Lecture Note

SUB: Textile Testing-I

BRANCH:- TEXTILE ENGG.

SEMESTER:5Th

GOVERNMENT POLYTECHNIC, BHADRAK

Prepared By: Shreepati Sundar Upadhyay(Lect.Textile Tech.)

Reasons for Textile 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).

The lack of reproducibility of results of material may be due to:

a) <u>Variation in the material</u>

It can be solved through,

- By proper sampling
- Use of suitable statistical methods to analyze the results

b) <u>Variation due to test methods</u>

- Due to operator (care in mounting of specimen, adherence to the test procedures, etc.)
- Specimen size
- Atmospheric condition
- Type of test equipment
- Test condition – speed, pressure, etc.

To *minimize* variation standard test methods are followed

- Bureau of Indian Standards (BIS) – India
- British Standards (BS) – Britain
- American Society for Testing of Materials (ASTM) - USA
- Deutsches Institut fur Normung (DIN) – Germany Standards Institute

TERMS RELATED TO TEXTILE EVALUATION

A) QUALITY: International Organization for Standardization (ISO)

"Ensemble of properties and characteristics of a product or a service which confer on it the capacity to satisfy expressed or implicit requirements" - "suitable for use" or "fitness for use".

B) TESTING

A means of determining the capability of an item to meet specified requirements by subjecting the item to a set of physical, chemical, environmental or operating actions, and conditions.

C) INSPECTION

Activities such as measuring, examining, testing, one or more characteristics of a product or service, and comparing these with specified requirements to determine conformity (end breakage study in R/F, looms, fabric inspection etc).

D) QUALITY CONTROL

The operational technique and activities used to fulfill requirements of quality D = f (B, C …)

E) STATISTICAL QUALITY CONTROL (SQC)

The application of statistical technique to the control of quality.

F) QUALITY ASSURANCE (QA)

All those planned or systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirement for quality. (Control of vendors for supply of raw material, chemicals etc., time management, e.g. idle time of m/c)

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.

Sample:

It is a relatively small fraction which is selected to represent a population.

Reasons for sampling:

- To minimize time requirement for testing.
- Design nature of many of the tests.

For example **:**

1) Only 20mg of cotton sample is used from 250kg of cotton:

$$\frac{20}{250 \times 10^6} = \frac{1}{12.5 \times 10^6}$$

Aim of sampling:

To produce an unbiased sample in which the population of the different fibre length in the sample are same as those in the bulk or through sampling systems of each fibre in the bale should have equal chance of being chosen for the sample.

YPES OF SAMPLE:

RANDOM SAMPLE:

In this type of sample every individual in the population has an equal chance of being included in it. It is free from bias, therefore truly representative of the population.

NUMERICAL SAMPLE:

A sample in which the proportion by number of, say, long, medium, and short fibers would be the same in sample as in the population.

BIASED SAMPLE:

When the selection of an individual is influenced by factors other than chance, a sample ceases to be truly representative of the bulk and a *biased sample* results.

Causes of bias in sampling:

Bias due to physical characteristics:

Longer fibers always have a greater chance of being selected.

Position relative to the person:

Lab assistant may pick bobbins from top layer of a case of yarn (whether to save himself the task of digging down into the case or because he has never been told otherwise, we do not know), but the bobbin chosen will be biased due to their position.

Subconscious bias:

Person selecting cones will pick the best looking ones free from ridges, cubwebbed ends, etc., without thinking about it.

FIBRE SAMPLING FROM BULK:

1.ZONING TECHNIQUE:

Handful of samples from at least 40 zones.(x: no. of original handfuls)

Take a quarter from each tuft to make the final sample looking ones free from any damages, etc.

- From the bulk, a sample of about 2oz is prepared by selecting about eighty large tufts chosen, so far as possible, over the bulk.

- Divide this sample into four quarters.

- Take 16 small tufts at random from each quarter, the size approximately 20mg.

- Each tuft shall be halved four times, discarded alternately with right and left hands and turning the tuft through a right angle between successive halvings. 16 'wisps' are thus produced from each quarter sample.

Combine each set of wisps into a tuft.

- Mix each tuft in turn by doubling and drawing between the fingers.

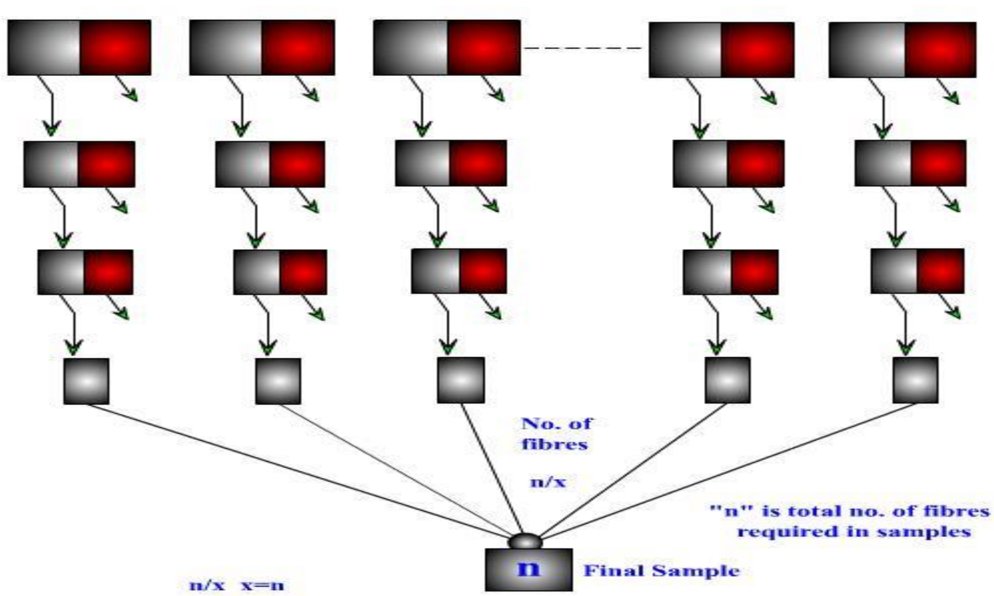
- Divide each tuft into four parts.

- Obtain four new tufts by combining a part of each of former tufts.

- Mix each new tuft again by doubling and drawing.

- Take a quater from each tuft to make the final sample.

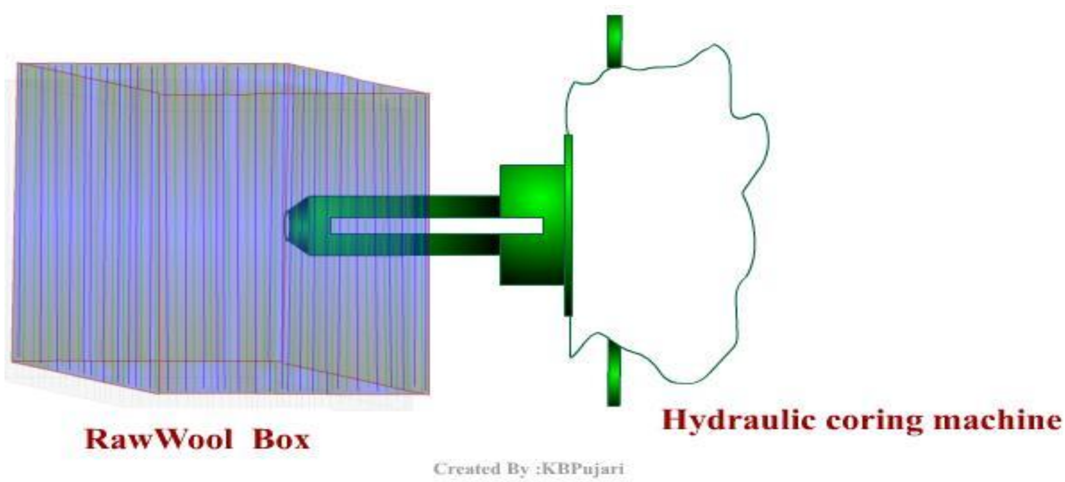
Zoning Technique:For selecting samples from raw cotton



2.CORE SAMPLING:

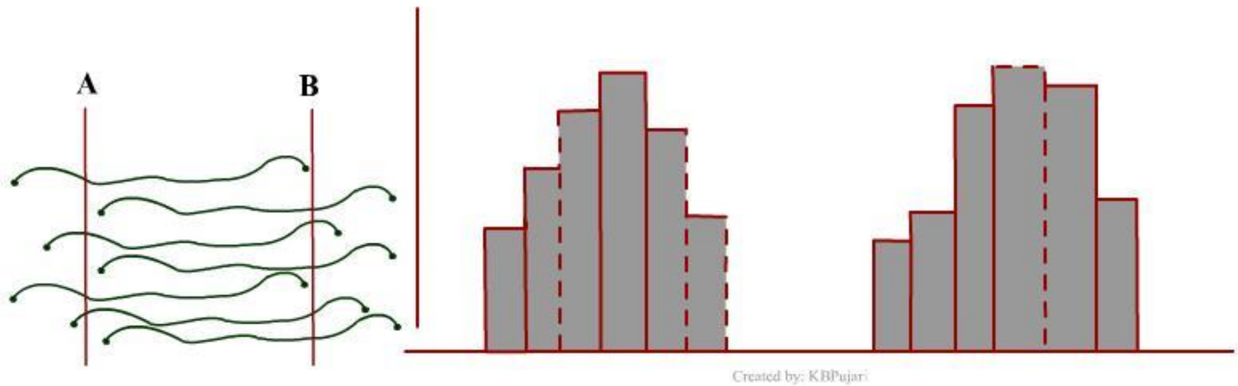
It is used for assessing the proportion of grease, vegetable matter in samples taken from unopened bales of raw wool.

It means half way into the bale i.e. samples from centre. The tube enters in the direction of compression, so perpendicular to the layers of fleece.



- Cutting tip dia is lesser than coring tube.
  - helps sliding the core upside the tube penetrates.
  - helps retaining the core as it is withdrawn.
- No. of cores are extracted and combined.
- Different sizes of tube 14, 15, and 18mm.
- After removal cores are kept in air tight container immediately.
- Hydraulic coring machine for large number of samples

Random/tuft sample:

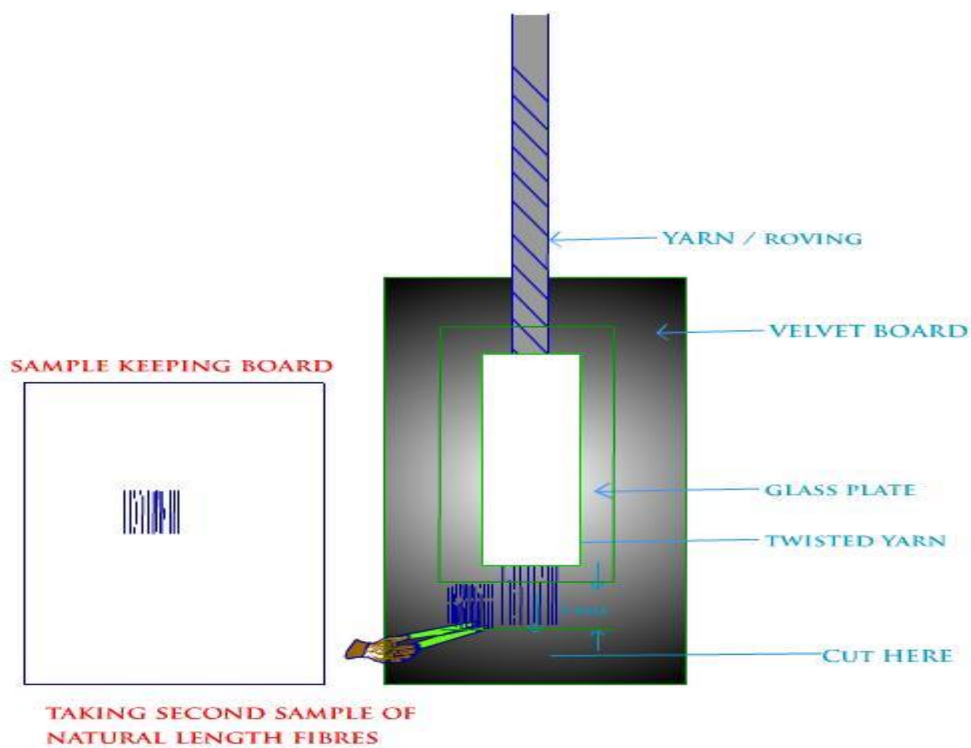


RANDOM DRAW METHOD:

Take out fibre (2mm at each stage) and discard until a distance equal to that of the longest fibre in the sliver has removed. After that each draw will be of numerical samples.

CUT SQUARE METHOD:

Cut all the projected fibres and discarded. The glass plate is then moved back few mm, exposing more fibres with "natural length" without cut. In each case projected fibre ends must be removed.



Why fibre length?

- Quality assessment, Fibre breakage study, machine settings, combing efficiency, etc.

- 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 fiber ends in a given length of yarn. Thirdly, a higher strength yarn can be produced from them for the same level of twist.

- The length and fineness are sometimes related in natural fibres whereas for man-made fibres, length and fineness can be controlled separately.

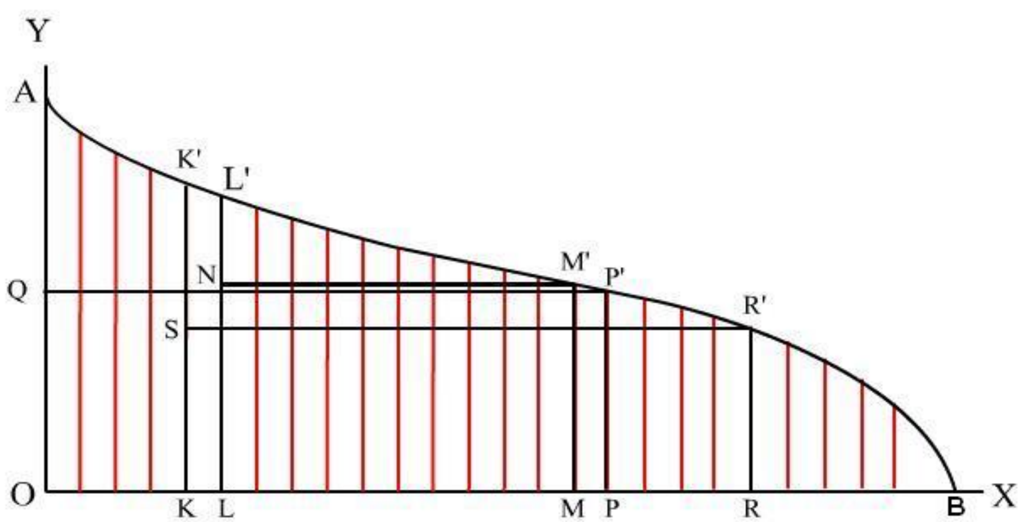
- The cut length of man-made fibres is often influenced by the fibre length of natural fibres.

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.

(B) Comb Sorter Method:



In the diagram

OQ = 1/2 OA

OK = 1/4 OP

KS = 1/2 KK’

OL = 1/4 OR

Short fibre percentage = (RB/OB) × 100%

LL’ = Effective length (because many m/c settings are related with this length)

LL’-MM’ = NL’=Inter-quartile range

Dispersion% = NL’/LL’

(For flatter middle zone, dispersion is minimum)

Frequency distribution in opposite way, i.e. the curve is known but the frequency distribution is to be obtained.

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 vapour 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)

Measurement of R. H. %:

- *Hygrometer* **–** Wet and Dry bulb hygrometer
- Dry bulb reading – 68° F
- Wet bulb reading – 61° F
- Difference – 7° F
- R. H. % from table 67 %

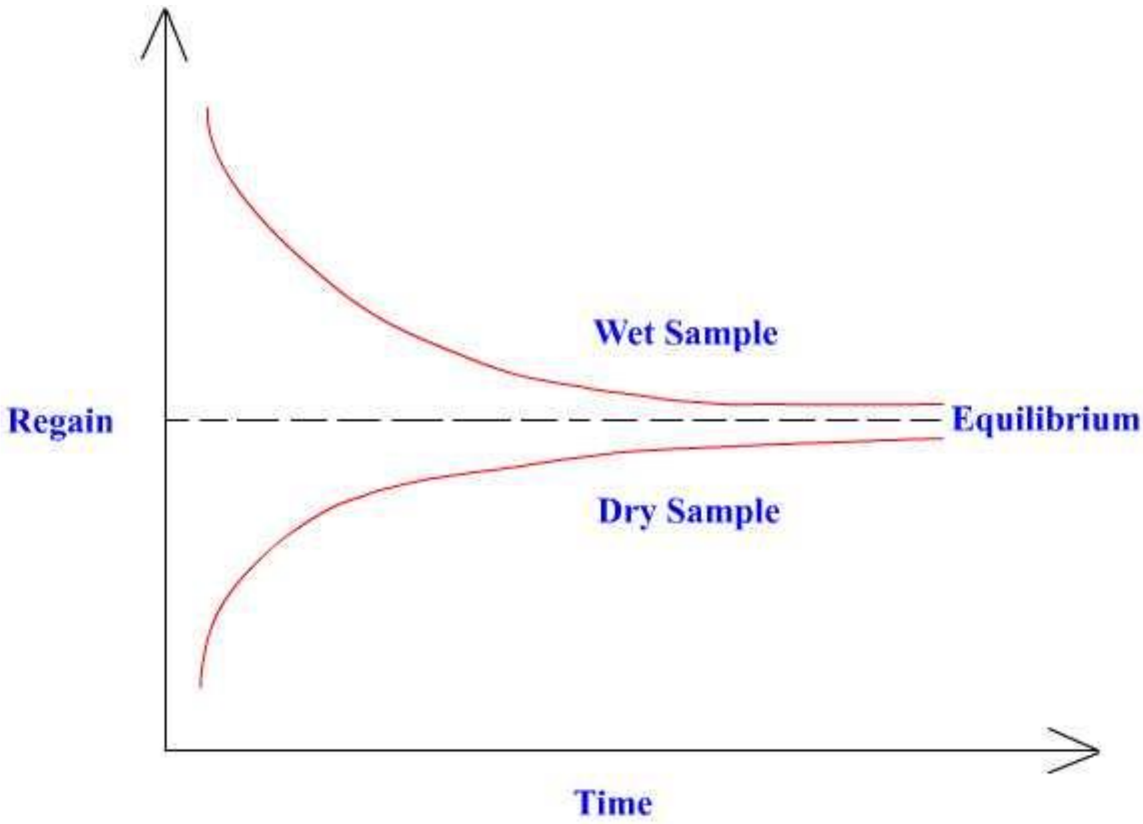
Moisture Regain:

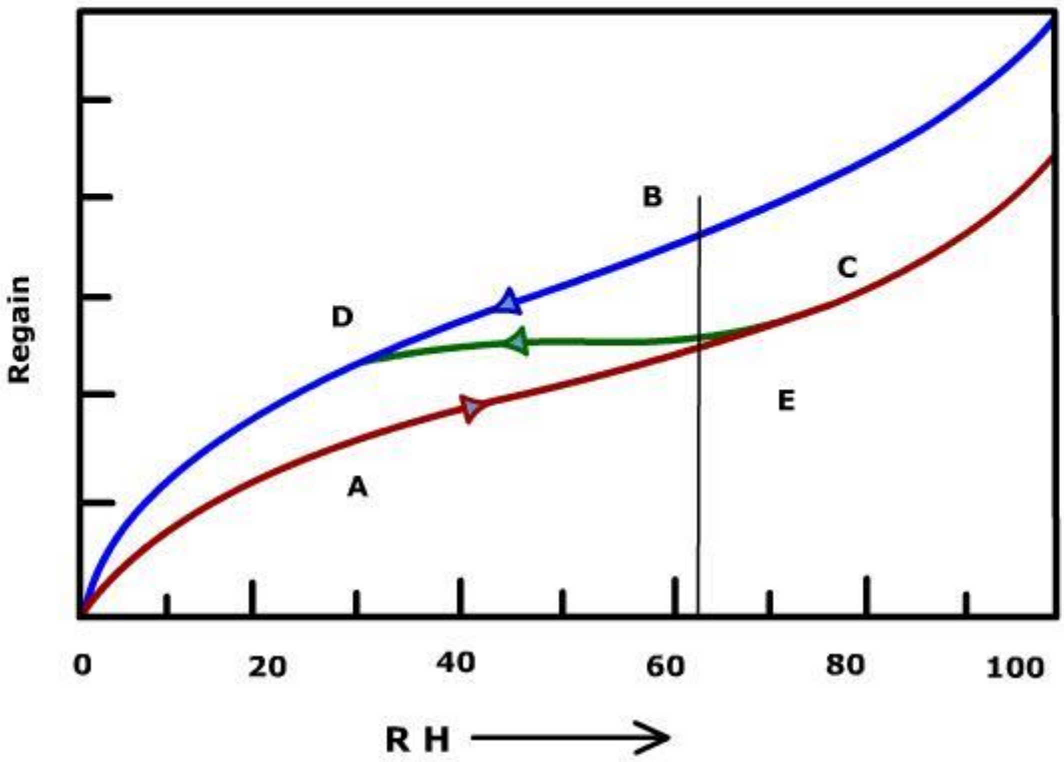
$$MR = \frac{W}{D} \times 100\ \%$$

Moisture Content:

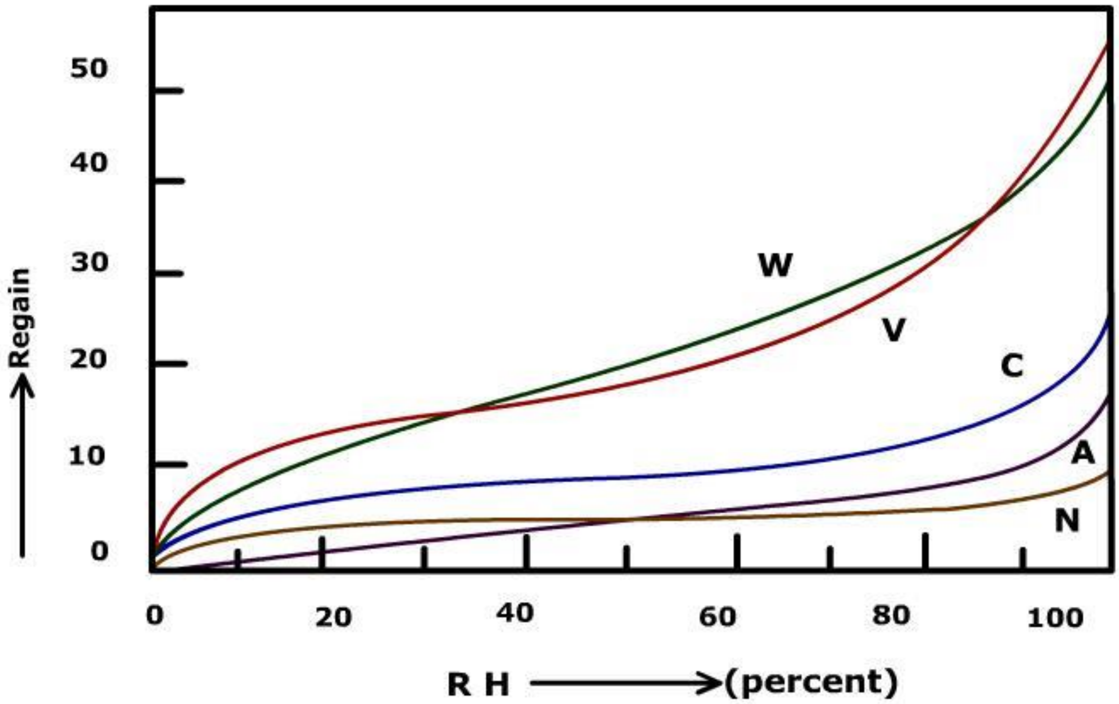
$$MC = \frac{W}{W + D} \times 100\ \%$$

$$M.C. = \frac{M.R.}{1 + \frac{MR}{100}}$$





Absorption Desorption Curves



Absorption curves for various materials

W- WOOL, V-VISCOSE, C - COTTON,
A- ACETATE, N- NYLON

Moisture and Fibre Properties:

- Dimensions: Swelling in diameter, fabric shrinkage occurs due to fibre swelling

  Advantage of swelling is taken in designing in water proof wrinkled appearance of suit (by change in RH%)

- Mechanical properties: Vegetable fibers such as cotton and flax are considered - an increase in strength is noticed when moisture absorbed by the fiber. Other than these fibers strength will be decreased when moisture absorbed by the fiber.

  Other mechanical properties affected by regain include extensibility, crease recovery, flexibility, and ability to be 'set' by finishing processes.

- Electrical properties: The 'before and after' effect of moisture on the electrical resistance of textile material is most striking. Other elctrical properties affected by the amount of moisture in the material are the dielectric characteristics and the susceptibility to static troubles.
- Thermal effect: Absorption of moisture results generation of heat, i.e. ‘heat of absorption’
- In winter from a hot room (low RH %) to outside (cold and high RH%) heat generation balancing of heat, otherwise body would suffer.

Factors Affecting the Regain of Textile Material:

- **Time:** A sample takes a certain amount of time to reach equilibrium. This rate of conditioning depends on size and from of material, the material type.
- **Relative Humidity**: Higher the RH Higher will be Regain.
- **Temperature:** No direct impact, but at high temperature the atmosphere can hold more water.
- T**he previous history of sample:** Bleached or scoured cotton will absorb more moisture than untreated material.

Why fibre length?

- Quality assessment, Fibre breakage study, machine settings, combing efficiency, etc.

- 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 fiber ends in a given length of yarn. Thirdly, a higher strength yarn can be produced from them for the same level of twist.

- The length and fineness are sometimes related in natural fibres whereas for man-made fibres, length and fineness can be controlled separately.

- 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.

Measurement of Individual Fibre Length: (Cotton fibre length)

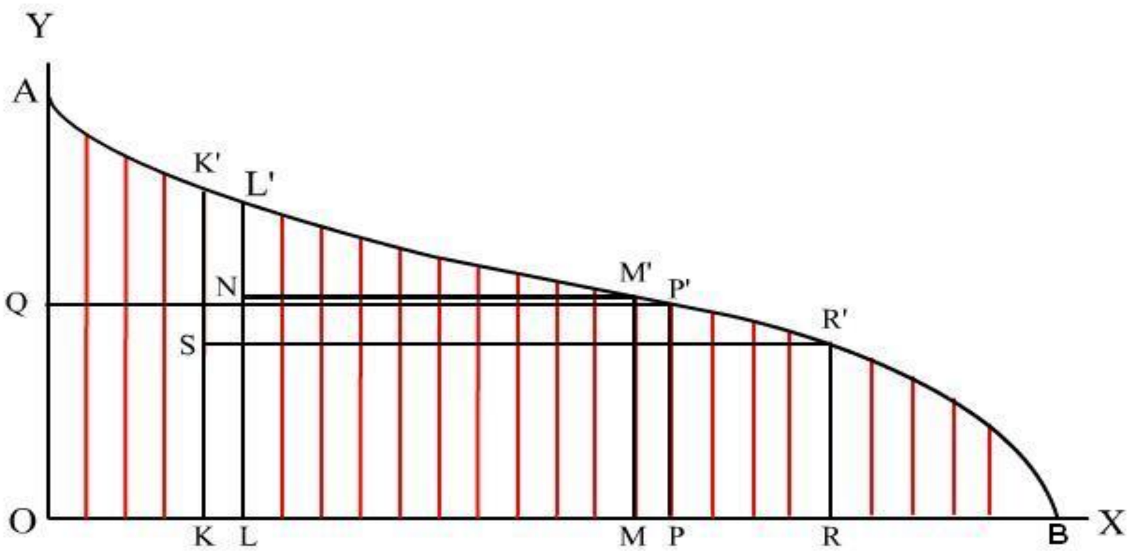
A representative sample is taken and the individual fibre length is measured. These values are arranged accordingly and the mean and coefficient of variation are calculated. This method is mainly used for the man made staple fibres as the variation in length is not much.

The fibres are straightened and placed on an oil plate and the individual length of fibres (around 300-500) is measured.

(A) Hand stapling method : (By trained classers):

- Selecting a sample and preparing the fibres by hand doubling and drawing to give a fairly well straightened tuft of about ½ inch wide.
- This is laid on flat black background and the staple length is measured.
- The shorter fibres will lie in body of the tuft and extreme ends (tips) will not be the limits used for measurement of staple length.
- The classer chooses the length where there are reasonably well defined edges.
- Subjective in nature, so difference in results between classers.

(B) Comb Sorter Method:



Click on Image to run the animation

In the diagram

OQ = 1/2 OA

OK = 1/4 OP

KS = 1/2 KK'

OL = 1/4 OR

Short fibre percentage = (RB/OB) × 100%

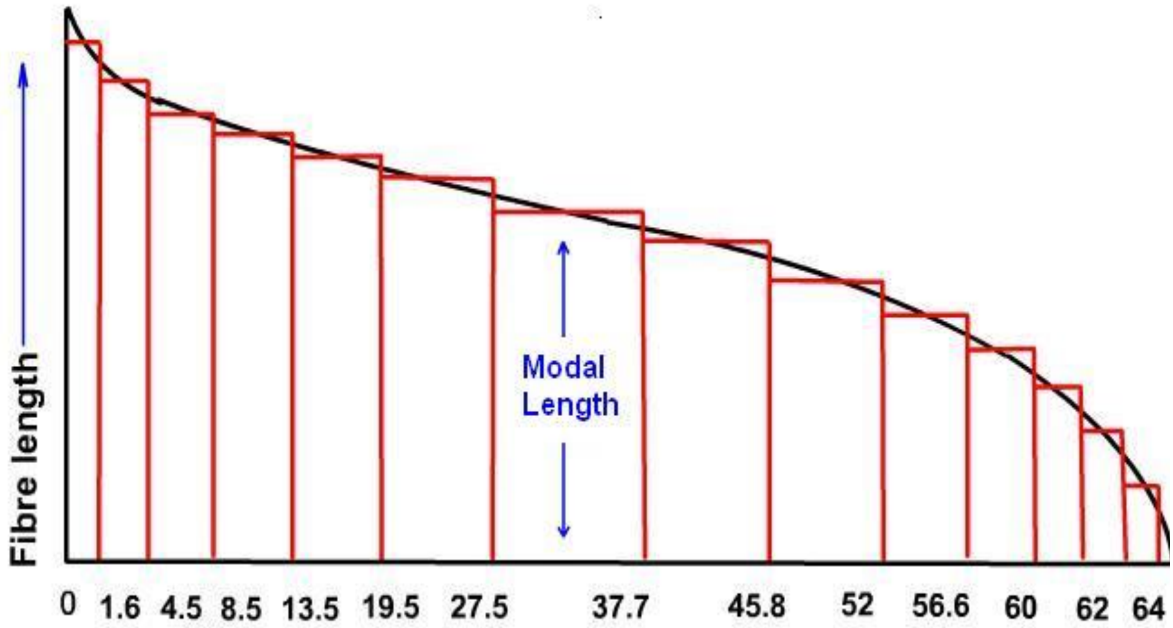
LL′ = Effective length (because many m/c settings are related with this length)

LL′-MM′ = NL′=Inter-quartile range

Dispersion% = NL′/LL′

(For flatter middle zone, dispersion is minimum)

Frequency distribution in opposite way, i.e. the curve is known but the frequency distribution is to be obtained.



Mean length (x 1/8) in. = (Sum of base line readings / Base line length)

= (453.2 / 64) = 7.1

Mean length (x 1/32 in.) = 4 x 7.1 = 28.4

Comb sorter diagram analysis:

Staple length US'' + 3/32'' = EL'' (34/32'' - 39/32'')

Staple length US''+ 1/8'' = EL'' (longer cotton)

Staple length US'' + 1/16'' = EL'' (shorter cotton)

Staple length US'' = 0.91 × EL''

Staple length Uk''- 1/32'' = EL'' (long staple)

Staple length Uk'' + 1/32'' = EL'' (medium staple)

"Effective length is a characteristic of the bulk of the longer fibres".

(C) Single fibre length measurement:

Each fibre is taken separately and gently straightened over the slide and length is recorded.

(Tedious and time consuming; not used in mill practice, used where number of fibres are small).

(D) Length measurement by weighing method:

After combing, the fibres are placed on a velvet pad.

Then ranked into groups so that length range in each group is 1/8''.

Groups are then weighed on a sensitive balance.

Mean length =$\Sigma WL / \Sigma W$

where L = Group length

W = Mass of fibre in length group

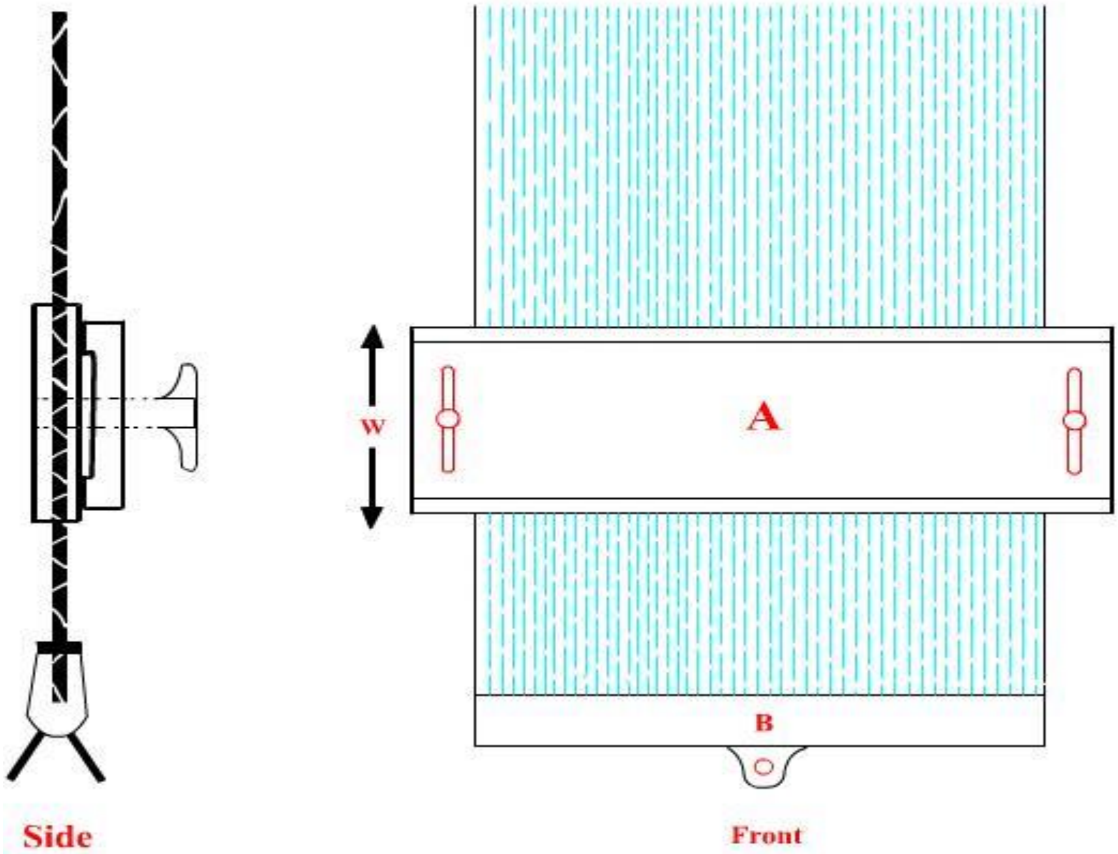
Upper Quartile Length (1/4 th of the fibres by mass is longer than that length).

(E) Clamped tuft method (Weighing method):

- Clamping.
- Combining to remove loose un gripped fibres.
- The protruding tufts are cut from edge of the clamp and weighed.
- The clamps then opened and fibres in side clamps are weighed separately.

Mean fibre length / Total mass = (W x Total mass of combed tuft) / mass of clamped fibre

where **W** is the width of clamp



(F) Thickness gauging method (Uster stapler):

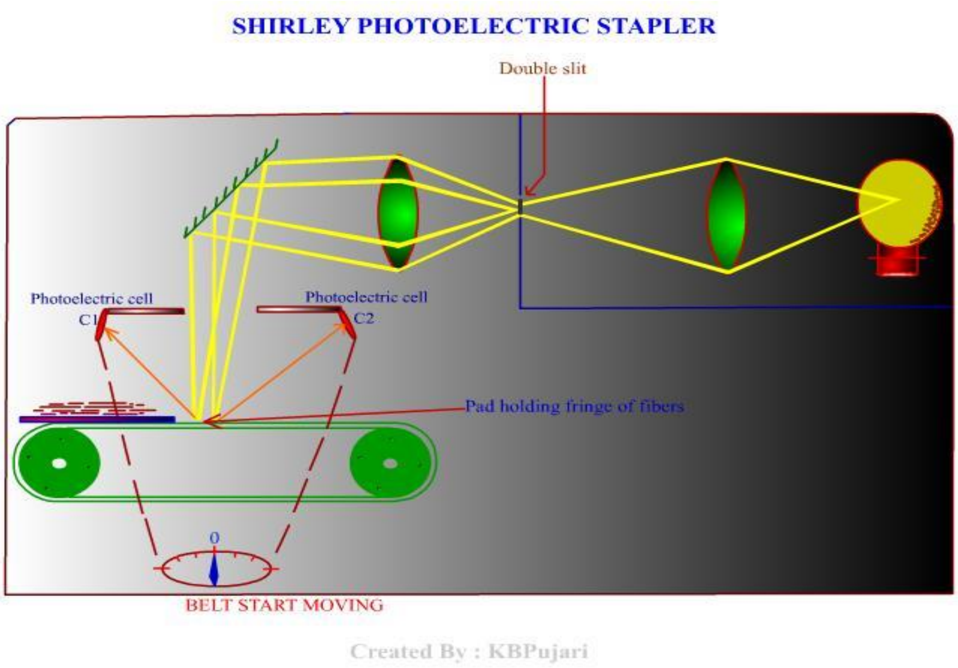
It is designed to reduce the time taken to produce sorter diagram and, at the same time, eliminate some operator errors by the use of mechanized fibre control systems

Draw frame sliver may be used and has the advantage of well mixed fibres

Where the raw cotton is used a sample between 10 and 30mg is prepared as described for bear sorter apparatus.

(G) Shirley photoelectric stapler:

- **For quicker measurement of length (staple length).**
- **Objective measuring technique of earlier staple length measuring method. (Classer judges by eye).**



Click on Image to run the animation

- **Fringes of fibre are prepared by hand and carefully placed over black velvet pad (The density of the fringe should be such that traces of the black velvet can be seen through central part where density is highest).**

- **The photoelectric stapler detects the distance between where the density gradient are maximum (on either side).**

- **Two photoelectric cells connected opposition to each other**

- **Depending on light intensity, the opposed cells pass a current, which is proportional to the difference in the intensity.**

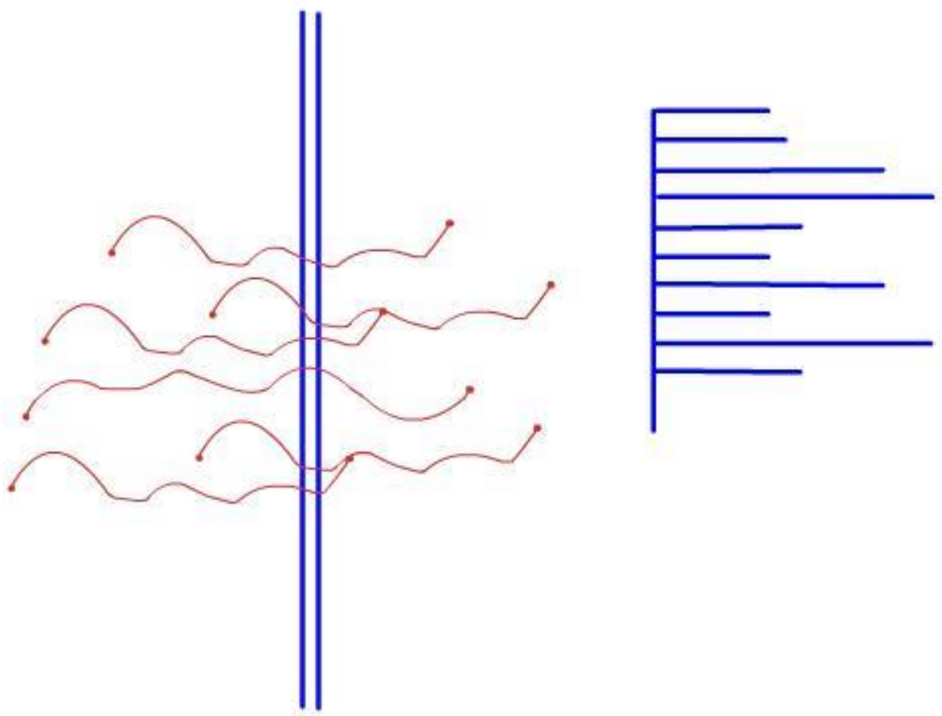
- **Variation in current is shown in sensitive galvanometer.**

- **As the fringe is advanced inside the instrument, two maximum density gradient point will be there and this distance is "staple length" (max. deflection of galvanometer in opposite direction)**

E.L. = P. E. Staple length × 1.1

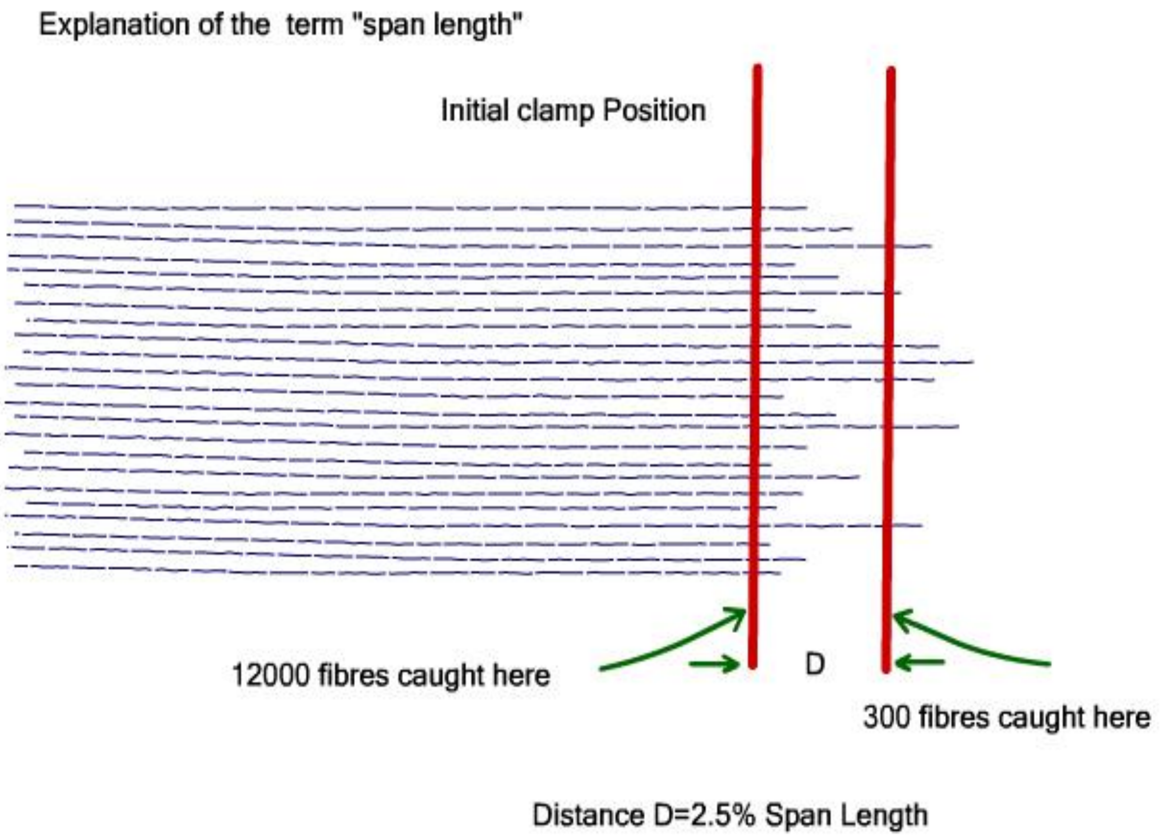
(H) Photoelectric method (Fibro graph):

- Optical method of measuring the density along the length of a tuft of parallel fibres.
- Samples are prepared by "fibro sampler".



Assumptions:

I. A fibre is caught on the comb in proportion to its length as compared with the total length of all fibres in the sample (longer fibres has greater chance)



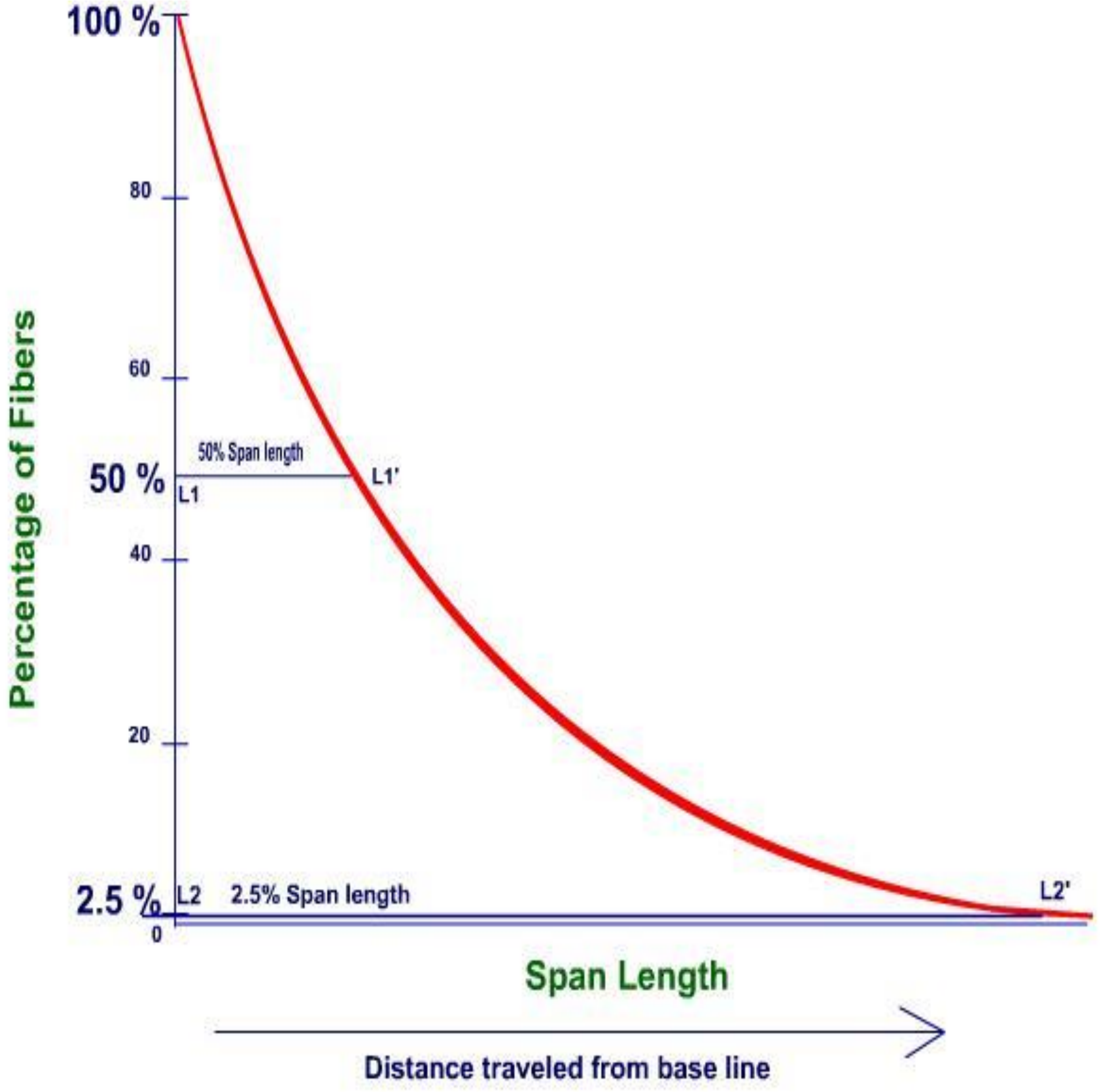
II. The point where it is caught is at random along its length.

Distance traveled from base line

Floating fibre (%) = [2.5%SL / L – 0.975} × 100

U.R. = (50%SL / 2.5% SL) × 100 **[apprx. 40-50% for normal cotton]**

Where L = avg. length of fibre



Influence of Fibre Fineness and Maturity on spinning Process

(1) Fibre Fineness:

Minimum 30 fibres are needed; usually over 100 fibres are required.

Fibre fineness influences spinning limit, drape of the fabric, yarn strength, lustre, yarn evenness, handle, yarn fullness and productivity.

- Productivity is influenced by reduced end breakage rate.

- Fibre fineness determines how many fibres are present in the cross section of a yarn of given thickness.

- Additional fibres in the cross section not only provide additional strength but also a better distribution in the yarn.

In a conventional spinning process, fine fibers accumulate to the core and coarse fibers in the periphery.

Fiber fineness is measured in dtex which is equal to ratio of mass in grams and length in 10 km. Decitex is equal to the product of Micronaire value of the cotton and 0.394.

Cotton fibers are generally classified as very fine if they have a micronaire value upto 3.1;

- Fine if they have value between 3.1 to 3.9;

- Medium if they have value between 4.0 to 4.9;

- Slightly coarse between values of 5 to 5.9 and

- Coarse if they have a micronaire value above 6.

Fibre Maturity:

- Cotton fiber consists of cell wall and lumen.

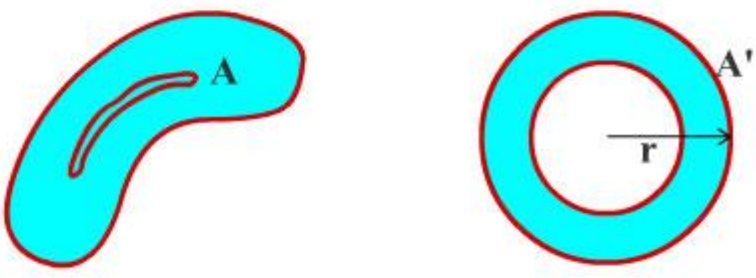
- The maturity index depends upon the thickness of the cell wall.

- 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.

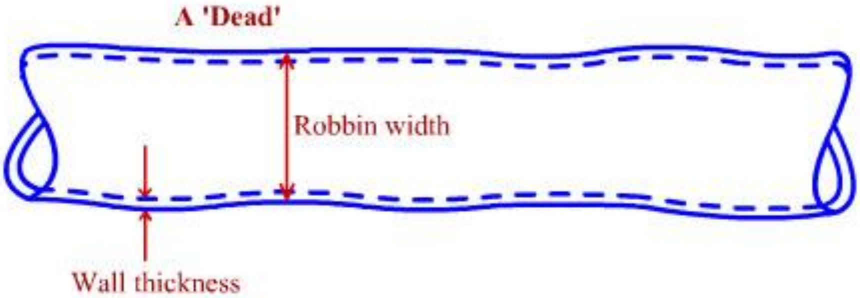
After sorter diagram test tufts of cotton are left on the velvet pad. Each tuft is laid on a microscope slide. the fibres are parellel but separated, and a cover slip put over the middle.

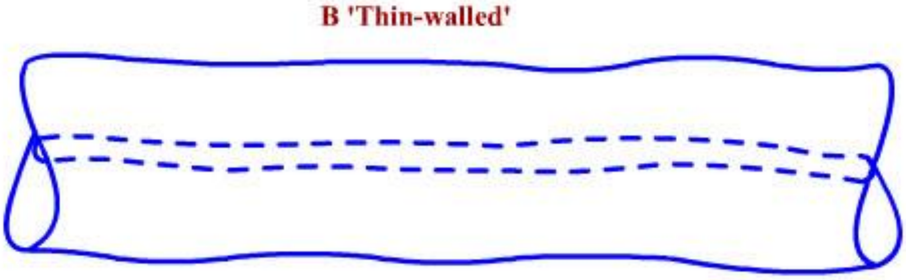
The fibres are then irrigated with a small amount of 18% caustic soda solution which has the effect of swelling them. After the fibers should be observed under projection microscope. This enables the fibers to be classified into three groups:

(1) Normal fibers (N): mature fibres with a well-developed cell wall cotton fibre become rod-l 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 d





- 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 $M = [(N-D)/200] + 0.7$

- 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.

Fibre fineness:

- Fibre fineness is another important quality characteristic which plays a prominent part in determining the spinning value of cottons.
- If the same count of yarn is spun from two varieties of cotton, the yarn spun from the variety having finer fibres will have a larger number of fibres in its cross section and hence it will be more even and strong than that spun from the sample with coarser fibres.
- Fineness denotes the size of the cross-section dimensions of the fibre.
- As the cross-sectional features of cotton fibres are irregular, direct determination of the area of cross-section is difficult and laborious.
- The Index of fineness which is more commonly used is the linear density or weight per unit length of the fibre.
- The unit in which this quantity is expressed varies in different parts of the world.
- The common unit used by many countries for cotton is micro grams per inch and the various air-flow instruments developed for measuring fibre fineness are calibrated in this unit.

Following are some methods of determining fibre fineness

- Gravimetric or dimensional measurements.
- Air-flow method.
- Vibrating string method.

Some of the above methods are applicable to single fibres while the majority of them deal with a mass of fibres.

As there is considerable variation in the linear density from fibre to fibre, even amongst fibres of the same seed, single fibre methods are time-consuming and laborious as a large number of fibres have to be tested to get a fairly reliable average value.

It should be pointed out here that most of the fineness determinations are likely to be affected by fibre maturity, which is another important characteristic of cotton fibres.

How small or large the diameter of a fibre is?

- If a given count is spun from a fine or a coarse fibre, a more uniform and a stronger yarn will result from the fine fibre.
- A finer fibre can be spun to finer count yarn than a coarse fibre.

Measurement of fibre fineness cannot be done by measuring the diameter (except for some fibres) because

- Cross sections of most of the fibres are not circular.
- Variation in the diameter along the length is very high (for natural fibres).
- The cross section shape of the fibres within a sample may not be uniform.

So, the most convenient way of expressing fibre fineness is by measuring the weight of a known length of fibre, i.e. linear density.

Mass = Volume × Density

= Cross-sectional area × length × Density

So, Mass/length a Cross sectional area

- Tex = mass in gms of 1000 mts of yarn
- Decitex = mass in gms of 10000 mts of fibre/yarn
- Denier = mass in gms of 9000 mts of fibre/yarn
- Micronaire = mass in µgms of 1 inch of fibre (for cotton)

Decitex = $10^{-2} \times \rho \times ((\pi \times d^2)/4) = 7.85 \times 10^{-3} \times \rho \times d^2$

ρ = density in gm/cc, d = diameter in µm

Methods of Measurement

a) Gravimetric method (Cotton):

- From comb sorter diagram, fibre tufts are taken and at spacing of 1 cm tufts sections are sliced out with th

- 100 fibres are counted and weighed on a sensitive micro-balance.
- Convert into mass/length.

b) Gravimetric method (for wool):

- Wool has almost circular cross-section.
- After completing a fibre length test the fibres are collected and thoroughly cleared of oil, allowed to conditi on microbalance.
- The total fibre length is calculated and knowing the number of fibres weight/unit length is derived.

Mean Wt/unit length = W / Σhn

where, h = the class length (cm)

n = number of fibres in each class

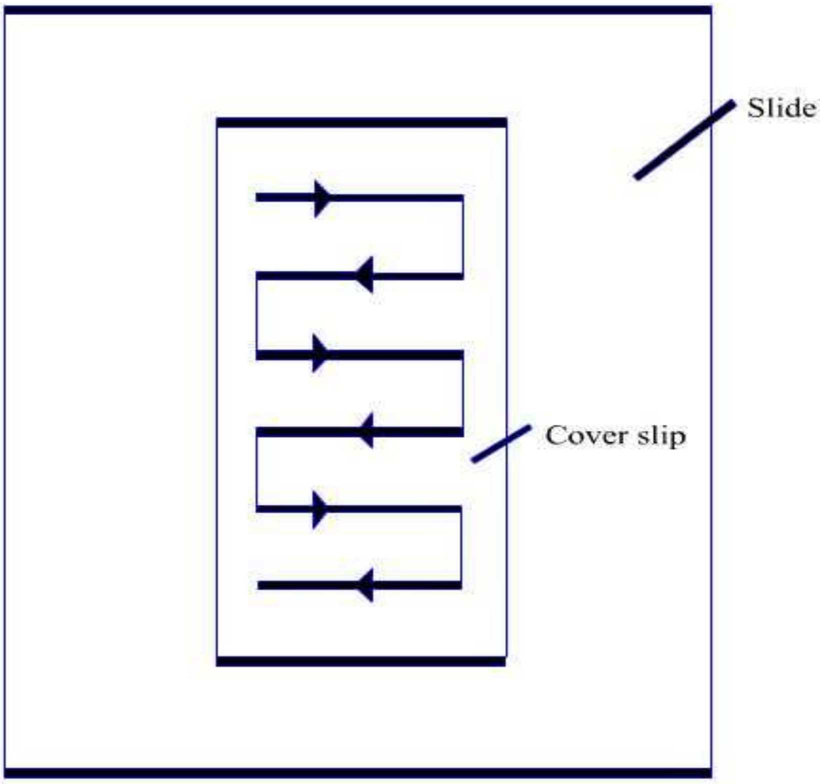
W = total wt of all the classes (mg)

d_{grav} (microns) = $\sqrt{(97190 \times W / \Sigma hn)}$

Assuming wool cross section is circular and density of wool is 1.31 g/cc

c) By microscope:

- Applicable to the fibres with circular cross section.
- A suitable random and representative sample is conditioned for 24 hrs in standard testing atmosphere.
- Fibres are cut into suitable small length and slide is prepared by carefully mixing the fibres into mountant.



The path taken when viewing a projection microscope slide

- The mounting agent should be non-swelling and have a suitable refractive index (liquid paraffin) [should not

- The mixture of fibres and mount is spread thinly on the slide and covered with a cover glass.

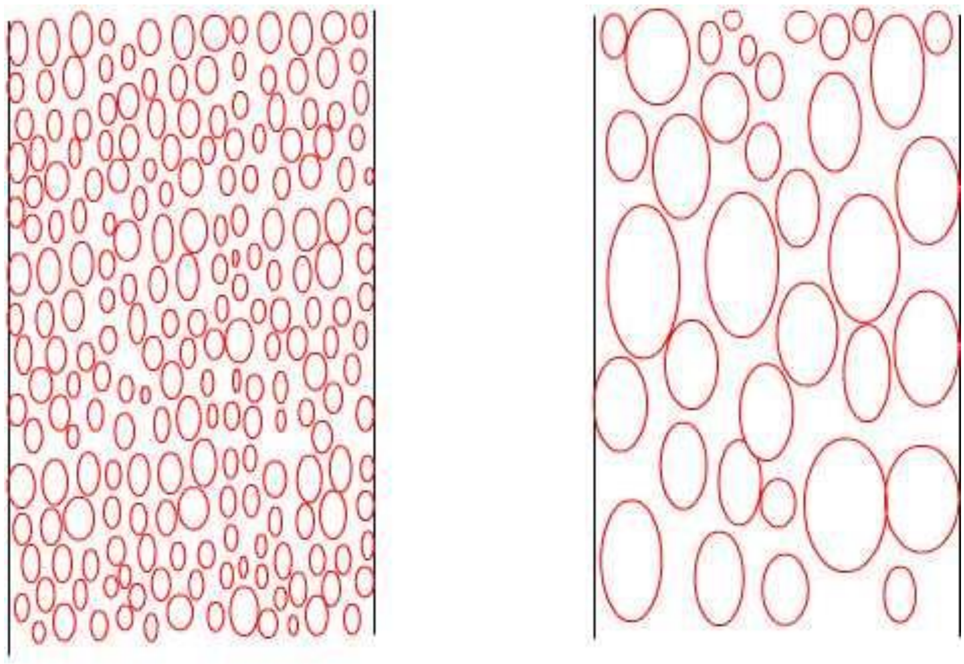
- The slide is traversed in zigzag fashion, to cover all the fibres randomly.

d) *By air-flow method:*

AIR-FLOW METHOD (MICRONAIRE INSTRUMENT):

- The resistance offered to the flow of air through a plug of fibres is dependent upon the specific surface are

- Fineness tester has been evolved on this principle for determining fineness of cotton.

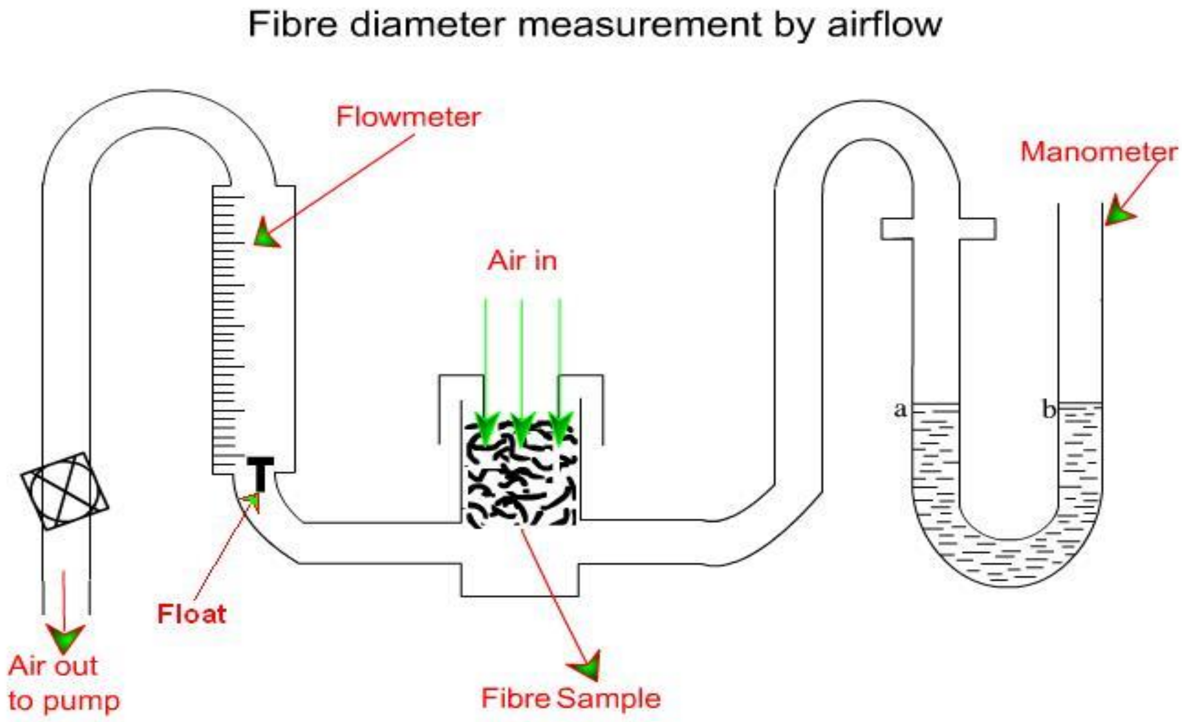

(a)　　　　(b)

Air flow through coarse and fine fibres

- The specific surface area which determines the flow of air through a cotton plug, is dependent not only upo the fibres in the sample but also upon their maturity.

- Hence the micronaire readings have to be treated with caution particularly when testing samples varying w

In the micronaire instrument, a weighed quantity of 3.24gram of well opened cotton sample is compressed into a fixed dimensions. Compressed air is forced through the sample, at a definite pressure and the volume-rate of flow rotometer type flow meter. The sample for Micronaire test should be well opened cleaned and thoroughly mixed (opening method). Out of the various air-flow instruments, the Micronaire is robust in construction, easy to operat difficulty as regards its maintenance.



- Suitable for mill practice due to its speed of measurement

- Air flow at a given pressure difference through a uniformly distributed mass of fibres is determined by the fibres (*Drag on water by river bank*).

- For a constant mass of fibre (i.e. the actual volume) the air flow is inversely proportional to the specific su

(*Air flow* α *1/s*)

$$\text{Specific surface area (s)} = \frac{\pi d l}{\pi d^2/4 \times l} \quad \alpha \quad \frac{1}{d}$$

By measuring the rate of air flow under controlled conditions, the specific surface area (s) of fibre can be determ fibre diameter (also the fibre weight/unit length)

Two types

a) Measurement of air flow at a constant pressure drop.

b) Measurement of pressure drop at a constant air flow.

e) OFDA (Optical Fibre Diameter Analysis):

- Automates the conventional projection microscope system

- Microscope stage moves with the help of two computer controlled stepper motor (X-Y scan of slide)

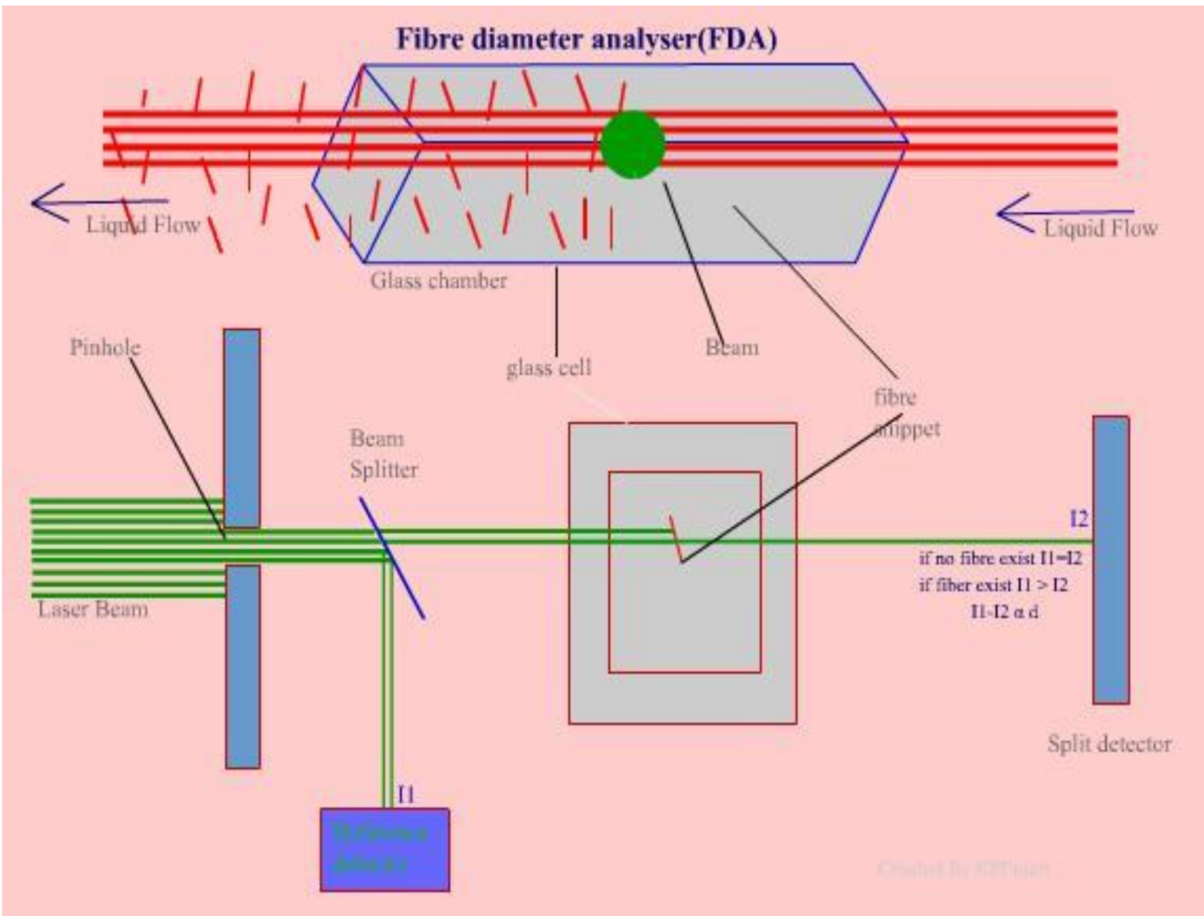
- Image is controlled with a video camera and digitized by frame grabber board with a 256×256 pixel matr

- The fibre diameter is then measured with the help of pattern recognition software, which identifies and m resolution of up to about 1 micrometer.

f) Light scattering method (FDA: Fibre Diameter Analyzer):

- It is a non-microscopically method of measuring fibre diameter and operates by light scattering.
- The fibre (cut into snippets 1.8mm long) and suspended in *Isopropanol* (to give a slurry) are caused to intersect a circular beam of light in a plane at right angles to the direction of the beam (not greater than 200 micrometer dia).
- The intensity of scattered light is proportional to the projected area of fibre, i.e. diameter.

Click on Image to run the animation



- Only fibres that completely cross the beam are recorded, so that the scattered light pulse is then proportional to the fibre diameter.
- The flow rate and concentration of the slurry are such that fibre intersect the beam one at a time.
- The snippets which do not fully intersect the beam are rejected.

- Capable of measuring 50 fibres per second.
- The beam diameter is maximum 200 micrometer to reduce the effect of any curvature due to fibre crimp

TENSILE TESTING

Importance of Testing:

To know the level of strength provided by fibers, yarns or fabric :

a) For Industrial and Technical products - It is very important to know the strength in products likes, industrial rope,conveyor belt, etc.

b) For household or apparel use - Merely need an adequate strength in order to withstand handling during production and use.

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.
- Elongation denotes elongation percentage of fibre at break.

Factors affecting the strength of fibres:

- Molecular structure
- No. and intensity of weak places
- Coarseness or fineness of fibre
- Relative humidity
- Elasticity

Fibre strength is determined by either testing individual fibres or group of fibres.

Manmade fibres are usually tested for their individual strength as there is very less variation in length and fineness the fibres. Natural fibres are tested for their bundle strength due to high variation in terms of length and fineness.

Bundle fibre strength testing:

A bunch of fibres are put in to two jaws. The jaws are moved until the fibres break. The breaking load and elongation at break are noted

$$\text{Tensile strength / Tenacity of the fibre in g/tex} = \frac{\text{Breaking load in kg} \times \text{Length of sample in mm}}{\text{mass of the fibres in mg}}$$

Bundle strength of cotton:

- The “Stelo”meter – the name coined from strength and elongation which functions on pendulum lever principle.
- Pressley fibre strength tester - functions on pivoted beam balance principle.
- Uster spin lab High Volume Instrument

ERMINOLOGY AND DEFINITIONS:

1) Load:

- The application of a load to a specimen in its axial direction causes a tension to be developed in the specimen.

- The load is usually expressed in *grams* or *pounds*.

2) Breaking Load/Breaking Strength:

- This is the load at which the specimen breaks.
- It is usually expressed in *grams* or *pounds*.

3) Stress: It is the ratio between the force and the area of cross-sectional of the specimen.

i.e., Stress = Force applied / Area of cross section

- But in case of textile material, only for circular materials, it can be measured.
- Cross section of yarns and fabrics, due to unknown packing characteristics the exact cross-sectional area is very difficult to measure.
- Also the cross-section of yarns, fibers or fabrics are irregular.

4) Specific/Mass Stress:

- In case of textile material the linear density is used instead of the cross sectional area.
- It also allows the strength of yarns of different linear densities to be compared.

Specific stress = Force/Linear density (initial)

The preferred units are *N/tex* or *mN/tex*, other units which are found in the industry are *gf/denier* and *cN/dtex.*

5) Tenacity or Specific Strength:

- The tenacity of material is the mass stress at break.
- It is defined as the specific stress corresponding with the maximum force on a force/extension curve.
- The nominal denier or tex of the yarn or fibre is the figure used in the calculation; no allowance is made for any thinning of the specimen as it elongates.
- Units are grams/denier or grams/tex.

6) Breaking Length:

- Breaking length is an older measure of tenacity.
- It is the theoretical length (in Km) of a specimen of yarn whose weight would exert a force sufficient to break the specimen.
- It is usually measured in kilometres.

e.g. 10 tex yarn breaks at a load of 150grams

∴ Breaking length would be = 15km (RKm)

The numerical value is equal to tenacity in **g/tex (150/10)**

7) Strain:

- When a load is applied to a specimen, a certain amount of stretching takes place.
- The elongation that a specimen undergoes is proportional to its initial length.
- Strain expresses the elongation as a fraction of the original length.

i.e., Strain = Elongation / Initial length

8) Extension percentage:

- This measure is the strain expressed as a percentage rather than a fraction.

i.e., Extension % = Elongation / Initial length

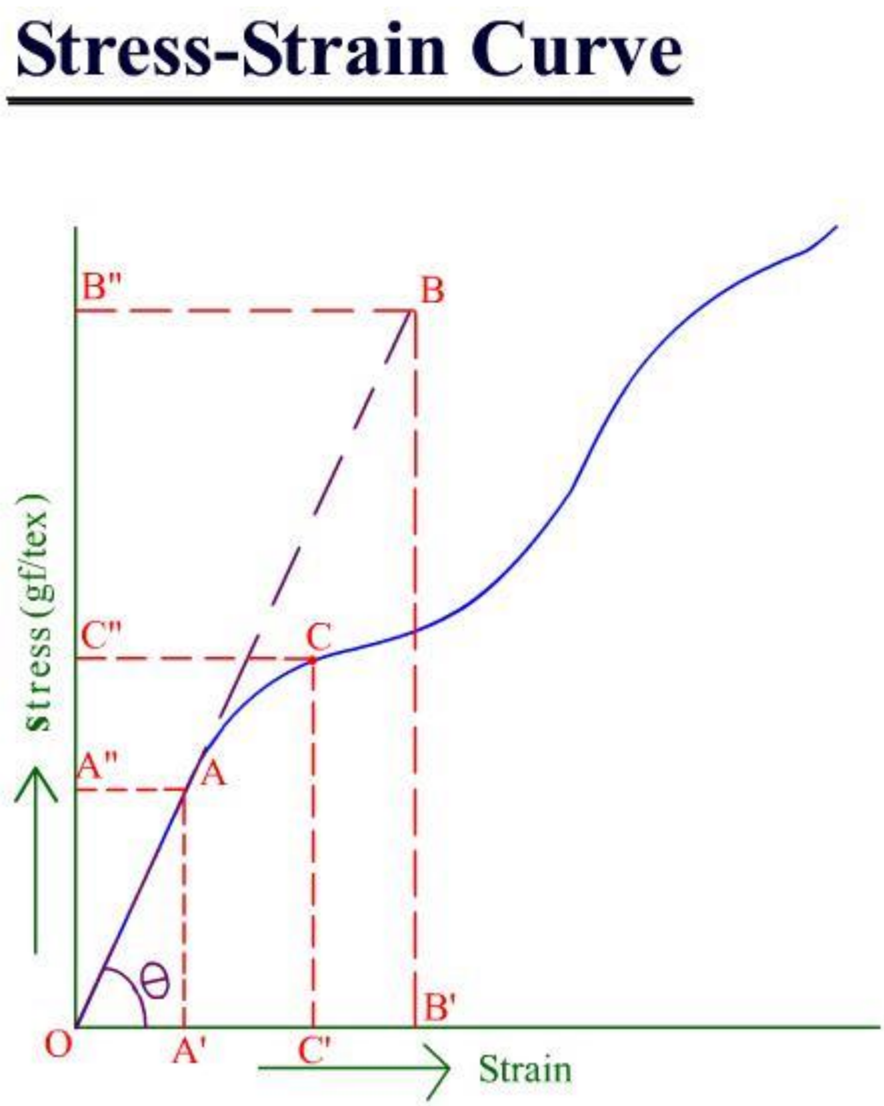
9) Breaking extension:

- Breaking extension is the extension percentage at the breaking point.

10) Gauge length:

- The gauge length is the original length of that portion of the specimen over which the strain or change of length is determined.

When an external force is applied to any material it is balanced by the internal force developed in the molecular structure of the material.



$$\textit{Initial Modulus} = \tan\theta = \frac{AA'}{AA''} = \frac{BB'}{BB''}$$

Initial Modulus or Initial Young’s Modulus (within Hook’s region)

When an external free is applied it is balanced by internal force developed in the molecular structure of the material

Secant modulus:

Slope of the straight line drawn between zero and a specific point (D), i.e. known strain or stress.

a) OA - Elongation is due to stretching of primary or secondary bonds, totally recoverable, elastic zone.

b) By further increasing the stress, the curve bends sharply at ‘C’, where larger strain at smaller stress - ‘***Yield point***’, *OC*′ - ***Yield strain***,*OC*″ - **Yieldstress**.

After this a plastic flow occurs, breaking of some secondary bonds. Rearrangement of molecules.

c) This rearrangement puts the material in a better position to withstand further stress.

d) The nature of curve varies, depending on the molecular structure of fibre or yarn structure.

e) Work of rupture: Measure of toughness of material. It is the energy of work required to break in specime under the load- Elongation curve (Area of shaded position) (gm. Centimeters)

Work factor > (1/2)

Work factor < (1/2)

It describes the nature of curve numerically

Factors affecting tensile results:

a) Specimen length:

- Breaking strength is the “load to break” at the “weakest” point of a specimen of a specified length.
- For length L_1, the breaking strength S_1 and so on (fig).
- With gauge length OO the breaking strength would be S_1, because S_1 is the weakest point (fig).
- When we test two halves, i.e. OO"^{2} , O"O , we get S_1 and S_2, the average

$$\frac{S_1 + S_2}{2} > S_1$$

- Hence, by testing yarn with shorter gauge length the apparent yarn strength has increased. This effect is known as ‘***weak link effect’***.
- For more irregular yarn, the “effect” is more
- Hence by adjusting gauge length, the test result may be changed (so, standardization of gauge length is important).

For processing point of view, slightly lower average strength with regular yarn is better.

b) Rate of loading and time to break:

- Most textile materials show an increase in breaking strength with increasing rate of extension together wit decrease in extension.
- Due to visco-elastic nature of textile material, they require certain time to respond to the applied stress.
- Different types of textiles (fibres/yarns/fabrics) respond differently depending on the structure.

Peirce's empirical equation

$F_T = F_{10}$ (1.1 - 0.1 log T),   if T > 10, $F_T < F_{10}$

F_T = The breaking load for a time to break of Tsec

F_{10} = The br. Load for a time to break of 10 sec.

$$\frac{F_T}{F_{10}} = 1 + 0.1 - 0.1\log T = 1 + 0.1\,(\log 10 - \log T)$$

$$\frac{F_T - F_{10}}{F_{10}} = 0.1\log\left(\frac{10}{T}\right)$$

If some other standard time than 10 sec is chosen, S sec, then,

$$\frac{F_T - F_S}{F_S} = 0.1\log\left(\frac{S}{T}\right)$$

So standard time to break a specimen has been specified, e.g. (20 ± 3) sec. B.S. (only for CRL, not for CRT)

c) Capacity of machine:

- If a very weak specimen is tested in a machine with very high capacity, the time to break will be short, so optimistic result will be produced.
- Also the break of the specimen should not be at the extreme of the instrument capacity (*1mg in 1ton capa equipment*).

1. Previous history of the specimen:

Specimen have been strained beyond the yield point earlier.

Specimen have been subjected to any chemical treatment before test

d) Effect of humidity and temperature:

- Behaviour of textile material changes with the relative humidity of the atmosphere.
- So standard humidity and temperature is recommended.
- Temperature, although have not much effect, but at very high temperature fibre may be degraded.
- Also at very low temperature fibres may be brittle.

e) Clamping problem:

Jaw slip -----> Too low clamping pressure

Jaw damage ------> Too high clamping pressure

(Module5. Yarn Number system
5.1 Define yarn count & various yarn numbering system. 5.2 Determination yarn count by different tools.)

Yarn Count:

Count is a numerical value, which express the coarseness or fineness (diameter) of the yarn and also indicate the relationship between length and weight (the mass per unit length or the length per unit mass) of that yarn. Yarn count is also called yarn number. Yarn count is a number indicating the length per unit weight of the yarn or weight per unit length.

There are two systems of yarn count or numbering:

1. Direct system
2. Indirect system

In direct system, yarn number is called the linear density of yarn with units of tex, denier and dtex, etc. Similarly, in the indirect system yarn number is called the yarn count with units of Ne, Nm etc.

Following is the detailed explanation of these two systems:

A. Indirect system

It is used for the measurement of length per unit weight of the yarn. In this system, weight is kept constant while length is variable.

In the indirect system, yarn thickness and yarn number are inversely proportional.

The count of yarn expresses the number of length units in one weight per unit. Higher the count, finer the yarn. This system is generally uses for linen (wet spun), cotton fibre, worsted etc.

Indirect system, $N = \frac{w \times L}{W \times l}$

Where,
l indicates the unit length of the system,
L indicates the length of the sample,
w indicates the unit weight of the system,
W indicates the weight of the sample.

The most commonly used indirect numbering systems are

1. English Cotton, Ne

Ne: The English cotton count indicates the weight in lb of material of 840 yds length.

2. Metric system, Nm

Nm: The metric yarn count indicates how many Km of yarn are contained in 1 kg or how many meters of yarn are contained in 1 gram.

B. Direct system

It is used for the measurement of linear density that is the weight per unit length of yarn. In this system yarn length is kept constant and weight is variable.

$$\textbf{Linear density} = \frac{\text{mass}}{\text{length}}$$

In the direct system, yarn thickness and yarn number are directly proportional.

The count of yarn expresses the number of weight per units in one length unit. If higher the count then coarser the yarn. This system is generally used for jute, synthetic fibre, silk fibre etc.

$$\text{Direct yarn count, } N = \frac{W \times l}{w \times L}$$

Where,
N denotes the yarn number or count,
W denotes the weight of the sample,
L denotes the length of the sample,
l denotes the unit length of the system,
w denotes the unit weight of the system.

The most widely used direct numbering systems are:

1. Tex: The system indicates the weight in gram of material of 1 Km length.

2. Denier (Man-Made Fibres) : Weight in grams per 9000 meters of fiber.

3. Grex (Grex = No. of grams / 10,000 m)

Count Conversion System for Textile Yarns

According to the yarn count definition given in British Standards by using following formula you can convert yarn count from one unit to another.

S/L	**From – To**	**Formula**
1	Cotton to Denier	5315 / Cotton Count
2	Denier to **Cotton**	5315 / Denier
3	Cotton to Metric	Cotton Count X 1.69
4	Metric to Cotton	Metric Count / 1.69
5	Denier to Metric	9000 / Denier
6	Metric to Denier	9000 / Metric Count
7	Cotton to Tex	590.5 / Cotton Count
8	Tex to Cotton	590.5 / Tex Count
9	Tex to Metric	1000 / Tex Count
10	Metric to Tex	1000 / Metric Count
11	Tex to Denier	Tex Count x 9
12	Denier to Tex	Denier / 9

	Ne	Nm	Tex	Grex	Denier
Ne=	1×Ne	0.5905×Nm	590.5/Tex	5905/Grex	5315/Den
Nm=	1.693×Ne	1×Nm	1000/Tex	10,000/Grex	9000/Den
Tex=	590.5/Ne	1000/Nm	1×Tex	0.1×Grex	0.111×Den
Grex=	5905/Ne	10,000/Nm	10×Tex	1×Grex	1.111×Den
Denier=	5315/Ne	9000/Nm	9×Tex	0.9×Grex	1×Den

Importance of yarn count:

The main purpose of manufacturing of the yarn is to convert it in to the fabric form. If the yarn is used as it is then there is no so much need of measuring its dimensions, but if it is to be converted in to the fabric form then in order to manufacture the required fabric, the yarn parameters plays vital role.

The fabric construction is varied with respect to its end use. The main important fabric factors deciding its construction are, yarn spacing and yarn thickness. Out of this the yarn spacing can be measured by counting the number of yarns per inch with use of magnifying glass. The yarn thickness i.e. yarn diameter (assuming that the yarn is almost circular in cross section) is not an easy process even by any of the means due to the following problems.

Count in Different System:

1. English System:

The number of hanks 840yds per pound is known as English yarn count.

$$\text{English cotton count, } N = \frac{\text{Length (yds)} \times 1 \text{ pound}}{840\text{yds} \times \text{weight (pound)}}$$

2. Worsted System:

It is defined as the n umber of hanks (560yds) per pound.

$$\text{Worsted count} = \frac{\text{Length (yds)} \times 1 \text{ pound}}{560\text{yds} \times \text{weight (pound)}}$$

3. Metric System:

It is defined as the number of hank (1000m) per kg.

$$\text{Metric count} = \frac{\text{Length (m)} \times 1\text{kg}}{1000\text{m} \times \text{weight (kg)}}$$

4. Tex System:

The weight in grams of 1000m is known as tex count.

Weight (gm) × 1000m

Tex count = ...

1gm × length (m)

5. Pounds per spindle (Jute System):

The yarn number or count in the pounds per spindle system is the weight in pounds of 14400 yards of yarn.

Weight (pound) × 14400 yds

Pounds per spindle,= ....

1pound × length (yds)

6. Denier System:

The number or count in the denier system is weight in grains of 9000m.

Weight (gm) × 9000m

Tex count = ...

1gm × length (m)

Yarn Count Conversion formula:

- Denier = 9 X Tex
- Ne X Denier = 0.5315
- Metric X Tex = 1000
- Tex X Ne = 590.5
- Ne = Metric X 0.5905
- Metric X Denier = 9000
- Tex = 34.45 X lb/ spyndle

Example:

A. 30/1 cotton (1 means single yarn) indices that 30 x 840 yards of yarn weight 1 pound.

B. 40/2 cotton (2 means ply yarn) indicates that 20 (Resultant count) x 840 yards of yarn weight 1 pound.

Questions:

1). English cotton count (Ne) :

The number of hanks 840yds per pound is known as English yarn count.

A yarn having length of 90,000 yards and its weight in 2 pounds calculate its English count.

Answer:

$$\text{English cotton count (Ne)} = \frac{\text{Length in yards}}{840 \text{ x Weight in lbs}}$$

$$Ne = \frac{90,000}{840 \times 2}$$

English cotton count (Ne) = 53.57

2. Worsted count (Nm):
It is defined as the no. of hanks each of 560 yards weighing in one pound of the yarn.

$$\text{Worsted count (Nm)} = \frac{\text{Length in yards}}{560 \times \text{Weight in lbs}}$$

Example:

A. 1/20 worsted cotton indicates that 20 × 560 yards of yarn 1 pound.
B. 3/40 worsted cotton indicates that 13.33 (Resultant count) × 560 yards of yarn.

Questions:

A) If 80 yards worsted yarn weighing 50 grains what is count of yarns.

Answer:

$$\text{Worsted count (Nm)} = \frac{\text{Length in yards}}{560 \times \text{Weight in lbs}}$$

$$Nm = \frac{80}{560 \times (50/7000)}$$

Nm = 20.0s

3. Linen count:
Linen count is the numbers of hanks of 300 yards weighing in pound.

$$\text{Linen count} = \frac{\text{Length in yards}}{300 \times \text{Weight in lbs}}$$

Questions:

A) If 240 yards of linen yarn weight 1 oz., what is the count of the yarn.

Answer:

1 lbs. = 16 oz.

$$\text{Linen count} = \frac{\text{Length in yards}}{300 \times \text{Weight in lbs}}$$

$$\text{Linen count} = \frac{240}{300 \times (1/16)}$$

Linen count = 12.8

4. Woolen Count (Yorkshire count):
Woolen count (Yorkshire count) is the number denoting number of hanks each of 256 yards weighing in one pound (lbs.).

$$\text{Woolen count} = \frac{\text{No. of hanks of 256 yards}}{\text{Weight in pound (lbs)}}$$

$$\text{Woolen count} = \frac{\text{Length in yards}}{256 \times \text{Weight in lbs}}$$

Questions:

A) The weight of 786 yards of woolen yarn is ¼ lb., what is the count of yarn.

$$\text{Woolen count} = \frac{\text{Length in yards}}{256 \times \text{Weight in lbs}}$$

$$\text{Woolen count} = \frac{768}{256 \times (1/4)}$$

Woolen count = 12s

5. French Cotton Count:
It is defined as number of hanks each of 1000 meters weighing in ½ kg.

$$\text{French count (NF)} = \frac{\text{Length in meter} \times 2}{1000 \times \text{Weight in kg}}$$

6. Metric count (Nm):
It is defined as number of hank's each of 1000 m weighing in 1 kg.

$$\text{Metric count (Nm)} = \frac{\text{Length in meters}}{1000 \times \text{Weight in kg}}$$

Example:
A. 30 Nm indicates that 30 Kilometers or 30,000 meters of yarn weight 1 kilogram.

Questions:

A) Calculate Metric cotton count of 60000 yards weighing 1.2 pound (lbs.)

Answer:

1 yard = 0.9144 meter
1 kg = 2.202 pounds

$$\text{Metric count (Nm)} = \frac{\text{Length in meters}}{1000 \times \text{Weight in kg}}$$

$$\text{Metric count (Nm)} = \frac{60000 \times 0.9144}{1000 \times (1.2/2.202)}$$

$$\text{Metric count (Nm)} = \frac{54864}{1000 \times 0.5449}$$

Metric count (Nm) = 100.68

Determination of the Yarn Count by Wrap Reel and Analytical Balance

Theory:
Yarn count: The **yarn count** is a numerical expression which defines its fineness or coarseness. It also expresses weather the yarn is thick or thin. A definition is given by the textile institute – "Count is a number which indicates the mass per unit length or the length per unit mass of yarn."

$$\textbf{Cotton Count} = \frac{\text{Length in yard} \times \text{Weight Unit}}{840 \text{ Yard} \times \text{Weight in pound}} \qquad \text{(Equation-01)}$$

Objectives of Experiment:

1. To know about yarn count .
2. To know about wrap reel & analytical balance.
3. To know how to determine the count by wrap reel & analytical balance.

Wrap Reel:
A wrap reel is a device for measuring yarn and making it into hanks of a standard size. The reel is of a standard size and its revolutions are counted as the yarn is wrapped around it. Typically, a set number of revolutions will be used so that the hank is of a standard size — a skein or lea. For example, a skein of cotton would be 80 turns on a reel of 1.5yard circumference, making 120 yards.

Wrap reel are two types on the basis of driving method:

1. Hand Drive
2. Power Drive.

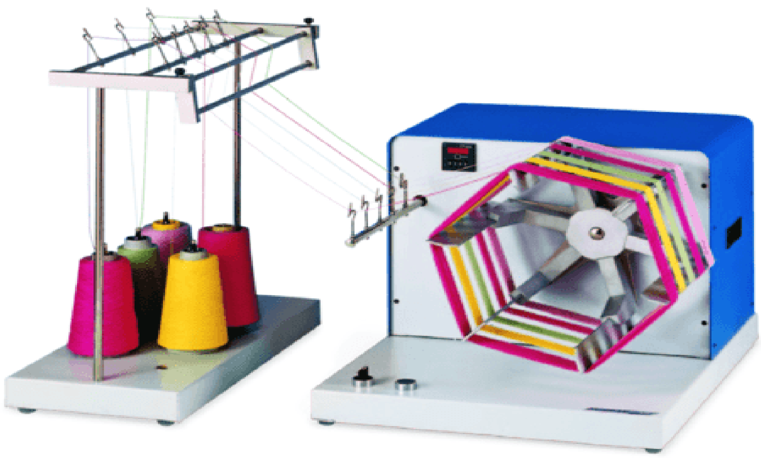


Fig: Motor drive wrap reel

Analytical Balance:
An analytical balance is a class of balance designed to measure small mass in the sub-milligram range.

Fig: Analytical balance

Calculation:

Let the sample wt. be 0.0044lb.

$$\textbf{Count} = \frac{\text{Length in yard} \times \text{Weight Unit}}{840 \text{ Yard} \times \text{Weight in pound}}$$

$$= \frac{120 \times 1}{840 \times 0.0044}$$

$$= 32.46\text{Ne}$$

Yarn Count Determination Procedure:

1. Make lea by Wrap reel.
2. Weight the lee by analytic balance.
3. Convert the weight gram to pound.
4. Now the data are put equation (1)
5. Now calculate the count by the equation.
6. Now average count is calculate which is cotton count of this sample.

Determination of Yarn Count of a Given Fabric by Beesley Balance

It is working on the principle of fixed weight and fixed length system

Objectives:

1. To know about thread count or **yarn count**.
2. To know about template & beesley balance.
3. To know how to determine the thread count by template & beesley balance.

Required Instrument:

1. Template
2. Beesleys Balance
3. Knife
4. Marking pen
5. Needle

Template:
Template is a length measuring instrument which contains eight arms. When a sample has short length (Fabric) which we cannot determine by the wrap reel then we use template by using that we can determine the length.

The following length is used to determine the count:

- Cotton: 4.32 Inch
- ½ cotton: 2.16 Inch

- Linen: 1.543 Inch
- Wool: 1.315 Inch
- Worsted: 2.88 Inch

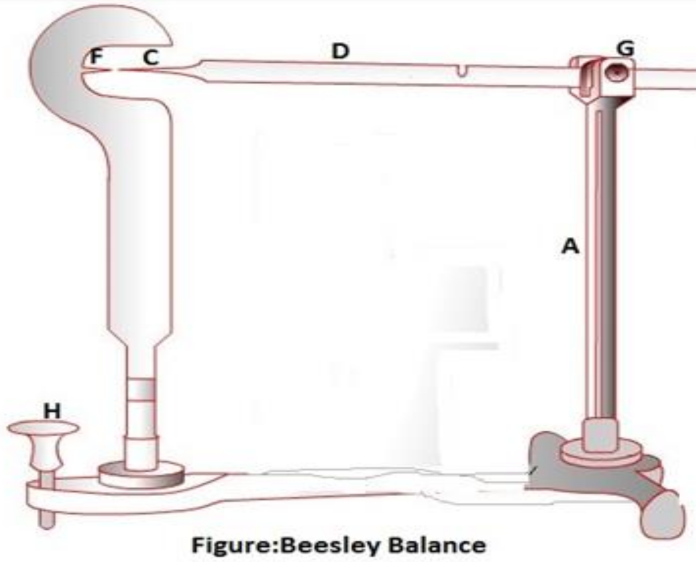


Figure:Beesley Balance

A-Pillar; B-Beam; C-Pointer; D-Notch; E- Sample hook; F-Detam Line; G-Pivot; H-Levelling Screw

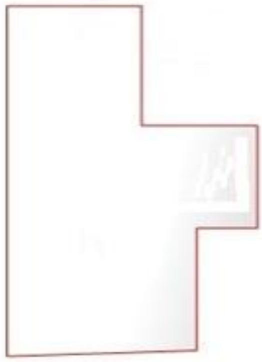


Figure: Templet

Beesleys Balance:

Beesleys yarn balance consists of a pillar A which carries a cross beam B, fulcrumed at knife edge at the point G (See figure in above). At one end the cross beam is a hook E upon which the yarn to be tested can be placed. The other end of the beam tappers to a point C. When the beam is in balance, the pointer will coincide with the detum line. The pillar is mounted on the base. The whole instrument is leveled by a leveled screw at one end of the base. The cross has a small notch at the point D to take the counter weight or rider.

Working Procedure:

1. Collect sample by appropriate sampling method.
2. This Sample conditioning at testing atmosphere.
3. Marked the fabric by using template
4. Cut that's fabric by knife according to the marking.
5. The pointer is set directly opposite to the detum line, with no material and counter weight in their proper places, by adjusting the leveling screw. The counter weight for the particular length which is supplied with the instrument is chosen and suspended at the notch D. (For full cotton the large rider is placed in the notch and for ½ cotton small rider is placed)
6. Now yarn is withdrawn from sample and placed sample hook until the pointer comes in level with the detum line.
7. At that stage the threads are taken out and counted which givers directly the cont of yarn teken for testing.
8. If there are 30 threads in the sample hook at the balanced condition so the count of the yarn is 30