form of HVI.
2. Write the full form of AFIS.
3. Name the physical characteristics of fibre which measured by the HVI.
4. Define maturity of fibre.
5. What is mature fibre?
6. Write the objective of Shirley trash anlyzer.
7. Write the name of method to be used determine the maturity of fibre.

Short answer type questions

1. Write the name of seven physical characteristics of fibre which measured by the AFIS.
2. Explain the oven dry method to measure the moisture regain.
3. Explain any one method to measure the maturity of fibre.
4. Explain the working principle of *Shirley trash analyse.*

Long answer type questions

1. What is the importance of fibre maturity? Explain the method of measuring the fibre maturity.
2. Explain the working principle of AFIS instrument to measure the physical characteristics of fibre.
3. Discuss the oven dry method to measure the moisture regain of fibre.

UNIT IV

Yarn Testing-I

Twist and its importance. Its effects on yarn properties. Twist factor, single and ply yarn. Twist Testers. Twist by direct count method, single yarn twist tester, ply yarn twist tester, twist untwist method. Yarn numbering systems. Direct, Indirect and Universal systems of yarn numbering. Conversion factors for various numbering systems in detail. Determination of count of yarn by simple weighing method and from small length by Bessley's yarn balance.

Yarn twist

Twist may be defined as the number of spiral or helical turn given to a yarn in order to hold the component fibres or strand together. The effectiveness of the twist will be a function of both the fibres being spun as well as the extent to which the fibred are parallel before the twist is imparted. The more parallel the fibres the more uniform and effective the twist.

Importance of yarn twist

Twisting is by far the most important operation in the production of spun yarn. The operation must be performed in such a manner that there is even twist in the yarn. Twisting confers on the yarn some distinctive properties that add both to the technical performance of the yarn and its visual appeal. Here are a few key points on the significance of yarn twist.

- Twist increases the tensile strength of yarn as well as the strength of yarn.
- The yarn shape becomes round i.e. shape factor goes near 1 due to twist.
- The inter-cohesion affinity of fibres increases due to twist and do not open easily.
- The more twist increased under the constant value; the yarn become so strength.

What exactly does twist do to a yarn?

-The twist in a yarn binds the fibres together and helps to keep them in their respective positions. It thus gives coherence to yarn.

-Twist gives sufficient strength to the yarn. This is mainly to withstand the stresses and strains during subsequent textile processes like winding, warping, and weaving. Besides the individual fibre strength, it is the inter fibre friction that contributes to the overall strength of the yarn.

-Twist is also used to bring about novel effects that are prominently visible when the yarn is converted to fabric. This is achieved primarily by having a combination of yarn with different twist level and twist direction in the fabric.

Its effects on yarn properties

The twist in yarn significantly affects its properties in several ways:

- **Strength and Durability:** The amount and direction of the twist can influence the yarn's tensile strength. A tighter twist generally increases strength, making the yarn more durable.
- **Elasticity and Flexibility:** The twist affects the elasticity of the yarn. A higher twist can lead to more elasticity, allowing the yarn to stretch more and return to its original shape.
- **Texture and Feel:** The twist impact the texture of the yarn. A looser twist often results in a softer feel, while a tighter twist can make the yarn feel firmer.
- **Appearance:** The way light reflects off the yarn is influenced by its twist. A higher twist can create more surface area for light to reflect, potentially giving the yarn a greater sheen.
- **Drape and Flow:** The way a fabric made from the yarn drapes and flows is affected by the twist. Different twist levels can either add stiffness or fluidity to the final fabric.
- **Moisture absorption.** A high level of twist in a yarn holds the fibres together and hence restricts the access of water to the yarn interior. Therefore, such a yarn would be used where a high degree of water repellence is required, for example in a gabardine fabric. A low-twist yarn will absorb water more readily than a high-twist one so would be used in those applications where absorbency is required.

Relation between yarn count and twist

On of the important relationship that influence the machinery settings in the spun yarn process is that between yarn count and yarn twist. These two yarn parameters are related by an important factor known as the twist factor or twist multiplier. The relationship is derived in what follows:

Figure shows a schematic diagram of single element or fibre of spun yarn as it lies on the surface the yarn. on account of the twist in the yarn, the fibres assume a helical shape about the fibre axis. So the full line represents the part of the fibre visible in front and the broken line that part of the fibre that spiral around on the other side.

Figure shows one unit length l of the yarn. The fibre AB is shown making one complete turn of helix around the yarn axis. Let d be the diameter of the yarn and Θ be the angle between the fibre and yarn axis.

Given this information, imagine now that the yarn surface is slit open along a line passing through the ends of fibre AB and the yarn is opened out. It will be realised that the opened out surface layer of the yarn assumes the shape of rectangle ACBD, as shown in the figure. It will also be clear that the fibre is in fact the hypotenuse AB of the right-angled triangle ABC. ∠ABC is the helix (or twist) angle and the circumference of the yarn is equal to AC. The yarn length l is represented by BC.

Let C be the count of yarn, n the twist in the yarn in terms of turns per inch and d the yarn diameter.

In Δ ABC, $\tan\theta = AC/BC$ = (circumference of the yarn) $/\ \ell = \pi\, d / \ell$

$$\therefore \tan\theta = \pi\, d / \ell \qquad \ldots(1)$$

As the yarn twist is n turns per inch and the length of the yarn accommodating one turn of twist is l, we have $n\ell = 1$(inch) or $n = 1/\ell$.

Considering C in terms of N_{ec}, the diameter d of the yarn can be expressed as $d = 1/(28\sqrt{C})$

Putting these values of n and d in Equation 1, we have,

$$\tan\theta = \pi \times \frac{1}{28\sqrt{C}} \times n$$

$$n = \frac{\tan\theta \times 28\sqrt{C}}{\pi} \qquad \ldots(2)$$

$$\therefore\ n = m \times \sqrt{C},\ \text{where } m = 28\tan\theta / \pi$$

The factor m is called twist multiplier or the twist factor. This is the relationship between the count and twist in a yarn and the twist multiplier and it can be stated generally as follows.

Twist Per Inch = Twist Multiplier × $\sqrt{\text{Yarn Count in } N_{ec}}$

If we consider the direct system of yarn numbering, such as the tex system, in which the yarn diameter is directly proportional to the square root of the yarn number, we have,

Yarn diameter $\propto \sqrt{C}$

$$\therefore \text{Tex twist factor} = \text{turns per metre} \times \sqrt{C}$$

$$\text{or Tex twist factor} = \text{turns per centimetre} \times \sqrt{C}$$

The tex twist factor relationship is also given in terms of turns per centimetre as the twist factor values in terms of the tpm are usually very large, ranging from around 2000 to around 10000. When twist is expressed as tpcm, this twist factor range is 20 to 100. These values are more convenient to express and use!

The twist multipliers (TM) recommended for a few types of roves and yarns are given in Table 4.4.

Single and ply yarn twist

Single yarn twist

The twist in the yarn may be an S twist or Z twist. To quick find out whether a yarn has S-twist or Z twist, hold it vertically and observe the direction in which its component fibres or strand lie.

S twist:

The yarn has S twist if its component fibre or threads are inclined to the axis of the yarn and are disposed in the same general direction of the central segment of the letter S. This is depicted in figure.

Z twist:

Similarly, the yarn has Z twist if the constituent fibres or threads are inclined to the yarn axis and the lie in general in the same direction as the central segment of the letter Z, as shown in figure.

In textile practice, it customary to have Z twist for warp yarns and S twist for weft yarns.

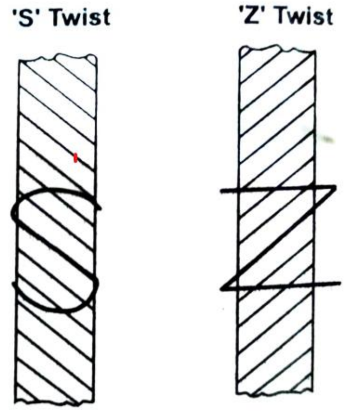


Figure. Type of twist

PLY yarn twist

If two Z axis yarn are twisted together in the Z direction, it simply means that twist is being inserted on twist. Speaking in general, if during the doubling process, two yarn are twisted together in the direction of twist of the component yarns, the process is referred to as a twist-on-twist process.

For example, two single yarn S twist yarns would be doubled on a twist o twist basis, if the doubling twist direction were also in the S twist direction.

Figure illustrates a situation where two single Z twist yarn are doubled and twist in the Z twist direction. The twist-on-twist method will produce a hard twisted strand. Crepe and voile are produced by this method.

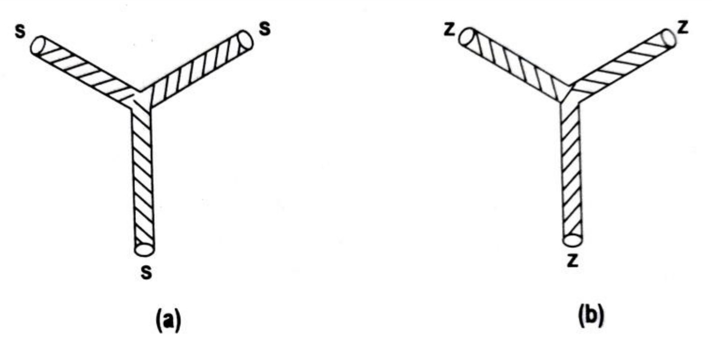


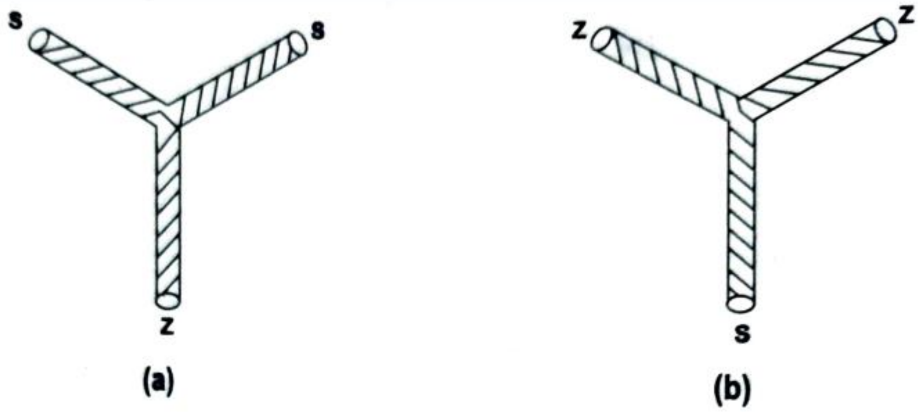
Figure 4.9 Twist on twist

Weft on twist

If two single S twist yarn are doubled and twisted in the Z direction, the process si known as weft on twist. This is shown in figure.

The case of weft on twist doubling of two Z twist single yarn shown inn figure.

The result of a weft-on-weft twist process is a soft twisted strand.



Twist Testers

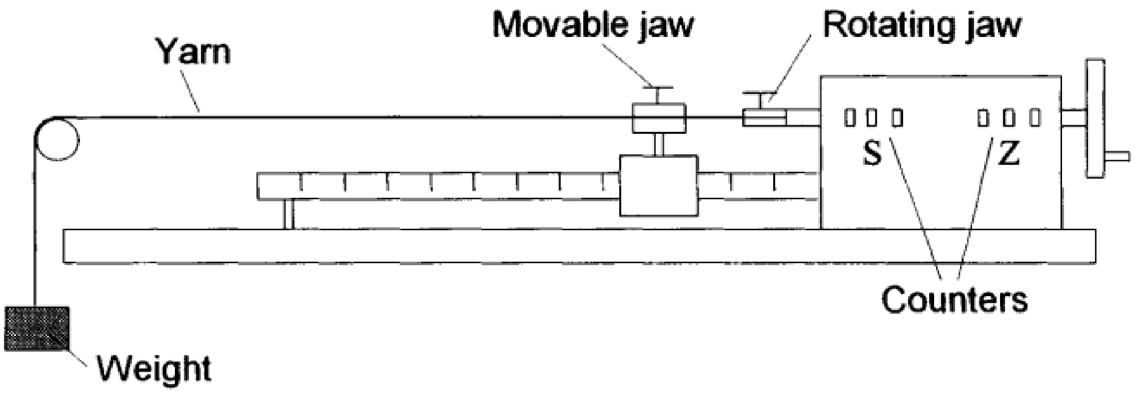
A twist tester is an instrument used in the textile industry to measure the twist in yarns and threads. The twist of yarn is a crucial factor that influences the strength, elasticity, and overall quality of the fabric produced.

Measurement of twist

Twist in yarns, direct counting method

Twist in yarns, direct counting method This is the simplest method of twist measurement. It is also the only method recognised as a British Standard; the US standard is similar. The essence of the method is to unwind the twist in a yarn until the fibres are parallel to the yarn axis and to count how many turns are required to do this. A suitable instrument, an example of which is shown in Fig. 4.8, has two jaws at a set distance apart. One of the jaws is fixed and the other is capable of being rotated. The rotating jaw has a counter attached to it to number the whole turns and fractions of a turn. Before starting any tests, the samples should have been conditioned in the standard testing atmosphere. Testing is started at least one metre from the open end of the yarn as the open end of the yarn is free to untwist so that the level of twist may be lower in that region. As the yarn is being clamped in the instrument it must be kept under a standard tension (0.5 cN/tex) as the length of the yarn will be altered by too high or too low a tension. The twist is removed by turning the rotatable clamp until it is possible to insert a needle between the individual fibres at the non-rotatable clamp end and to traverse the needle across to the rotatable clamp. The use of a magnifying lens may be required in order to test fine yarns. The twist direction and the mean turn per centimetre or per metre are reported.

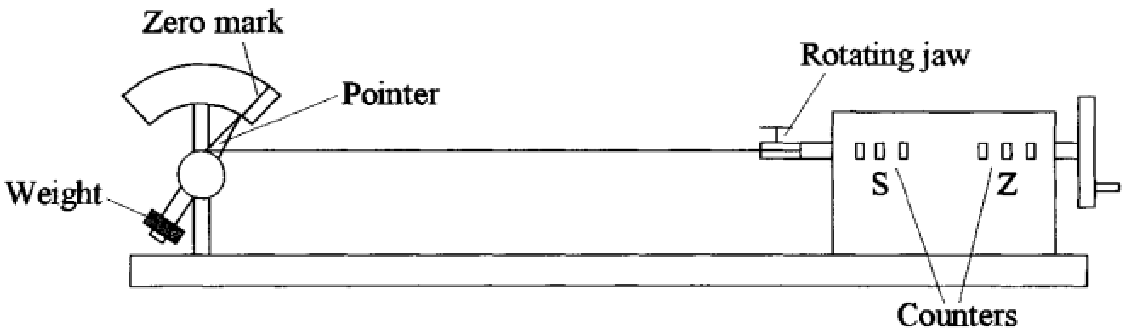
Number of tests 1 Single spun yarns. A minimum of 50 tests should be made. The specimen length between clamps must not exceed the average staple length of the yarn. For cotton yarns 10 or 25 mm between the clamps is suitable, for woollen or worsted yarns 25 or 50mm should be used. 2 Folded and cabled yarns and single continuous filament yarns. A minimum of 20 tests should be carried out with a specimen length of not less than 250mm.



4.8 A simple twist tester.

Untwist-twist method

This method is based on the fact that yarns contract in length as the level of twist is increased. Therefore, if the twist is subsequently removed, the yarn will increase in length reaching a maximum when all the twist is removed. The method uses a piece of equipment such as that shown in Fig. 4.9 in which the end of the yarn distant from the counter is attached to a pointer which is capable of magnifying its changes in length. At the start of the test the yarn is placed under a suitable tension, either by a clip-on weight or by a weighted arm as shown. The test procedure is to untwist the yarn until all its twist has been removed and then to continue twisting the yarn in the same direction, until it returns to its original length. The basis of the method is the assumption that the amount of twist put in is equal to the twist that has been removed. However, this is not necessarily the case. For woollen yarns the method may give results up to 20% below the true value, whereas for worsted yarns the results may be 15% higher owing to fibre slippage. One source of error in the method is that at the point of total twist removal the fibres in the yarn are unsupported so that any tension in the yarn may cause the fibres to slip past one another, so increasing the length of the yarn. The difference in length if unnoticed will cause an error in the measurement of turns per unit length. Another source of error is the fact that with some yarns, when the twist is removed, the amount of twist to bring it back to the same length is not equal to the twist taken out. Because of these problems the method is not recommended for determining the actual twist of a yarn but only for use as a production control method. There is a US standard for this method but it warns that the measured values are only an approximation of the true twist. It suggests that 16 samples are tested using a gauge length of 250 or 125 mm. However, the method is easy to use and has less operator variability than the standard method so that it is often used for measuring the twist in single yarn.



4.9 A tension twist tester.

Yarn numbering system or yarn count

A number which indicates the mass per unit length or length per unit mass of yarn.

• It expresses the fineness of yarn

There are two system to calculate the yarn count.

(a). Direct system

(b). Indirect system

-Direct system

Direct system is a method of expressing the mass per unit length of yarn.

There are two main direct system used in yarn manufacturing system.

(1). Tex

(2). Denier

Tex: Weight in grams per 1000 meter or 1 km of yarn.

Denier: Weight in grams per 9000 meter or 9 km of yarn.

Note*: Higher the number (Tex or Denier) coarser the yarn.

-Indirect system

Indirect system is a method of expressing the length per unit mass of yarn.

There are three indirect system used in yarn manufacturing system.

English count (Ne): It is the number of hanks of 840 yard per one pound of that yarn.

Metric count (Nm): It is the number of hank of 1000 meter per kg of yarn.

Worsted system (Nw): It is the number of hanks of 560 yards in one pound.

Important

1 lea=120 yard, 1 hank= 840 yard or 768 meter , Denier=0.354×micronair

Conversion formula for yarn number system

$Tex = \frac{590.5}{Ne}$, $Denier = \frac{5315}{Ne}$, $Ne = Nm \times 1.693$

Conversion for weights

1 pound (lbs)=453.59 gram

1 kg=1000 gram

1 ounce=28.350 gram

1 grains=0.0648 gram

Conversion for linear measurement

1 yard=0.9144 meter

1 feet= 12 inch

1 meter=100 cm

1 inch=2.54 cm

Determination of count of yarn by simple weighing method

The following instrument is generally used to determine the count of the yarn with the wrap reel. The wrap reel is used to prepare the sample of length 120 Yards.

1. Analytical Balance.

2. Knowles Balance.

3. Quadrant Balance.

4. Beesley Balance.

1. Analytical Balance:

In the mills, the leas of yarn are wrapped using the wrap reel and their weight is found out using the analytical balance.

The weights are measured in terms of grains and the count is calculated using the formula.

Count Ne = 1000 / Weight of a lea in grains

For the internal routine testing purpose, this may be considered sufficiently accurate for the end in view.

1 grain = 0.0647989 grams.

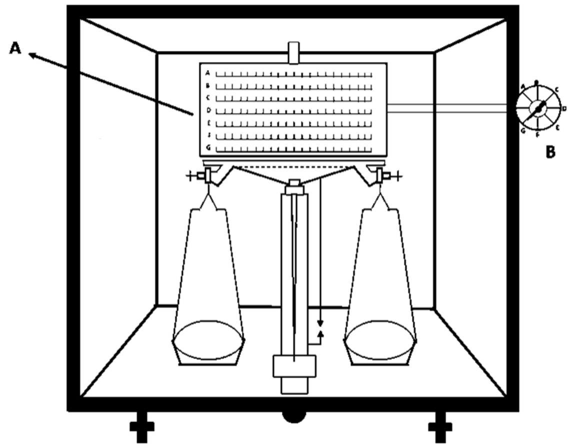
2. Knowles Balance:

This is a direct reading yarn count balance. It is used when the sample is available in large quantities such as hank, ring cops, etc. so that leas of 120 yards can be wrapped using the wrap reel.

Knowles Balance is similar to the ordinary physical balance as shown in the above fig. Behind the beam, the balance, a hexagonal scale, or a rectangular board is mounted. The principle used in this instrument is the fixed weight and fixed-length system i.e., principles of the moment of balancing length. The hexagonal scale or the rectangular board is mounted on a pillar, behind the main pillar of the balance. The faces of the hexagonal scale are lettered from A to F and each face is calibrated to cover different each range of count from coarse to fine. In the case of a rectangular board, seven scales are calibrated and are lettered from A to G. Anyone face of the rectangular board can be brought to the level of the beam by turning a knob in front of the balance. Two counterweights are provided with the instrument, one is circular and the other is rectangular and are marked with the letters A, B, C, D, E, F, and G. The circular weight is placed on the left-hand pane of the balance and the rectangular weight on the beam. The sample of the yarn in the lea form is placed on the right-hand pane.

The count of the yarn is approximately assumed and depending upon the count, the face of the hexagonal scale is selected for example: if the count of the yarn is assumed as the 30s then B face is selected. Which has a range of counts from 20s to 40s to find the exact count of the yarn. In the case of the rectangular board, the scale the rectangular board the scale which has that count is bought in level with the beam of the balance by turning the knob. Then the circular weight with the mark similar to that on the scale, in this case, B is placed on the left beam. Then a sample of lea is placed on the right-hand pane and the position of the rectangular weight is adjusted on the beam until the beam is balanced. The count of the yarn is then read off directly from the scale the value opposite a line marked in the center of the rectangular weight.

KNOWLES BALANCE



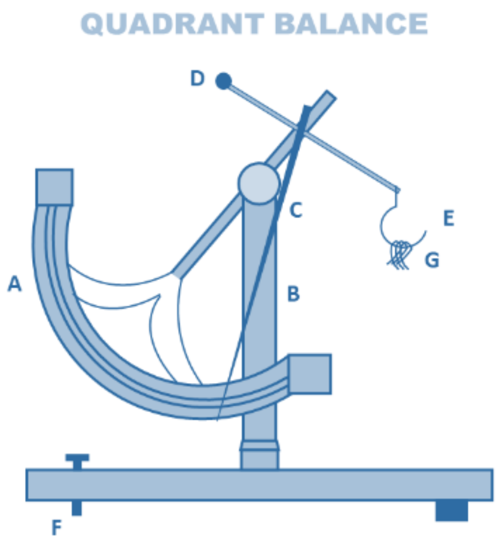
A = Rectangular Scale B = Adjusting Knob

3. Quadrant Balance

If the sample is available with a length less than 120 yards then Quadrant Balance can be used to determine its count.

This is a direct reading yarn count balance and it consists of a quadrant scale fixed to a pillar as shown in fig. At the top of the pillar, the pointer is pivoted so that it moves over the face of the quadrant scale. A crossbeam is also pivoted n the same pivot of the pointer which has a sample hook at its one end and a counterweight at its other end. The counterweight determines the capacity of the instrument. The addition of any weight to the sample hook makes the pointer move Infront of the scale.

The quadrant scale is divided into three scales. The top scale can be used to find the weight per square yard of a cloth sample in ounces, the middle scale to find the counter of yarn of length 8 yards, and the third scale to find the count of yarn of length 40 yards.
On the top of the pointer and the beam pivot, there is a small adjusting screw the adjustment of which brings the pointer in line with the datum line. The instrument can also be leveled with a leveling screw provided at the base of the instrument.
To operate the instrument, it is calibrated after leveling with the base screw. A counterweight marked the 40s is used for calibration for this the counterweight is suspended from the sample hook. If the balance is level the pointer reads the 40s on the 40 yards scale. If it does not read the 40s the pivot of the pointer is adjusted until it reads 40s on the 40yard scale.
If a sample of length 8 yards is used its count can be noted from the 8 yards scale and if the sample of length 40 yards is used, its count can be noted from the 40 yards scale.



A = Quadrant scale B = Pillar C = Pointer
D = Counter weight E = Sample hook F = Levelling Screw G = Yarn Sample

4.1.4.4 Beesley's Balance

A Beesley-type balance is used to find out the count of yarn removed from a small sample of cloth. It therefore uses much shorter lengths of yarn for a test than the Knowles and quadrant balances. The special advantage of this kind of balance is that it is available in a compact size so it is portable.

Principle

The principle of a Beesley's balance is similar to a common balance, except that no pans are used here. Standard lengths of warp or weft threads removed from a fabric of specific dimensions are counterpoised against a standard weight. The number of threads that exactly balances the standard weight is the count of the yarn under test.

Description

A typical appearance of this kind of balance is shown in Figure 4.7. 'A' is the beam of the balance pivoted at C on a rigid pillar B. The beam has three features. The first is that there is a sample hook D attached to its right end; the second is that it has a tapered left end that also serves as a pointer E; and thirdly, it has a notch F about midway on its left-hand section. The standard weight, G that comes as a part of the balance is hung on the notch during a test.

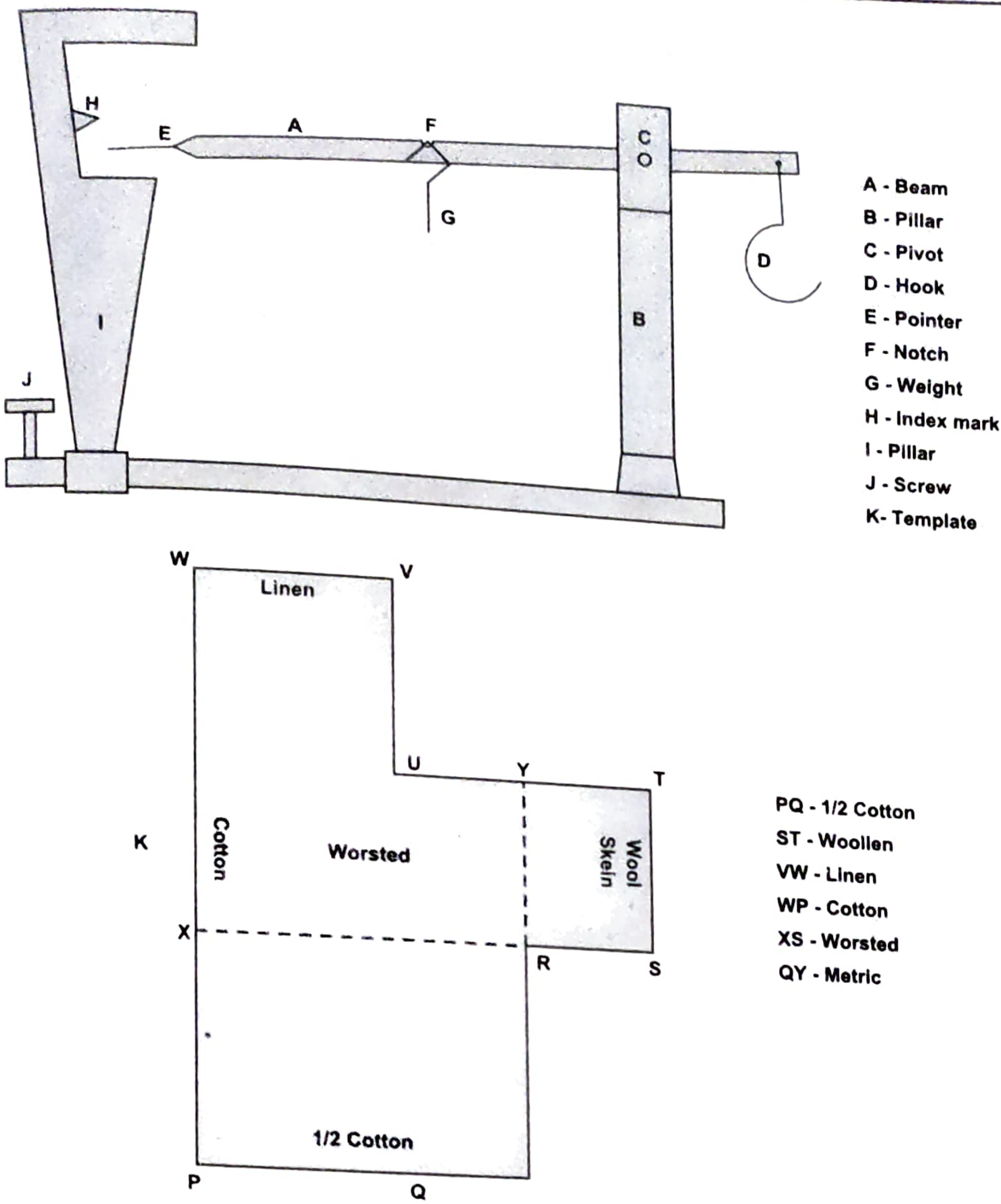


Figure 4.7 Beesley's balance

In the CD-ROM, watch Animation No. TT - I 4.4

With no sample on the hook and no weight in the notch, the pointer E of the beam coincides with an index mark H on another pillar I.

The instrument also comes with a template K. The edges of the template are the standard lengths to which the warp or weft threads in a test fabric are cut under different systems of yarn count. For example, the edge WP of the template represents a "full-cotton" length. If only a very small piece of the test fabric is available, the edge PQ of the template is used to measure off the threads. This is the "half-cotton" length. Similarly, the other edges ST, VW, XS and QY represent the standard lengths meant for woollen, linen, worsted and metric count systems respectively.

The standard weight G is used for all tests of yarn count determination irrespective of the system. For the "half-cotton" length alone a smaller standard weight of correspondingly lower mass than G is used.

As the beam is light, air draughts could interfere with accurate testing as it does in a physical balance. The instrument is therefore always enclosed in a glass casing that can be temporarily open at the front for operator convenience.

Procedure to determine yarn count

a) Levelling the instrument

When the beam is free of test specimen and the standard weight, its pointer should be exactly in line with the index mark H. Any deviations can be set right by adjusting the levelling screw J.

b) Determination of count

- First of all, place the standard weight G on the notch of the beam; if the half-cotton length on the template is to be used, use the smaller standard weight instead.
- Next, the test fabric is laid flat and a square of fabric is cut off with a sharp blade. The side of the square should be about 1½ times longer that the standard yarn length required to be used.
- The warp and weft threads are unravelled from the fabric, taking care to keep them separately.
- The warp threads are then taken, a few at a time, aligned parallel to each other, and straightened to just remove crimp. The straightened set of threads is held parallel to the required edge of the template and cut off using a sharp blade. A number of warp threads are cut off thus from the unravelled threads.
- The warp threads of the required standard length are placed on the hook of the beam, one by one, until the standard weight on the beam is exactly counterpoised, as indicated by the coincidence of the pointer with the index mark.
- The threads on the sample hook are removed and counted. The total number of threads is equal to the count of the warp yarn in the test fabric. For example, if there are 20 warp threads, the yarn count is 20^s if the warp consists of single yarn and $2/40^s$, if it is double yarn.
- The weft threads unravelled from the test fabric are tested in exactly the same manner as described for the warp threads and the weft yarn count determined.

Advantages and disadvantages of the Beesley's balance

- The balance is easy to operate and the counts of the threads in a fabric can be quickly estimated.
- This instrument is the only alternative if only a small sample of fabric is available for analysis and speed of test is important.
- The accuracy is not high as the yarn is decrimped manually for cutting it off to standard length and operator errors could therefore easily occur.

EXERCISE

Multiple choice questions

1. One method/instrument used to measure the yarn twist:

a. Beesley balance b. Qudrant balance

c. Untwist-twist d. Wrap reel

2. Which method is used to measure the count of yarn.

a. Analytical Balance. b. Knowles Balance.

c. Quadrant Balance. d. All of the above

3. How many types of twist present in the yarn?

a. 1 b. 2

c. 3 d. 4

4. 1 hank is equal to….

a. 840 yard b. 560 yard

c. 120 yard d. 260 yard

5. What is the denier of a 10 Tex yarn.

a. 100 b. 180

c. 90 d. 560

6. Mass of yarn in grams per 1000 meter of yarn length is known as:

a. Denier b. Cotton count

c. Worsted count d. Tex

Very short answer questions

1. What is TPI?

2. Define twist?

3. Write the name of the instruments to measure the twist in yarn.

6. What is Count?

7. What Denier?

8. What is Tex?

9. Covert 180 denier into Tex.

10. Define twist multiplier.

Short answer type question

1. What is the use of wrap reel and wrap block?

2. What is the importance of twist in relation to yarn properties.

3. Write the effect of twist on the properties of yarn.

4. Explain the working of quadrant balance to measure yarn count.

5. If the mass of 840 yard of yarn is 20 grams. Find the Tex and denier of the yarn.

Long answer type of question

1. Differentiate the direct and indirect system of yarn numbering. Write down the procedure of determining of count of yarn by weighing method.

2. Discuss the procedure to determine the twist in the yarn by twist-untwist method.

UNIT V
Yarn Testing-II

Yarn strength- Single yarn and lea strength tester. Elongation- Breaking elongation. Elongation at break. Count strength product. CRE, CRL, CRT type. Factor affecting the tensile property of yarn. Principle of tensile testing machine. Tensile strength Testing of Yarn. Single and lea strength tester. Evenness of yarn. Principle, working and advantage and disadvantage of uster eveness tester. Classification of Yarn Faults and Its Removal. Classimate yarn fault analysis.

Yarn strength

Introduction

Yarn strength plays an important role in the determining the performance and end use of fabrics. The strength of given yarn depends upon the characteristics of fibre from which it is made and the structural characteristics of the yarn itself, such as the twist, etc. The routine testing of yarn for its strength is thus of great importance to the yarn manufacturer, the trader and the textile technologist.

Principles of applying load to yarn test specimen

There are three ways of applying the load to the test specimen are prevalent in tensile testing:

1. Constant rate of loading (CRL)

2. Constant rate of extension (CRE)

3. Constant rate of traverse (CRT)

The CRL, CRE, and CRT principles

1. CRL: The ends of specimen A are mounted respectively in an immovable jaw J1and a traversable jaw J2. A gradually increasing force F, starting from zero but increasing at a constant rate, is applied to the specimen. The applied force causes the specimen to extend until it breaks. In this case, the loading causes elongation. Since the load on the specimen increases at a constant rate, this principle of loading is called the constant rate of loading (CRL) principle.

2. CRE: Specimen B has its end mounted respectively in a non-traversable jaw J3 and a traversable jaw J4. The latter is moved downward at a constant rate of speed by a screw mechanism. The initial tension in the specimen is zero, but when the bottom jaw moves downward, the specimen suffers extension, and this would cause it to be loaded; the tension in the specimen would go on increasing until it is so high that the specimen breaks. In this case, the applied elongation is responsible for the tension or loading in the specimen. So, this principle of loading is called the constant rate of elongation.

CRE: The specimen C is fixed exactly like specimen 2 but between Jaw J5 and J6. The upper jaw is not truly fixed as in the above case, but due to an instrumental design feature, is connected to pulley at the top to operate a load indicating mechanism. The lower jaw traverse downward at a constant rate to elongate the specimen, exactly like J4. The movement of the upper jaw relative to that of the lower jaw prevents the extension of the specimen at precisely constant rate. This principle of loading is therefore referred to as the constant rate of traverse (CRT) principle. Though in this case too, specimen extension causes loading. It is different from the CRE principle.

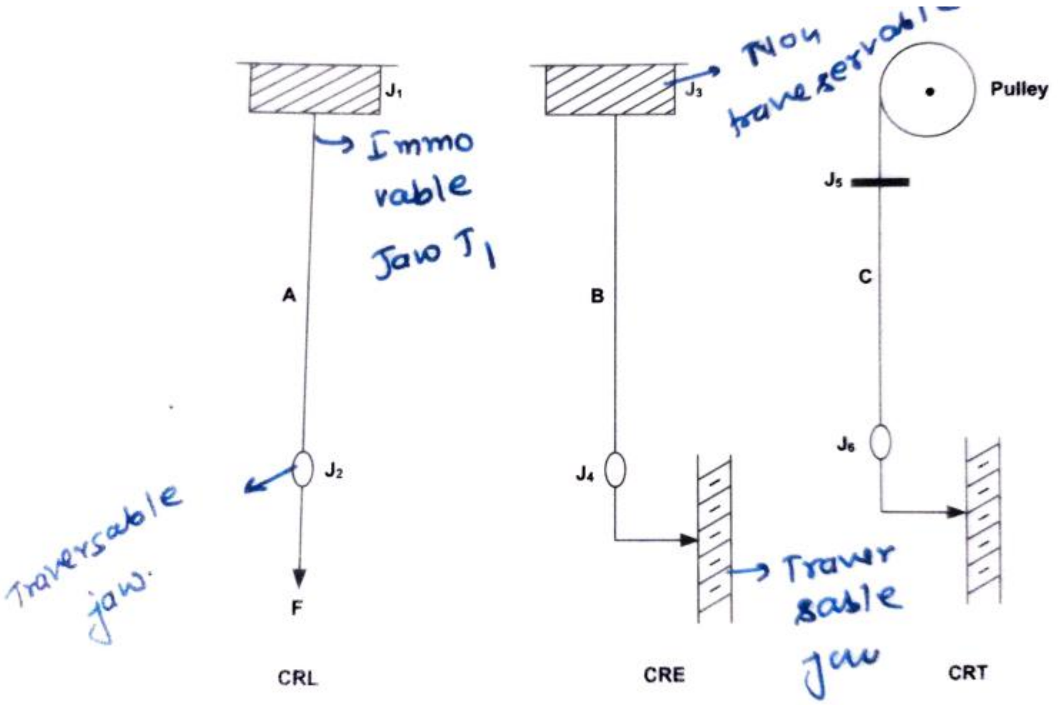


Figure 4.22 The CRL, CRE and CRT principles of applying load to tensile test specimens

1. The Pendulum Lever Single yarn Strength Tester

This instrument is based on the CRT principle. The principle on which this instrument works and some of the factors to be borne in mind when using it have been discussed above. The parts of the instrument and the test procedure normally followed are discussed in what follows.

Description of the instrument

The salient features of the instrument are shown in Figure.

The instrument consists of an upper jaw J1 and a lower jaw J2. A yarn specimen 'A' taken from supply package B passes through the thread guide C and is clamped at the jaws.

The lower jaw is driven by a screw-thread spindle-rod D, driven by a motor E through a gear box F, a stepped pulley G and a clutch H. A traverse speed control handle I connected to a variable stepped-pulley drive enables the bottom jaw to be traversed in two ranges namely: i) 50 to 150 mm/minute and ii) 150 to 500 mm/minute. The clutch can be used to lower or raise the lower jaw. This jaw is connected to a rod and a pin arrangement (J and K) that can be raised or lowered to accommodate test specimens of

desired gauge lengths from 0 to 500 mm. The rod on which the lower jaw is mounted is housed inside the screw-thread spindle rod D.

The upper jaw is connected to a chain L, which in turn is connected to a sector M and a pendulum N. The sector replaces the pulley in some of the older versions. The arm of the pendulum is connected to a pointer O, such that when the pendulum moves, along the serrated quadrant scale P, the pointer too is pushed along with it.

The quadrant scale is graduated in two ranges. The upper range includes the breaking strength values from 0 to 2000 g and the regular pendulum is used. The lower scale is graduated to read from 0 to 10 kg and a small additional weight Q is added to the pendulum when this scale is required to be used.

When the instrument is at rest, the pendulum arm and the pointer are in line with the zero reading on the scale. The pendulum is held in this position by means of a catch R. A set of pawls S, attached to the arm of the pendulum, work on the serrations on the top face of the quadrant scale when the pendulum is in motion. As soon as the test specimen breaks pawls fall into the serrations and the movement of the pendulum is arrested.

A pointer T, connected to the upper jaw, helps to read the specimen elongation on the elongation scale U. A catch V, inserted below the lower jaw rod, keeps the specimen under tension at the start of a test.

The instrument breaking is usually set to give a specimen breaking time of 20±3 seconds. The rate of traverse of the lower jaw is normally set at 300 mm/min (or 12 inches per minute in the older models of the instrument).

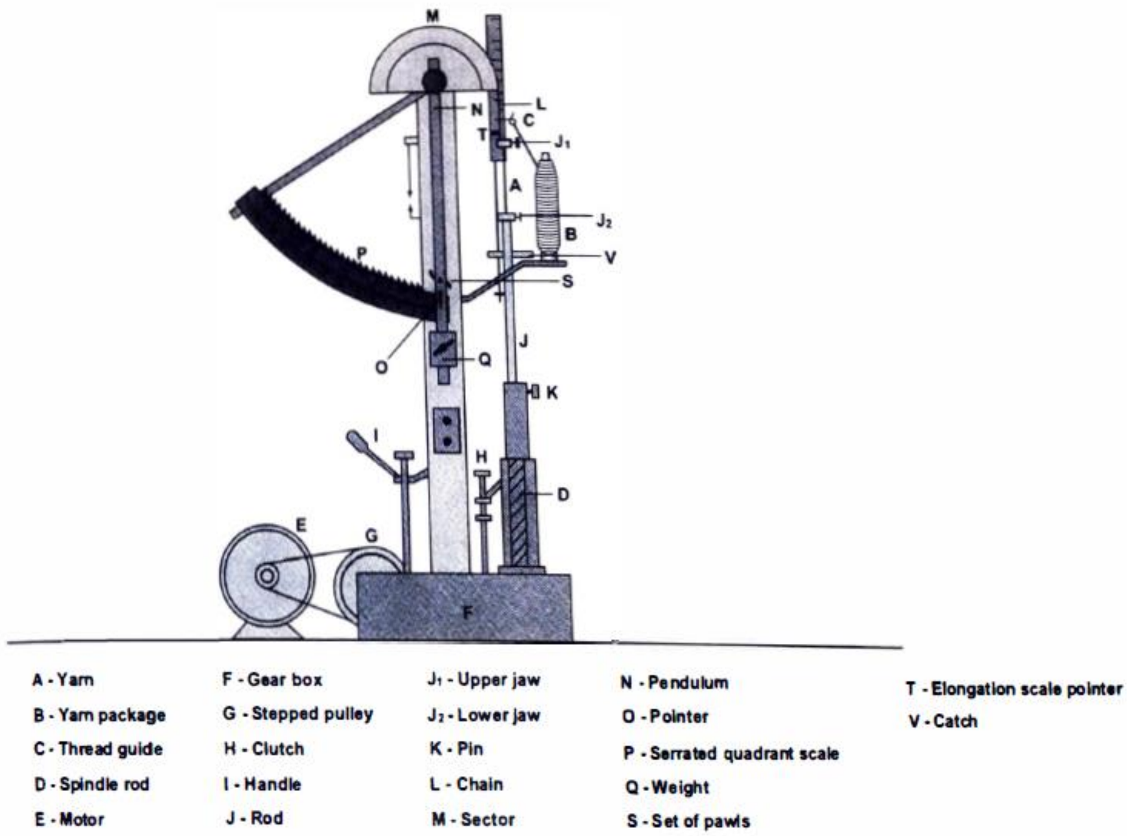


Figure: Single yarn strength tester

Test procedure

The required specimen length is set by using the rod and pin (J and K). The traverse speed is set by using traverse speed control handle (I). The pointers on the strength scale and elongation scale are brought to zero position.

The pendulum and the movement of the upper jaw are arrested with a catch. The specimen to be tested is taken and clamped between the upper jaw and the lower jaw. The extra material is cut off exactly at the jaw position and then the catch is taken out. So, the yarn is under tension before testing. When the instrument is started, the lower jaw traverse downward imposing tension on the specimen on the specimen a thereby pulling the upper jaw; this I turn will make the pendulum to move over the quadrant cale. When the specimen ruptures, the pendulum arm is arrested in the position by a set of pawls working over the serrated portion of the quadrant. The position of pendulum arm gives the breaking load of the specimen. This is read by pointer (o). 50 tests are done for single yarns and 25 for plied yarns. Every time the pendulum arm is brought to zero position and movement of the upper jaw is arrested. Then the tenacity is calculated using the formula,

$$Tenacity\ in(\frac{g}{tex}) = \frac{mean\ breaking\ load\ in\ kg\ \times 1000}{coun\ of\ the\ yarn\ in\ tex}$$

Apart from breaking load, the elongation is also measuired by noting down the relative position of the upper jaw. The elongation scale pointer (T) directly reads the difference in the movement of both the lower and upper jaws. This can be calculated in terms of percentage by :

$$Elongation\ \% = \frac{elongation\ scale\ reading \times 100}{guage\ length\ or\ specimen\ length}$$

2. The Lea strength Tester

The lea tester is popularly used instrument and is a common sight in the test hours of yarn manufacturing organisation. It is very sturdy machine and works on the pendulum lever principle. It uses the CRT principle of loading the specimen, which is a 120-yard skein or a lea of yarn. Both the pendulum lever and the CRT principle have already been explained above.

Description of the machine

It is a motor driven, pendulum type lea tester. It consists of an upper jaw and a lower jaw. The lower jaw can be engaged with a screw mechanism, which is driven at a constant speed by a motor. Thus, a constant rate of traverse of 12 inches/minute is given to the bottom jaw. The top jaw is connected to a pendulum arm by means of a steel tape. A heavy bob is attached to the pendulum arm and the arm moves over a serrated quadrant. A pawl is attached to the pendulum arm to control the movement of the arm and helps the arm to stop when the lea breaks. There is a dial, calibrated in pounds, over which a pointer moves through the geared movement of the pendulum arm. The pointer indicates the lea strength in pounds on the dial.

Working Principle of Lea Tester

Samples of lea are prepared from the ring bobbins or cones using wrap reel. The length of the lea is 120 yards. The bobbins are reeled under the same tension and with a small traverse to separate the layers. When the set length is wound, the reel automatically stops and the lea is transferred from the wrap reel to the lea tester.

The lea is mounted over the jaws and when in doing so, care should be taken to avoid the formation of any twist in the lea and the gripping of threads on the jaws.

Then the bottom jaw is engaged with the screw mechanism and the motor is switched on. As the bottom jaw descends, a load is imposed on the loops of yarn constituting the lea. Because of the pull on the upper jaw, the pendulum arm is pulled which moves the pointer over the dial. At one point, one or two strands break and then many will slip and at the stage, there will not be any further movement of the pendulum. The pendulum will be prevented in falling back suddenly by the pawl which engages with the teeth over the serrated quadrant. At that place, the pointer also stops moving and indicates the maximum load on the dial. This load is called the strength of the lea. The lower jaw is then brought up and the lea is removed from the jaws.

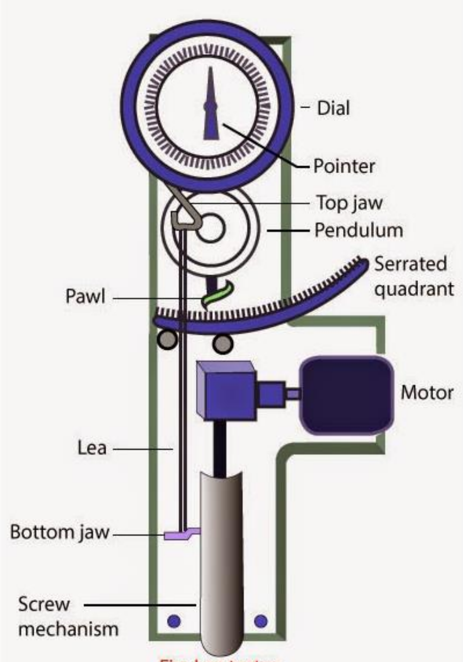


Fig: Lea tester

Lea Count strength product (Break factor or yarn factor)

The product of the count of yarn in Ne and its lea strength in pound is called the lea strength product or lea CSP. It has also been referred to as the break factor or the yarn factor. The lea CSP is used even today as an important yarn parameter. It has been found to be very useful in the assessment of the character of given cotton yarn from strength point of view.

$$\textit{Count strength product (CSP)} = \textit{Count in Ne} \times \textit{lea strength in pound}$$

- **Factor affecting the tensile property of yarn**

Staple Length

Longer staple cotton gives higher strength, and this is true even in the case of synthetic staple fibre such as nylon and terylene. Low twist factors will give stronger yarn in case of longest fibre.

Fibre Fineness

Fine fibre gives strong yarn compared to coarse fibres which are spun into the same given count of yarn. This is due to the fact that more number fibres in the cross-section and also increased internal friction provided by the higher number of fibres in the cross-section of the yarn. Hence the result is higher yarn strength.

Fibre Strength

Logically speaking fine fibre results in providing strong yarn but the paradoxical statement of Dr. Balls states that weak and fine fibres produces stronger yarn. In the case of cotton fibre, fibres will have a longer length and hence more fine fibre can be accumulated in the same cross-section and such as the strength of the individual fibre is of no significance. Therefore, yarn strength is the strength of a group of fibres.

Twist

For a single spun yarn, increases in twist gives a higher strength up to a certain limit and any twist than this optimum will decrease the strength. The amount of twist for maximum strength depends on the twist angle and for any given fibre the twist angle for maximum strength remains constant over a range of yarns.

Evenness

Evenness in the yarn or uniformity in the spun yarn influences the yarn strength. Greater uniformity shows an increase in strength and uneven yarn will show a reduction in strength. An investigation has proved that there is a very close relationship between yarn strength and yarn evenness.

Fibre Length Variation and Distribution

Fibre length variation and distribution will also cause the variation. When spinning cotton, containing more short fibres, the resultant yarn will have lower strength. In the presence of short fibres, the resultant yarn will have lower strength. The presence of short fibres influences, to a very great extent, the yarn strength. Therefore, limitations have to be introduced while mixing such fibres.

Fibre Finish

The man-made fibres, especially synthetic fibres, are treated with several chemicals to change the processing character. The type and amount of chemicals will have a definite influence on the strength properties of yarn and on the processing characteristics of staple fibres.

Yarn Faults / Defects

A yarn which is not uniform is said to be irregular or to contain yarn defects or faults. These faults vary in their cross-sectional size and length. Yarn quality is influenced by various types of yarn faults which also affects the quality of fabric produced. During the yarn manufacturing process various types of irregularities are generated in the yarn diameter regularly or at intervals which are known as yarn faults. Yarn faults are represented based on their size, length and their frequency of occurrence.

- Unevenness or irregularity
- Imperfections
- Objectionable yarn faults

“**Unevenness” or “irregularity”**

In all staple spun material (yarn, rovings and slivers), the fiber distribution along the material varies. The mass per unit length variation due to variation in fiber assembly is generally known as “Irregularity” or “Unevenness” (in practice the Um% or CVm% value). It is the skill of the spinner to arrange all machine settings in such a way that all fibers are spread as even as possible over the length of the material.

Imperfections

The extremes of variations, i.e., the thin places, thick places and neps, are usually referred to as “Imperfections”. These “imperfections” are determined according to a frequency figure or number per 1000 m or yards.

Objectionable yarn fault

If one now considers faults larger than +100% based on the mean yarn cross-section, one moves into the range of 'yarn faults' and correspondingly a further reduction in the frequency. Yarn defects have sizes from +100% and larger and lengths of 1 mm and longer.

Classification of Yarn Faults / Defects

Yarn faults are mainly categorized as below:

A. Frequently Occurring Faults (Analyzed by Uster Evenness Tester)

B. Seldom Occurring Faults (Scanned by Uster Classimat Tester)

A. Frequently Occurring Faults:

These are faults occurring in the range of 10 to 5000 times per 1000 m of yarn. Yarns spun from staple fibers contain imperfections, which can be subdivided into three groups:

1. Thick Places
2. Thin Places
3. Neps

Thick places: Cross-sectional size +30% to +100% of normal yarn with fault length ranging from 4 to 25 mm.

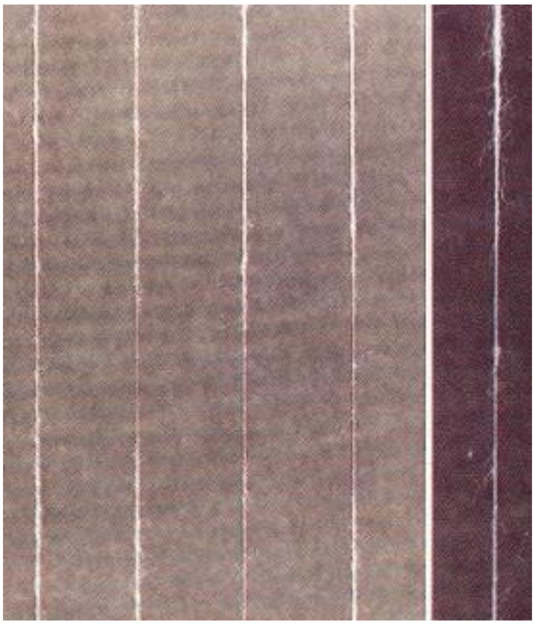


Fig: Thick and thin places in yarn

Thin places: Cross-sectional size -30% to -60% of normal yarn with fault length ranging from 4 to 25 mm.

Neps:

Neps are defined as small, tight balls of entangled fibers seen in linear textile strands. Cross-sectional size +140% to +400% of normal yarn with a fault length of 1 mm.

Fig: Neps in yarn

Thin and thick places are produced due to drafting irregularities and neps are generated due to immature fibers in raw material.

B. Seldom Occurring Faults:

1. Slubs
2. Spun in fly
3. Long thin places

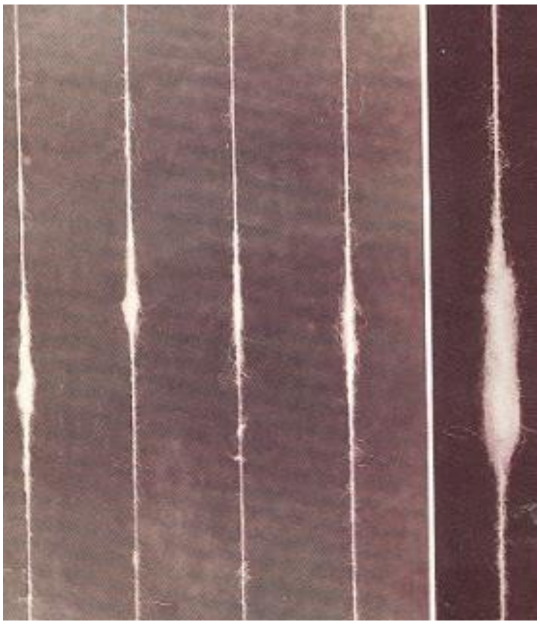


Fig: Slubs in yarn

These are the thick and thin places in yam which occur so rarely that spotting them would require testing at least 100,000 m of yarn. These faults may be classified further into the following types:

1. Short thick places: 1 to 8 cm and above +100%
2. Long thick places: Above 8 cm and above +45%
3. Long thin places: Above 8 cm and less than -30%

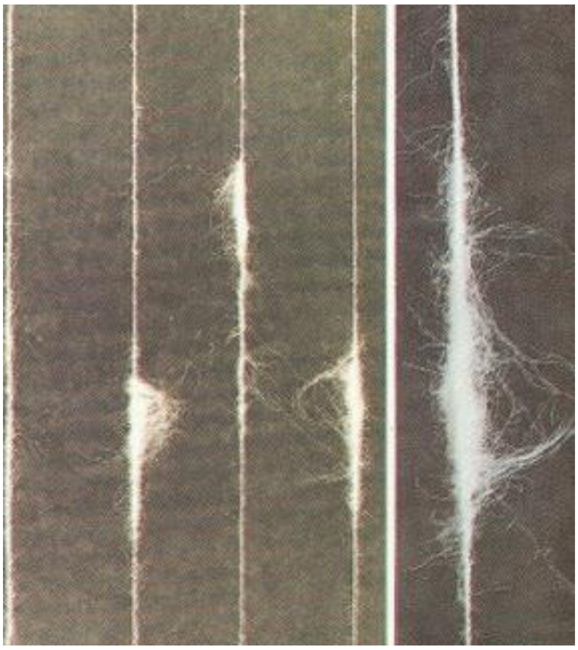


Fig: Spun in fly

These faults are also known as objectionable faults.

Why These Yarn Faults to be Avoided?

- Causes breaks during post spinning operations.
- Detract aesthetic appeal of the fabric, if allowed to pass.

Objectionable yarn faults can be categorized in three groups:

1. Faults due to raw material
2. Faults due to piecing
3. Faults due to Spinning machine

1. Faults due to raw material: The number of objectionable faults due to raw material varies from 16% to 30% with different yarns.

2. Faults due to piecing: The number of objectionable faults due to piecing varies from 9% to 16% of the total objectionable faults.

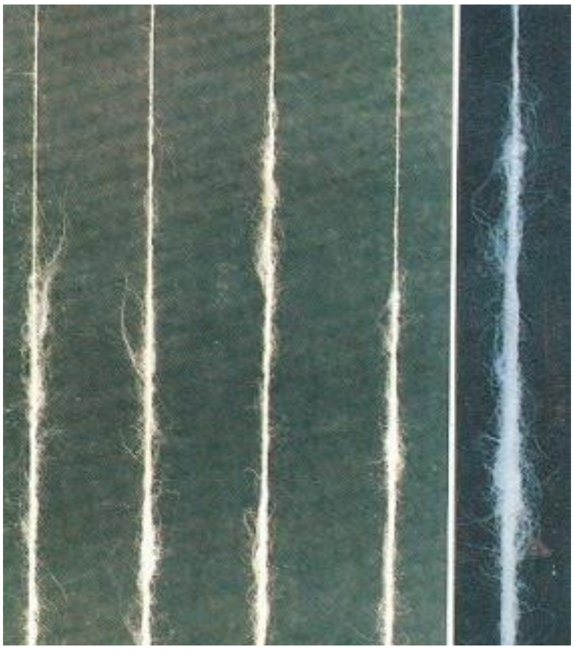


Fig: Bad piecing

3. Faults due to spinning machine: The spinning frame (R/F) is responsible for about 50% to 60% of the total objectionable yarn defects.

Remedies of Yarn Faults:

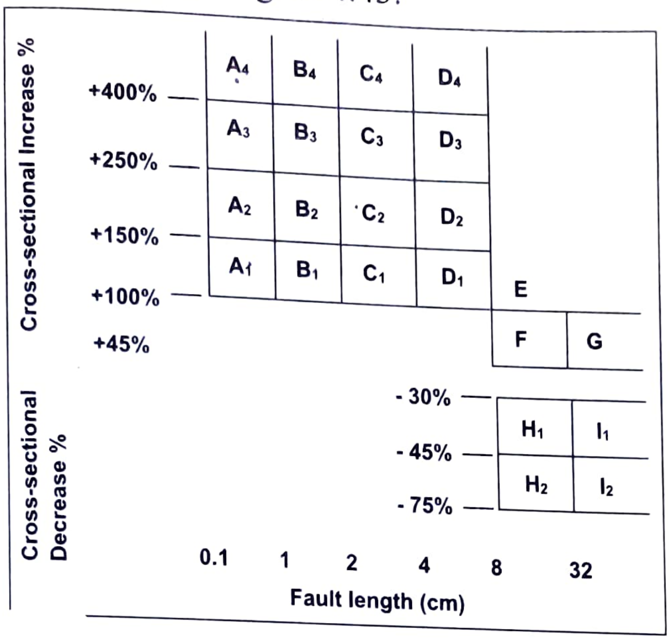
- Machine surfaces to be maintained clean.
- Broken teeth gear wheel to be avoided and proper meshing to be ensured.

Setting at ring frame to be maintained.

- Proper functioning of pnemafil/roller clearers to be ensured.
- Removal of foreign matters (such as jute fibers, color cloth bits) to be ensured during preparation of mixing.
- Better fiber individualization at cards to be achieved.
- Correct tension weights and slub catcher settings to be employed at winding.
- Optimum twist to be used for the type of cotton processed.
- The yarn to be conditioned.
- Vibration of bobbins on the spindles to be avoided.
- Use of optimum roller settings.
- Optimum top roller pressure to be maintained.
- Use of travellars of correct size and shape and rings in good condition to be ensured.
- Optimum relative humidity to be maintained in the spinning room

The Classimat classification of faults

The Uster Classimat (UCM) provides a detailed break-up of yarn faults on the basis of the length and dimension of the faults. This instrument presents the results of fault classification in the format shown in Figure 4.43.



Classes of yarn faults as given by the Classimat

There are totally 23 types of faults. A letter of the English alphabet and a number identify each fault. The letter represents the length range in which the fault lies and the number indicates the transverse size range in which the fault lies. A-type faults are those that have a length in the range 0.1-1 cm; similarly, B-type faults are in the length range 1-2 cm; C-type faults, 2 - 4 cm and so on. The letters A to G denote the thick yarn faults while the letters 'H' and 'I' represent the thin faults.

The number 1 represents a fault of size +100% to +150% over the nominal cross-sectional size of the yarn in the case of thick places and –30% to –45% in the case of thin places; number 2 denotes +150% to +250% for the thick places and –45% to –75% for the thin places and so on.

No numerals are attached to the E to G types of faults since they are generally few in number. The E-type of fault represents faults that are +100% and above the average cross-sectional area of the yarn and of length equal to or greater than 8 cm. The F and G faults characterise faults that have cross-sections in the range +45% to +100% over the mean transverse area of the yarn but the length ranges are different; the F-type fault includes faults in the length range 8 - 32 cm while the G-type fault includes those above 32 cm.

The classimat system is programmed to perform a cumulative counting of the faults within each length class. Very simply, this means that the bigger faults are automatically included as faults in the lower categories also. Table 4.10 explains this feature of the classimat for the A-type faults.

Table 4.10 Classimat (cumulative) counting of yarn faults - A-type faults

Instrument Classification	Types of faults* includes
A_1	$a_1 + a_2 + a_3 + A_4$ or $(a_1 + A_2)$
A_2	$a_2 + a_3 + A_4$ or $(a_1 + A_2)$
A_3	$a_3 + A_4$
A_4	A_4

* a_1,a_2 and a_3 are the absolute faults in the respective categories.

The above is applicable for all the length classes. The cumulative indication of the faults facilitates the evaluation of the sum value of all disturbing yarn faults for each length class. The 23 classes of faults are further grouped into three categories. These are listed below.

1. Short thick faults: $A_1 + B_1 + C_1$
2. Long thick faults: E + F + G
3. Long thin faults: $H_1 + I_1$

Causes of the short thick faults

1. Presence of large amount of trash or high proportion of seed coat fragments in the mixing resulting in insufficient opening and cleaning at blow-room and carding
2. Use of low-micronaire cottons with high level of immaturity
3. Use of cotton lots containing a high proportion of short fibres
4. Excessive fibre entanglements while opening and cleaning in blow-room
5. Use of improper settings between cylinder and flats in cards
6. Damaged wire points in cylinder, doffer and flats in cards
7. Absence of top roller clearers in speed frame
8. Use of broken and damaged surface of the floating condensers and roving guides
9. Use of too wide or narrow settings in roving and spinning machines
10. Use of improper spacers in speed and ring frame

Causes of the long thick faults

1. Presence of unopened rovings in the blow-room lap or card slivers
2. Folding or overlapping of the blow-room layers while feeding to the licker-in of the cards

3. Use of improper settings in draw frames
4. Too low a web or creel draft in draw frame resulting in improper drafting
5. Loose bottom and top aprons in speed frames
6. Improper seating of floating and fixed condensers in speed frames
7. Improper piecing in speed and ring frames
8. Occurrence of lashing-in and excessive end breaks in speed frames
9. Absence of top or bottom roller clearers in speed and ring frames
10. Occurrence of short fibre choking in the hollow leg flyer of speed frames
11. Too close a setting between traveller clearer and traveller in ring frames
12. Use of narrow spacer in ring frames resulting in non-drafted ends
13. Use of fibres having excessive variation in fibre length resulting in formation of crackers in the yarn

Causes of the long thin faults

1. Excessive incidence web falling (partial or full) in cards
2. Too high a break/creel draft or web drafts in draw frames
3. Excessive variation in top roller pressure in draw frames
4. Loose top roller end bushes in draw frames
5. Disturbance to the free rotation of creel calender rollers in draw frames
6. Sliver stretch of the creel in speed frames due to too high a creel draft
7. Too high a break draft in speed frames
8. Excessive roving stretch due to improper function of builder mechanism
9. Use of empty roving bobbin in speed frame with wide variation in bare bobbin diameter
10. Sliver splitting in speed frames while drafting
11. Creel stretch in ring frames on account of obstruction to free rotation of bobbin holders
12. Use of ring bobbins with improper fit on the spindles
13. Use of excessive tension weights in single end winding

Evenness of yarn

Introduction

- Whether we say evenness or unevenness, regularity or irregularity, all these mean the degree of uniformity of a product.
- For textile products such as laps, slivers, rovings, and yarns, which are the products of various spinning machines, the level of uniformity is expressed in terms of evenness or regularity or in terms of unevenness or irregularity.
- Producing a yarn of uniform characters such as uniformity in weight per unit length, uniformity in diameter, turns per inch, strength etc., is indeed a work of very great magnitude and perfect uniform are only dreams.
- This is so, because in the case of staple fibres, that too with natural fibres, this work of transforming millions of individual fibres of varying fineness, maturity, length, colour, diameter, etc., into a yarn of uniform character is hypothetical.
- Another important aspect about natural fibres is a lot of variation in length, colour, thickness, etc., which results in variations in yarns and fabrics.

Types of Irregularity:

1) **Weight per unit length:**

- Variation in weight per unit length is the basic irregularity in yarn. All other irregularities are dependent on it. This is because weight per unit length is proportional to fibre number i.e.; number of fibres in cross section of yarn.

- Variations in number of fibres are the factor influenced by drafting. So any improvement in drafting or spinning will first reflect in improvement in variability of weight per unit length.

2) **Diameter:**

- Variability in diameter is important because of its profound influence on appearance of yarn.

- Variations in diameter are more easily perceived by eye.

- Latest models of evenness testers have therefore a module for determining diameter variability.

- Diameter variability is however caused by weight variability.

- As twist has tendency to run into thin place, variability in weight gets exaggerated in diameter variability.

3**) Twist:**

- Twist variation is important because of its influence on performance of yarn and fabric dye ability and defects.

- Soft ends are a major cause of breaks in weaving preparatory and loom shed. They arise from twist variations.

- Soft twisted yarns take more dye and so uneven dyeing is caused by high twist variation. Weft bars and bands are also caused by low twisted yarns.

- Twist variations come from slack spindle tapes, jammed spindles. A certain amount of variation is also present along the chase of cop.

4) **Strength:**

- Importance of strength variation is easy to appreciate.

- Yarn breaks at the weakest element and so yarns with high strength variability will result in high breakages in further processes.

- Strength variability is partly dependent upon count variability and partly upon spinning conditions and mechanical defects.

5) **Hairiness:**

- High variation in hairiness leads to streaky warp way appearance and weft bars in fabric.

- More light will be scattered from portions of weft where hairiness is more and this leads weft bands.

- High hairiness disturbs warp shed movement in weaving and results in breaks, stitches and floats.

- Among other factors, worn out rings and travellers, vibrating spindles, excessive ballooning and variation in humidity in spinning room cause variations in hairiness from bobbin to bobbin.

6) Colour:

- Variations in colour of yarn cause batch to batch variation in fabric colour, which leads to rejects. This is particularly critical in cloth marketed to garment units.

- Variations in colour of yarn and fabric are caused by variations in colour of cottons used in mixing. Larger lot sizes made from a large number of bales help to mitigate this problem.

- Checking of cotton and mixing for colour will also minimize large variations in colour.

- HVI testing equipments have therefore a module for checking colour.

4.4.8.1 The Uster Evenness Tester

The Uster evenness tester was among the earliest of the capacitance testers to find great commercial success. The tester gives an output of the unevenness (U%) of the test strands sliver, rove and yarn and the imperfections in yarn.

Principle

The instrument works on the 'capacitance principle', mentioned above. The textile strand is passed through a parallel-plate capacitor. The capacitance of the capacitor varies as the cross-sectional area of the test strand. Change in the capacitance are transformed into signals which are amplified and converted by suitable circuits to give an output of the following information, of which a printout can be obtained.

i) U% (Unevenness %)

ii) Imperfections - neps, thick places and thin places.

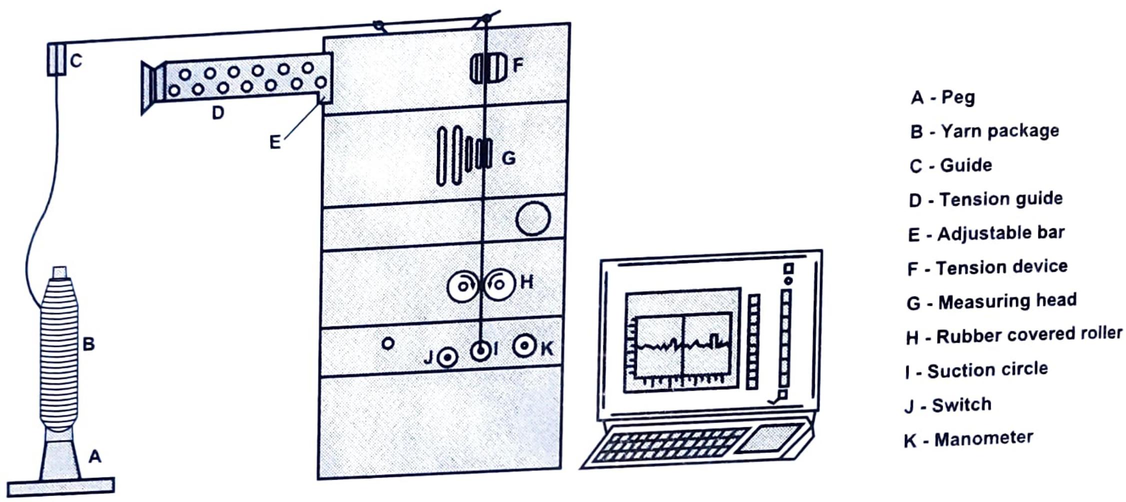
iii) CV % (Variation)

iv) Spectrograph

Description of the Uster Tester – 3 (UT3)

This is a fairly recent model of the Uster tester and its salient features are shown in Figure 4.39. The instrument consists of three main units. These are,

i) The tester ii) Signal processor and iii) Printer



i) Tester

The tester consists of a peg A to hold a test yarn package B. Separate creeling devices are available for holding and guiding larger and softer strands like the sliver and rove. The test strand is led through a regular guide C, tension guides D and a adjustable bar E. The bar can be pushed leftwards or rightwards so as to increase or decrease the gap between the tension guides. A magnetic-control tension device F adjusts itself according to the test yarn count.

The instrument also consists of measuring head G, rubber-covered rollers H, a suction circle I, a push-button switch J and a manometer K. The measuring head consists of four slots of varying width for accommodating the following specimens.

Slot No. 1 - For sliver

Slot No. 2 - For rove

Slot No. 3 - For yarns up to 30^s N_{ec} count

Slot No. 4 - For yarns of count greater than 30^s N_{ec}

The rubber-covered rollers are positively driven rollers that draw the test material through the instrument. They can be run at any one of the following speeds, 25, 50, 100, 200 and 400 m/mm. The speed is usually varied according to the test material. They deliver the test material into the suction circle, which is a hole into which the material is sucked for disposal. The push-button switch is used for getting the initial pressure during testing. The manometer indicates the pressure of the air in the suction tube; this is usually kept at 1 kg/cm^2.

ii) Signal processor

The signal processor consists of a processing unit with video screen, a keyboard and push button switches. The following information is keyed in for every test.

a) Test programmes - This push button sets the required test programmes.

b) Test parameters - This push button is used to select the test particulars.

c) Report parameters - The parameters required for getting a printed report are selected by this push button.

d) Video results - If the results are required on the video screen, they can be seen by using this button.

e) Test Series: This button is for selecting the number of samples to be tested and also series to be tested.

f) Start/stop button: This is to start or stop the instrument.

g) A key for initialising the signal processor; this is indicated by a red bulb indicator.

iii) Printer

A printer is connected to the signal processor. It gives a printout of the test results when required. All the results are stored in the signal processor and immediately after the tests have been completed the results can be printed.

Testing procedure for yarns

- The instrument is switched on.
- At least 30 minutes are allowed for warm up.
- The test programmes, test parameters, test series and report parameters are selected by operating the keyboard and the other buttons of the signal processor. The selections are made to include the following information.

  i) Test material particulars

  ii) Results required on printer/video

  iii) Operator and other reference data required.

- Yarn from the creel is passed through guides, the tension device, the measuring slot (capacitor) and finally fed into the suction circle.
- The pressure in the manometer is checked to ensure the correct pressure.
- When all of the above has been set, the instrument is ready for a test.
- The start button is now pressed and the guide at the measuring head moves automatically to guide the yarn into the 3rd or 4th slot according to the yarn count.
- The yarn passes continuously through the slot and it is monitored for a pre-selected period of one minute at a pre-selected speed of 400 m/min (for yarns).
- The normal stroke diagram (variations with respect to the mean level) and the U% can be seen on the video screen.
- When the first test has been completed, the next specimen is threaded through the parts as before and the second test is started.
- The test procedure is repeated until the selected number of tests is completed.
- If there is any problem during a test, the signal processor clearly indicates it and the operator rectifies it before resuming the test.
- After completing all the tests, the printer is switched on and the test reports are printed out. The printout normally provides the following information both in numerical and in graphical form.
  1. Data relating to the test material, machine and test house particulars
  2. U%, CV% and imperfections
  3. Spectrogram
  4. Variance - length curves.

EXERCISE

Multiple choice questions

1. Full form of CRL?

a. Constant rate of loading b. Constant rate of lower

c. Concrete rate of lower d. Conclude rate of loading

2. The Pendulum lever single yarn strength tester based on the principle of **….**

a. CRL b. CRT

c. CRE d. None of the above

3. How many yards are equal to one lea?

a. 120 yards b. 240 yards

c. 420 yards d. 840 yards

4. CSP is calculated by using the formula of …….

a. CSP=Count (Ne) × lea strength in pound b. CSP=Count (Tex) × lea strength in pound

c. CSP=Count (Tex) × lea strength in kg c. CSP=Count (Nm) × lea strength in gram

Very short answer type of questions

1. What is CRT?
2. What is CRE?
3. What is CRL?
4. What is test specimen?
5. Name two yarn strength tester.
6. Write the name of faults in yarn.
7. What is evenness of yarn?
8. What is breaking strength?
9. What is breaking elongation?

Short answer type questions

1. Discuss the single yarn strength testing instrument.
2. Explain the working principle of lea strength testing instrument.
3. Write the factor which affects the tensile properties of yarn.
4. Discuss the classification of yarn faults.

Long answer type questions

1. Explain the working principle of uster evenness tester and write their advantages and disadvantages.

2. Discuss the working principle of lea strength testing instrument with diagram

4. Discuss the classmate yarn faults .