Chapter -two

Cotton Fiber Property testing

❖ The important cotton fiber properties in the spinning are:

- ✓Length & length uniformity
- ✓Short fiber content
- ✓Fineness or micronaire
- ✓Strength
- ✓Color
- ✓Trash
- ✓Neps
- ✓Maturity /Dye- ability

❖ These fiber properties vary in importance according to the spinning system in use

Table.. Importance of various Fiber Properties for Different Spinning Systems

Ring Spinning	OE-rotor spinning	Air Jet spinning	Friction Spinning
1. Length & length uniformity	1.strength	1.finennes	1. Fiber to fiber friction
2. Strength	2.fineness	2. Maturity	2. Strength
3. Fineness	3. Length & length uniformity	3. strength	3. Fineness
	4. Trash & Dust content	4. . Length & length uniformity	4. Length & length uniformity
		5. Fiber to fiber friction	5.Trash Content

Fiber Fineness /Micronaire testing

✓ The fiber fineness has a number of effects on the properties of the yarn and hence the fabric that is made from it.

✓ The finer the fiber, the finer is the yarn that can be spun

As the yarn becomes thinner, the number of fibers in its cross-section decreases and the yarn becomes increasingly ***uneven .*** because the presence or absence of a single fiber has a greater effect on the yarn diameter.

✓ If all other properties are held constant ,finer fibers will produce stronger yarn than course fibers.

❖ The most important effect of fiber fineness is on the fiber stiffness. This is because the rigidity of a fiber increases with the fourth power of the fiber diameter so that a coarser fiber is a great deal stiffer.

✓ The stiffness of the fibre affects the stiffness of the fabric made from it and hence the way it drapes and how soft it feels.

Therefore fineness is a prime consideration in choosing fibers for yarn.

✓Cotton fiber is a ribbon -like tube with a hole(lumen) in its center.

✓Low micronaire fibers may cause neps in yarn & fabric

❖ If they are mature, they may be strong; truly fine & very desirable. If however, they are not mature, they may be weak and not desirable ultimately causing yarn & fabric dyeing problems.

✓ Cotton fineness can be defined in various ways:

- Perimeter;
- Diameter;
- Area of cross-section;
- Mass-per unit length;
- Surface area.

Fibre fineness measuring instruments

✓ For practical purpose ,it is necessary to consider only two definitions for cotton fineness :

1. Gravimetric
2. Biological fineness

Gravimetric can be expressed as the ***mass per unit length of fiber***

✓ Biological fineness is either the ***perimeter of the fiber, cross –section*** ,or the **diameter of the section** is assumed to be round

✓ To define “true” cotton fineness ,both perimeter (or preferably total surface area) and cell wall thickness (or total volume of cellulose) must be known

Gravimetric

✓ For a given fiber (that is of a fixed density) its mass is proportional to its cross-sectional area:

Mass of a fiber = cross-sectional area X length X density

✓ Therefore for a known length of fiber its mass will be directly related to its cross-sectional area.

✓ This relationship is made use of in the gravimetric definition of fiber fineness in which the mass of a given length of fiber is used as a measure of its fineness.

✓ This is similar to the system of measuring yarn linear density. The primary unit is tex (g/l000m),

but it is also common to use:

✓Decitex = mass in grams of 10,000 metres of fibre

✓Millitex = mass in milligrams of 1000 metres of fibre

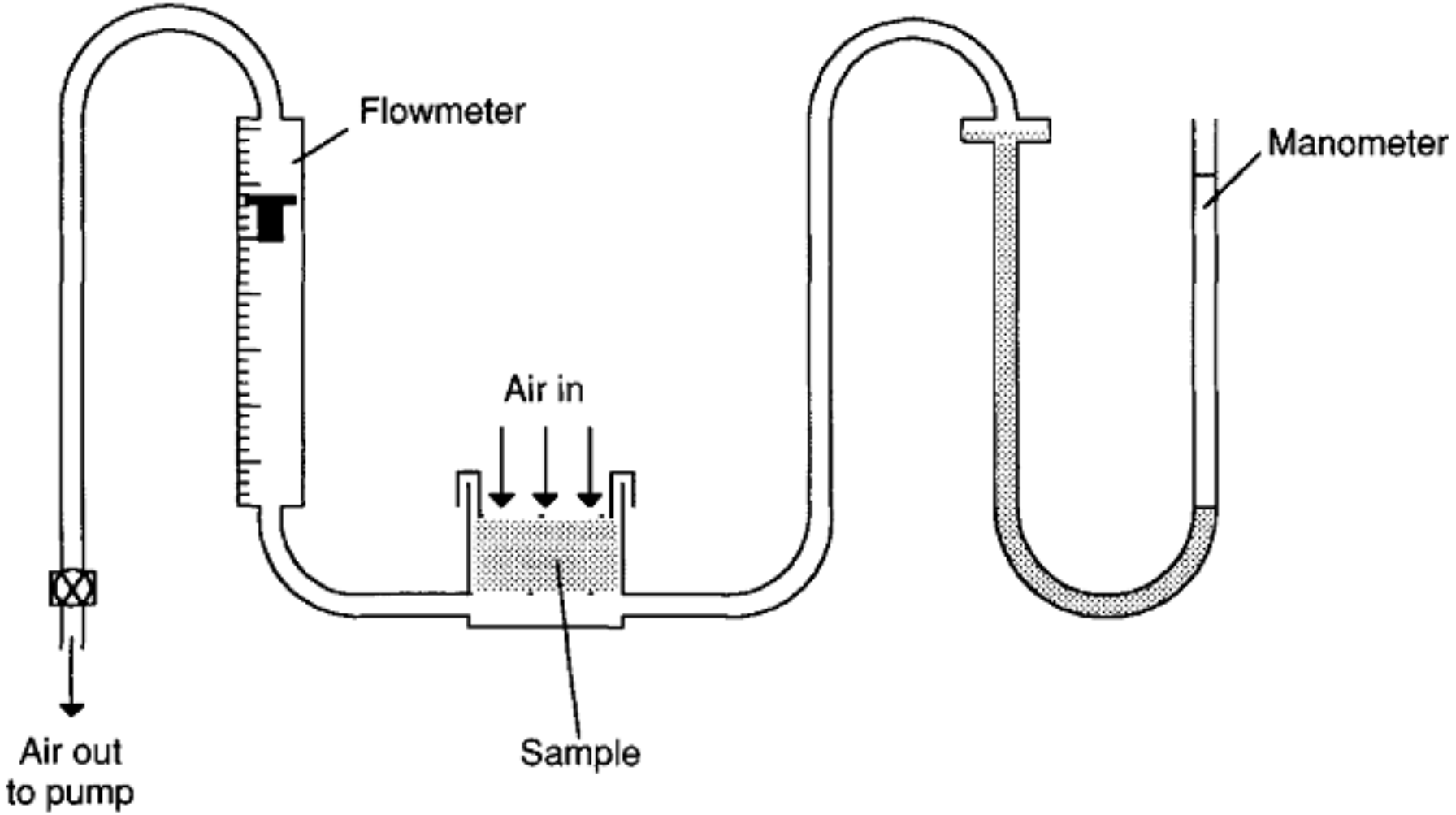
✓Denier = mass in grams of 9000 metres of fibre

Micronaire

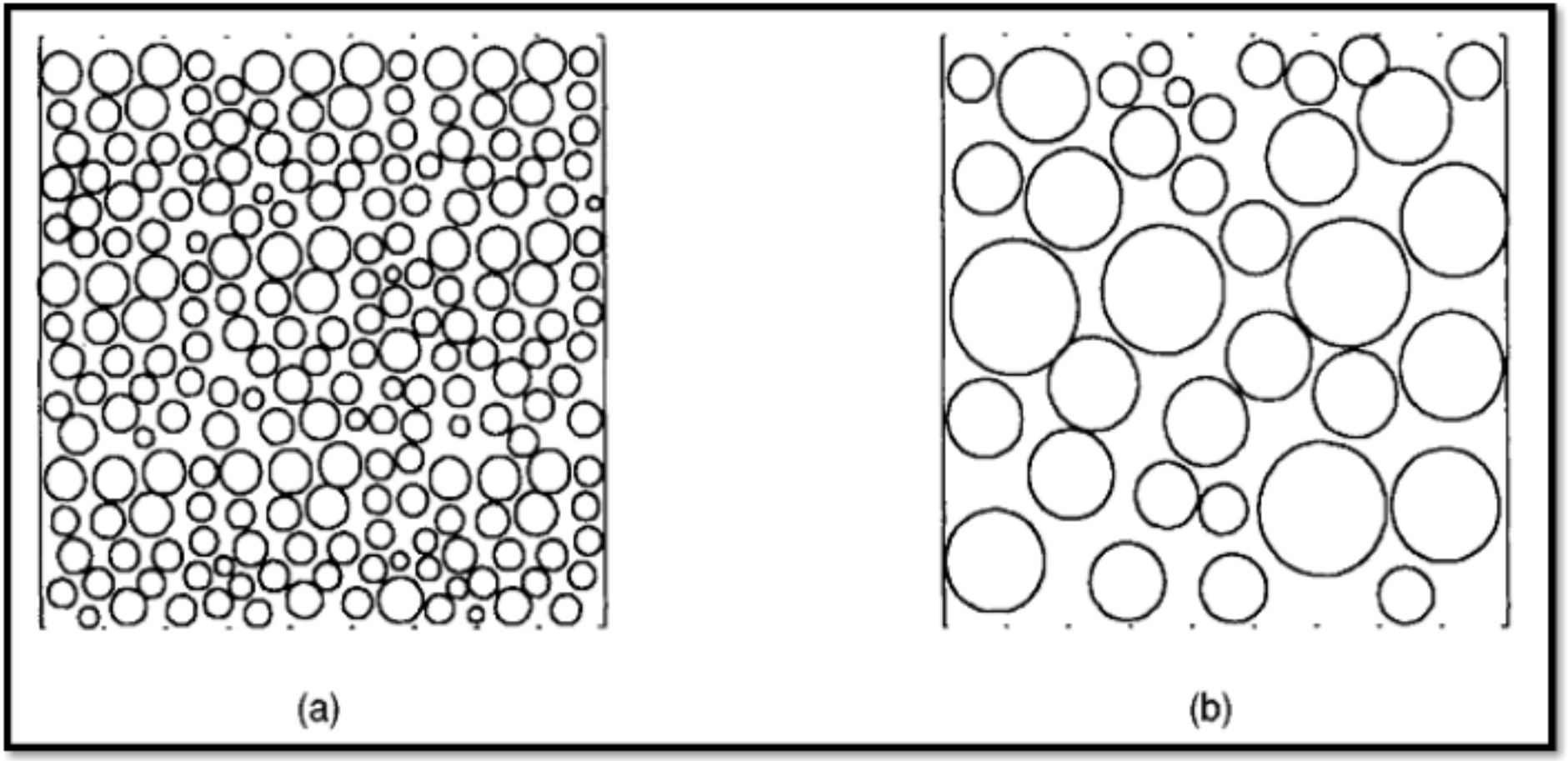
The Micronaire tester is the most widely used instrument to measure surface area of fibers or cotton fineness ,which was introduced in 1964,and consists of an ***air gauge*** to measure air flow through a cotton sample of specified weight w/c is placed in a chamber of fixed dimension

✓ The mocronaire “scale” was originally calibrated by using the measured linear density of group of test cottons.

✓ The instrument readings were assumed to indicate gravimetric fineness in ***micrograms /inch .***



Fig…Fibre diameter measurement by airflow.



Fig…Airflow through coarse and fine fibres.

The Micronaire value ranges from about 3.0 to 6.0

1. Below 3.0 - very fine :possible small perimeter but mature (good fiber) or large perimeter but immature (bad fiber)
2. 3.1- 3.9 -fine : Various degree of maturity and perimeter
3. 4.0- 4.9 -average : average degree of maturity and /or perimeter
4. 5.0- 5.9 – course : usually fully developed (mature) but large perimeter
5. 6+ very course : fully developed ,large perimeter fiber

fiber Maturity testing

- ✓ Fiber maturity is an important character of cotton and is an index of ***developments of the fibers***.
- ✓ The maturity of the cotton fibers varies not only between fibers of different samples but also between fibers on the same seed. Thus a ripened full mature cotton boll contain fibers of both mature and immature.
- ✓ A cotton fiber consists of a cuticle, a primary wall and secondary wall of cellulose surrounding the lumen or the central canal.
- ✓ In the case of mature fiber, the secondary wall thickening is very high and in some cases, the lumen is not visible(**see the**

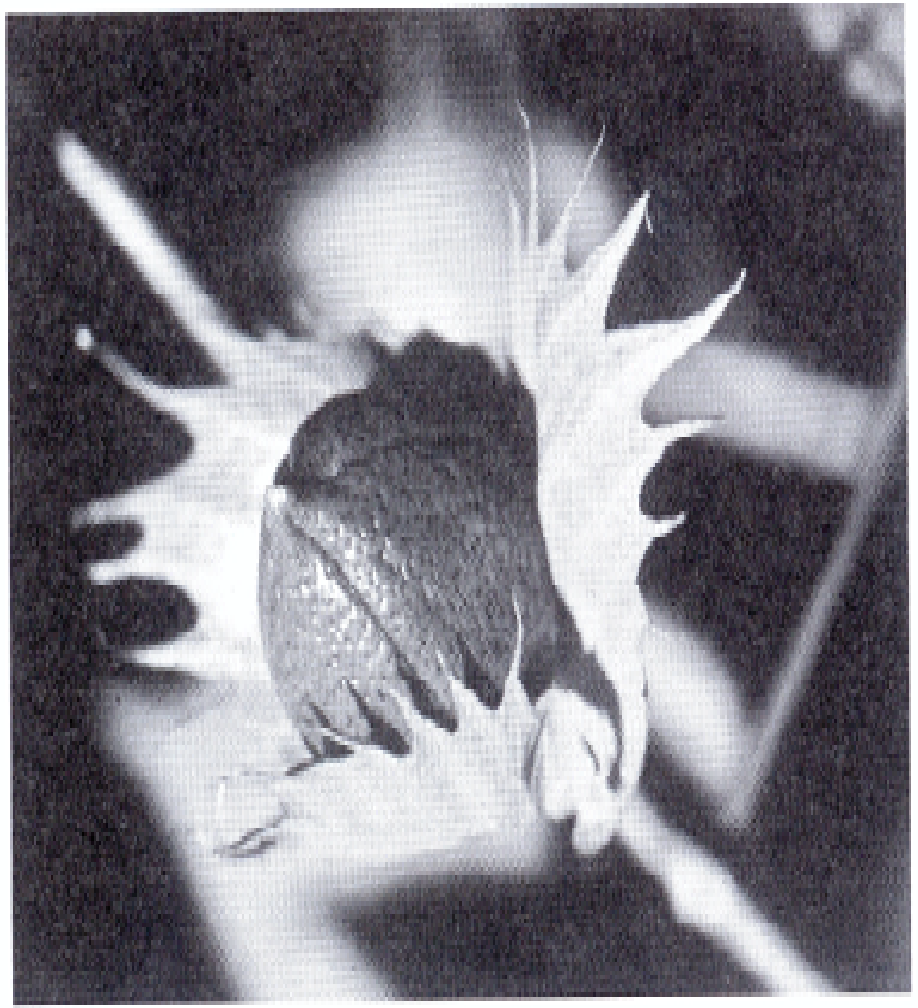


Figure … Cotton pod

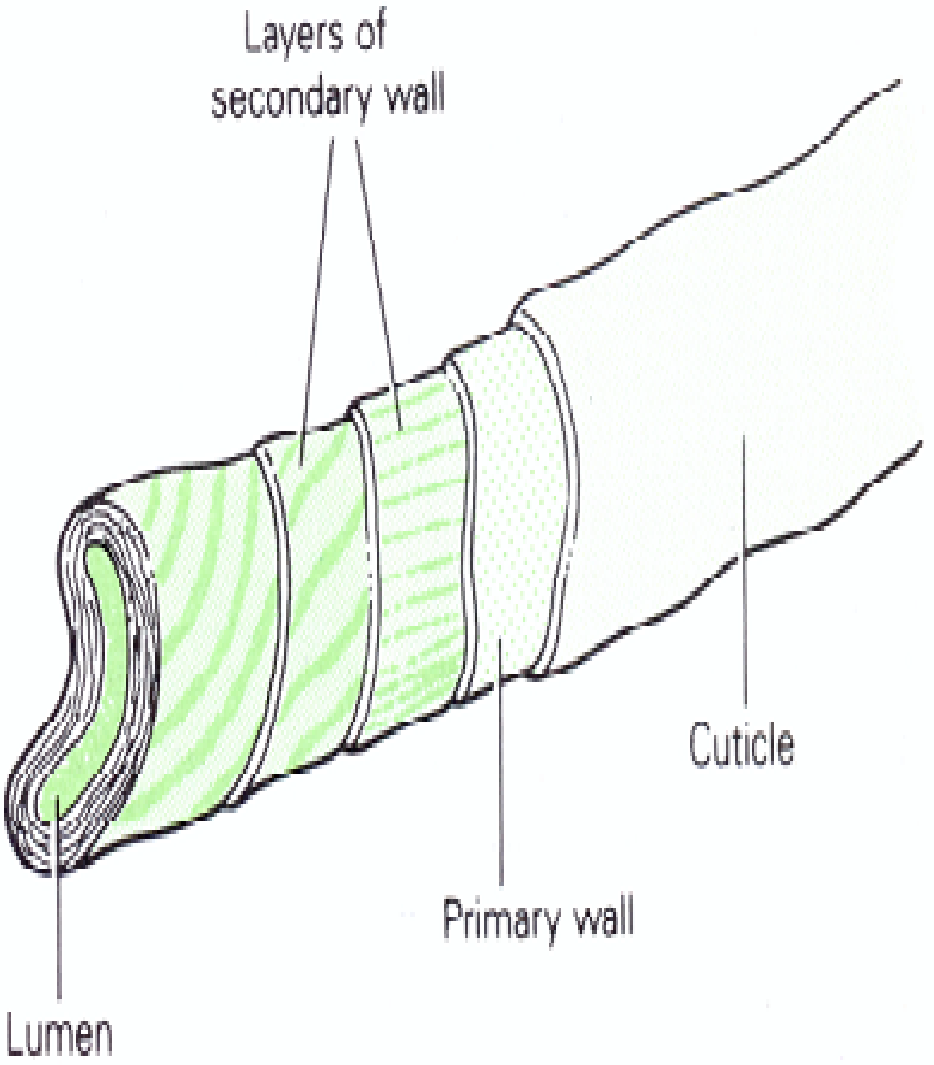


Figure … Cotton Fiber

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- In the case of immature fibers, due to some physiological causes, the secondary wall thickening is practically absent, leaving a wide lumen throughout the fiber.
- Hence to a cotton breeder, the presence of excessive immature fibers in a sample would indicate some defect in plant growth, either variety or environmental.
- To a technologist the presence of excessive percentage of immature fibers in a sample is undesirable as this **causes waste, losses in processing, lowering of the yarn appearance grade due to formation of neps, uneven dyeing etc.**

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- ✓ The determination of the fineness of cotton is affected by maturity of the sample.
- ✓ An immature fiber will show a ***lower weight per unit length*** than mature fiber of the same cotton, as the immature fiber will have less deposition of the cellulose inside the fiber.
- ✓ Hence it is essential to measure the maturity of a cotton sample in addition to the determination of its fineness., to check whether the observed fineness is an inherent varietal characteristic or is a result of immaturity.
- ✓ The maturity of the fiber is concerned with ***development of cell wall.*** The cell wall thickening is highly sensitive to growing conditions. Adverse weather, poor soil plant, plant diseases and pests etc., will increase the proportion of immature fiber and lead to trouble in processing.

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- Troubles caused by the presence of these thin walled immature fibers are :
- Nepping - causes like small bits or fragments of seed particles attached to the fiber forms neps:
  - Neps are created during processing starting at ginning stage.
  - Further when rubbing of substances takes place, as in carding, minute knots of **tangled fibers are caused** and the immature fibers are more prone to this nepping effect.
  - When fine cottons are being processed, the danger of nepping is even more acute, since even the mature fibers are likely to cause neps by faulty processing. In addition, the neps so formed are usually more prominent because of their size relative to the diameter of the yarn

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- ✓ The presence of neps in a yarn will also form weak places and therefore the average strength of the yarn will be reduced.
- ✓ Neps will show up as specks (dots) in the dyed cloth

✓ Immaturity also affects the shade after dyeing.

✓ As the response of the primary wall to certain classes of dyestuffs is less intense, the thinner the secondary wall lighter will be shade.

✓ Hence fine cotton tends to be lighter in shade than coarse cotton.

So summarizing the maturity, the following points are noted.

- ✓ Maturity affects the quality of the yarn and its processing. The effect of the immature fibers are seen especially in the spinning process.
- ✓ The large number of ends downs in a ring frame is due to the immature fibers.
- ✓ The loss in yarn strength, the dyeing troubles are all due to the presence of immature fibers.

Methods of Determination of Maturity

- Several methods are available to determine the maturity of cotton. These can be grouped as below:

1. Direct method - caustic soda swelling method
2. Indirect method
   - ✓ Differential dyeing method
   - ✓ Causticaire method
   - ✓ Polarized light method.

Direct method- Caustic soda swelling method

- It is the most commonly used method. A thin tuft of fibers is drawn by means of tweezers from a silver held in a comb sorter. The tuft is laid on a microscope slide., the fibers parallel and separated and a cover slip is put over the middle. Likewise four to eight slides are prepared. There are two steps involved in this method.

1. Treatment with 18% caustic soda.
2. Examination under a microscope to count the ***mature, half mature and immature fibers.***

- The fibers on the microscope slide are then irrigated with a small amount of 18% caustic soda solution, which has the effect of swelling them.

✓The slide is then placed on the stage of a microscope and examined.

✓The presence or absence of the convolution is observed and the fibers are classified into three groups.

i. Mature or normal fibers.

ii. Half mature or thin walled fibers.

iii. Immature or dead fibers.

✓The presence of caustic soda changes the appearance of both mature and immature fibers by swelling.

- ✓ Mature fibers with a well developed cell wall and pronounced convolutions in the raw state become ***rod like swelling***. These rod like fibers are classified as ***normal or mature fibers***. In the case, the lumen is practically absent.
- ✓ Dead or immature fiber **appear ribbon like even after swelling**. In dead fibers, the wall thickness is less than 1/5th of the ribbon width.
- ✓ ***Thin walled or half mature fibers*** are those lying between the other two classes.
- ✓ The fibers are classed as above based on the ratio of lumen width (L) to wall thickness (W) as indicated below:

Class	**Ratio of lumen width to wall thickness** (L / W)
Mature	Less than 1
Half mature	1 - 2
Immature	Greater than 2

✓ All the slides are examined as above and the percentage of ***mature (N) half mature (H)*** and the ***immature (I)*** fibers are calculated.

✓ Then the maturity of the cotton fiber is expressed by any one of the following terms:

Cont…

- ✓ Percentage of mature fibers, N
- ✓ Maturity Ratio ,M
- ✓ Maturity Coefficient ,Mc

- Knowing the total number of fibers examined and the number of mature fibers the percentage of mature fibers can be calculated as below:

Percentage of maturity

$$\text{Percentage of Mature fibers} = \frac{\text{Number of mature fibers}}{\text{Total number of fibers examined}} \times 100$$

Maturity Ratio M

- The percentage of the three classes of fibers are combined into a single index termed the maturity ratio and is approximately proportional to the degree of cell wall thickening. i.e. **Degree of cell wall thickening ø = 0.577M**
- Maturity ratio is calculated using the following equation:

$$M = \frac{(N - D)}{200} + 0.7$$

where N = Percentage of normal fibers

D = Percentage of immature fibers

- The theoretical value of M will vary from 0.2 for all dead fibers to 1 and very rarely more than one for too mature fibers and can cause problem in the spinning process.

Maturity coefficient Mc: (Maturity count)

The fiber maturity count is denoted by the percentages of the mature, half mature and immature fibers in a sample. It can be calculated using the formula,

$Mc = (N + 0.6H + 0.4I)/100$

where N - percentage of mature fibers.

H - Percentage half mature fibers

I - Percentage of immature fibers

For the chosen standard, N = 67% D or I = 7% and H = 26%.

$Mc = (67 + 0.6(26) + 0.4(7))/100 = 0.85$

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- Based on the maturity coefficient, the cottons are classed into different groups as shown below:

Maturity Coefficient	Rating
Below 0.6	Very immature
0.60 to 0.70	Immature
0.71 to 0.80	Average maturity
0.81 to 0.85	Good maturity

Fiber length testing

After fineness, length is the most important property of a fibre. In general a longer average fiber length is to be preferred because it confers a number of advantages.

✓ longer fibres are easier to process.

✓ more even yarns can be produced from them because there are less fibre ends in a given length of yarn.

✓ a higher strength yarn can be produced from them for the same level of twist.

✓Alternatively a yarn of the same strength can be produced but with a lower level of twist, thus giving a softer yarn.

the three major yarn spinning systems are each designed for processing a certain range of staple lengths : 1 to 2 inches for cotton system machines ,roughly 2 to 4 inches for the woolen system and beyond 4 –inches for the worsted system

The length of natural fibers, like their fineness, is not constant but it has a range of values even in samples taken from the same breed of animal or plant.

Man-made fibers on the other hand can be cut during production to whatever length is required with either all the fibers having the same length or with a distribution of lengths.

❖ In earlier years ,average stable length was usually measured by hand after straightening and bunching together a tuft of fibers

❖ Then semi –mechanical methods were developed that allowed arrays of fibers to be sorted ,weighted and measured to determine quantitative length distributions

❖ Now –a-days high volume automated equipment is available to scan stored arrays of fibers automatically. Hence staple –length distribution is particularly critical to the evaluation of raw cotton

Fiber Length Measuring Instruments

✓ There are three well known instrumental methods of assessing cotton fiber length , and each are quite different.

1. The array method
2. The fibrogram method (HVI)
3. The AFIS method

➢ **The array method** - sorts a sampling of fibers by length and produces a category by weighed distribution –staple diagram. This method is most commonly applied using the Suter –Webb Array apparatus (Comb sorter)

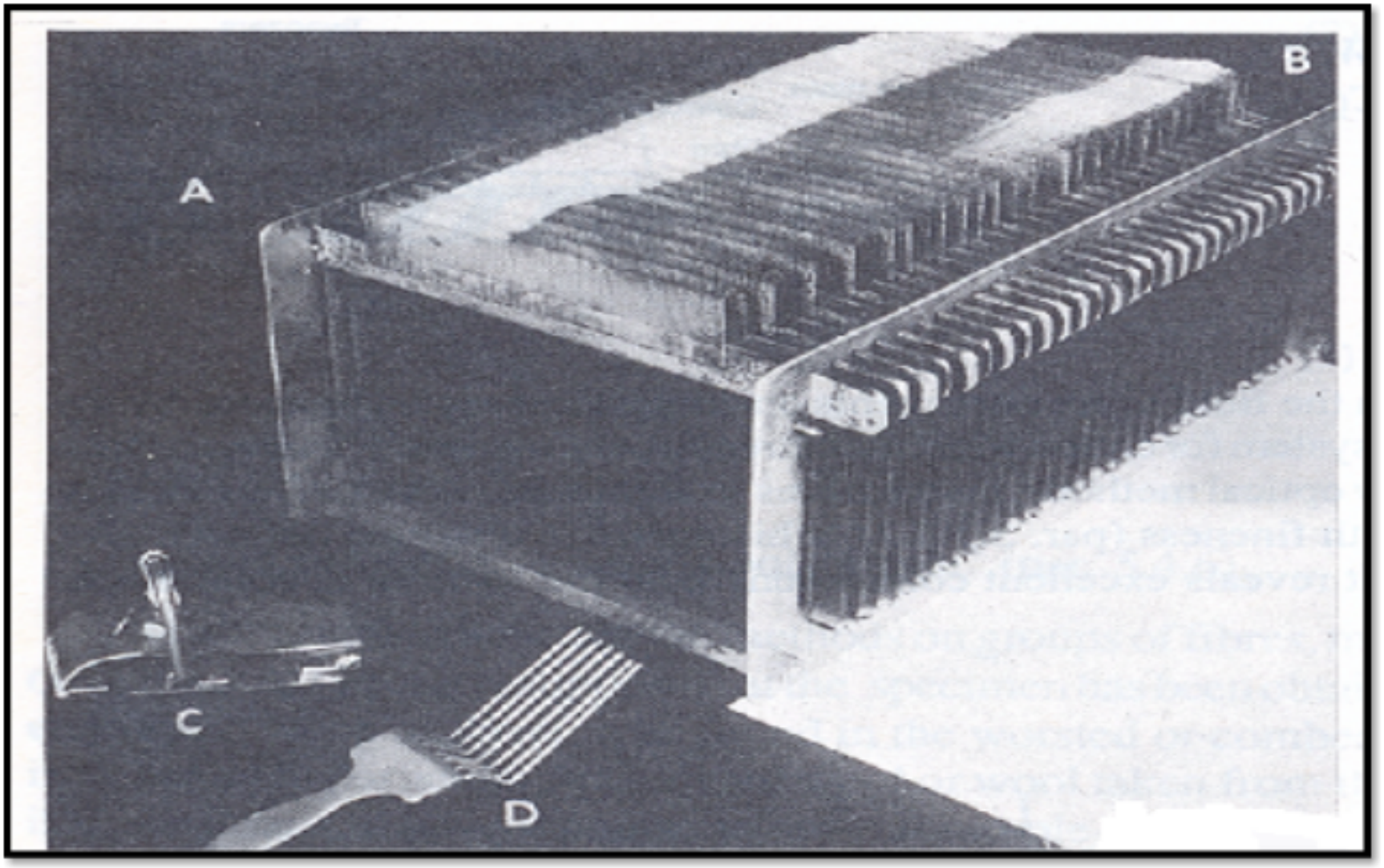
- **The fibrogram method (HVI)** – a different sampling simulates the way those fibers will occur in the yarn making process by randomly catching then along their length to produce “span length(the distance fibers extend from their catch point), and then “arrays” the fiber segments from shortest to longest .This method is used in Uster fibrograph and HVI instruments

- **The AFIS method** – the AFIS method takes a sample and individualizes the fibers, separating the fibers from the dust ,trash & neps in a manner very similar to that of open-end spinning .Those individual fibers are then sent through an air stream and pass an optical sensor w/c measures each fibers length. The resulting number of distribution is optically “weighted “to also produce by –weight staple diagram

The array method

- The fiber sorter is an instrument which enables the sample to be fractionized in to length groups.
- Basically the operation involves four main steps:

1. The preparation of fringe or tuft with all the fibers alined at one end
2. The separation or withdrawal of fibers in order to decrease length
3. Preparation of a fibre diagram by laying fibres alongside one another in decreasing order of length with their lower ends in a line.
4. The analysis of the diagram



Fig… Preparation of a numerical sample for length measurement using array method

- ✓ sample composed of parallel fibers aligned with one end laid out on the bed of equidistant
  - ✓ Respective distance b/n the teeth,0.5-1.3mm
  - ✓ Sample is prepared by cutting a stretch of combed sliver and pressing it onto one side of the bed of combs ,

✓ Placing the drawing (class of fibers) onto a table covered in black velvet to obtain fiber diagram.

✓ In this method predetermined weight (grams) of fibers are sorted in to common length groups on a velvet board in 0.125(1/8”) inch intervals.

✓ The velvet board shows the staple length distribution of the sample. Then ,beginning with the longest group each length group is weighed

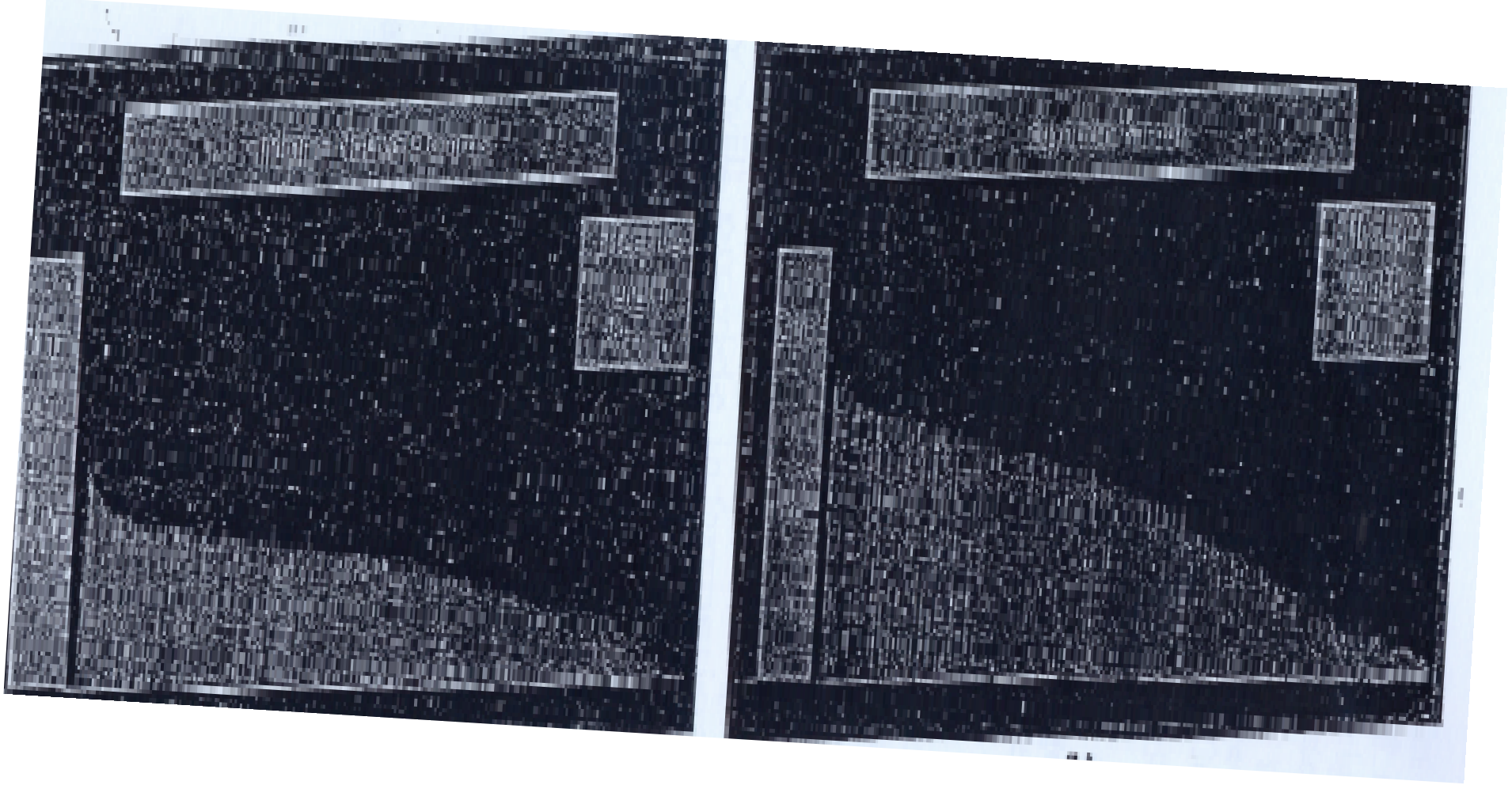
✓ Weight data are used to calculate mean length and other length measurement

Mean length =∑WL/ ∑W

where **L** = Group length ,

W = Mass of fibre in length group

Staple –length: "a quantity estimated by personnel judgment by which sample of fibrous raw material is characterized as regards its technically ***most important fiber length***" or frequent length in a fibrous sample.



(a) (b)

Fig… Fiber arrays of two type of cotton

a- Indian native

b- Egyptian Karmark

Mean length- the average length of all fibers in the test specimen based on weight -length data

Effective length-is longer than the average length and is a measure of the length of the majority longer fibers in the sample

Span length –is the distance spanned by a specific percentage of the fibers in the test beard ,taking the reading at the starting point of scanning as 100%

The upper –Half –Mean Length(UHML)-is the average length by number of the longest one –half the fibers when they divided on a weight basis

Fibrograph Measures of length: The fibrogram

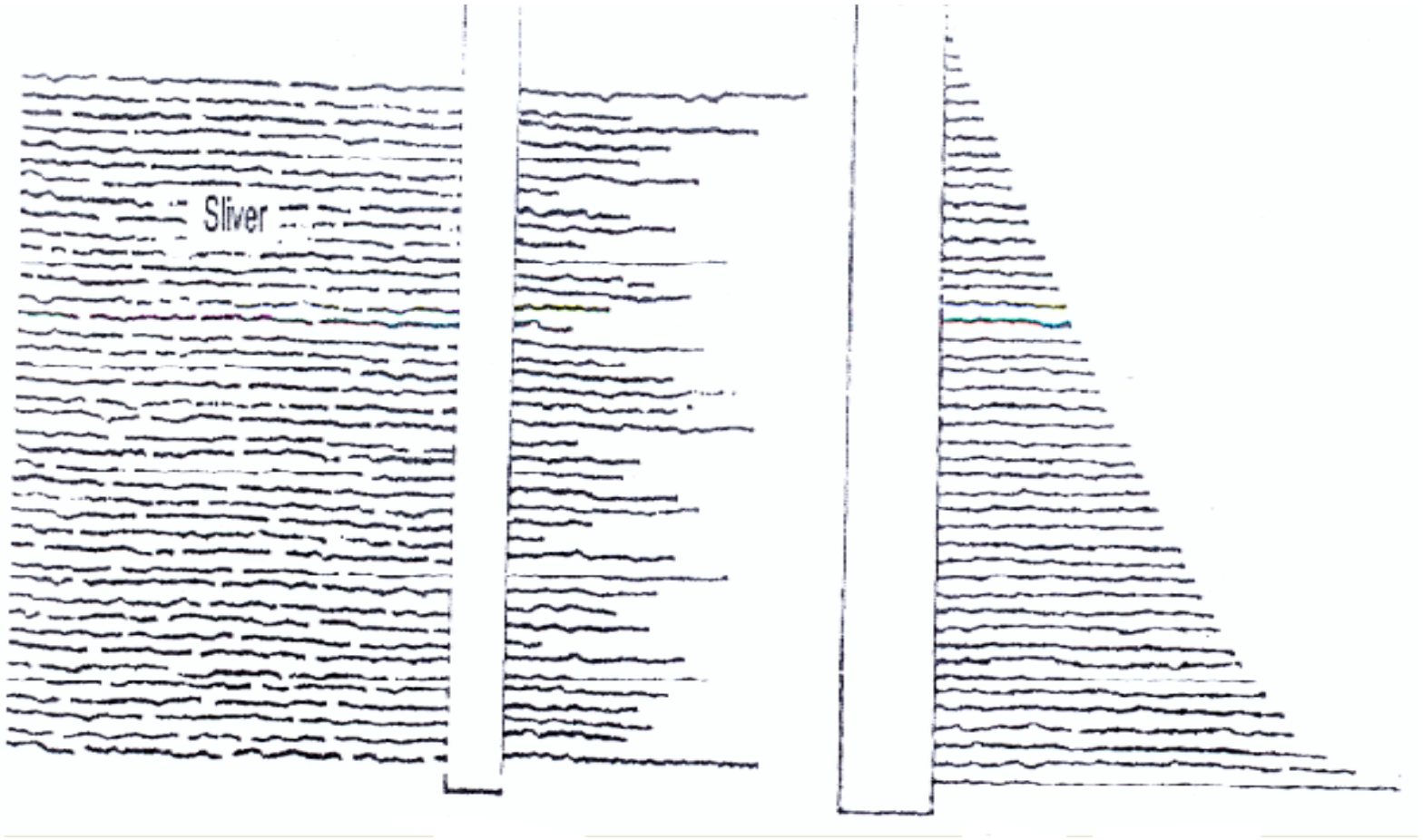
✓ Fibrogram –is a graph showing the length distribution of a sample of cotton fibers as determined using the Fibrograph instrument

✓ The test specimen is a random selection of fibers along their length from a “beard”.

✓ the beard is scanned photoelectrically from base to tip.

✓ The beard simulates fiber arrangement during yarn production process, where fibers are randomly overlapping and parallel (see Fig…)

✓ To understand the fibrogram concept ,consider fibers that are arranged in order of their extension distances from the

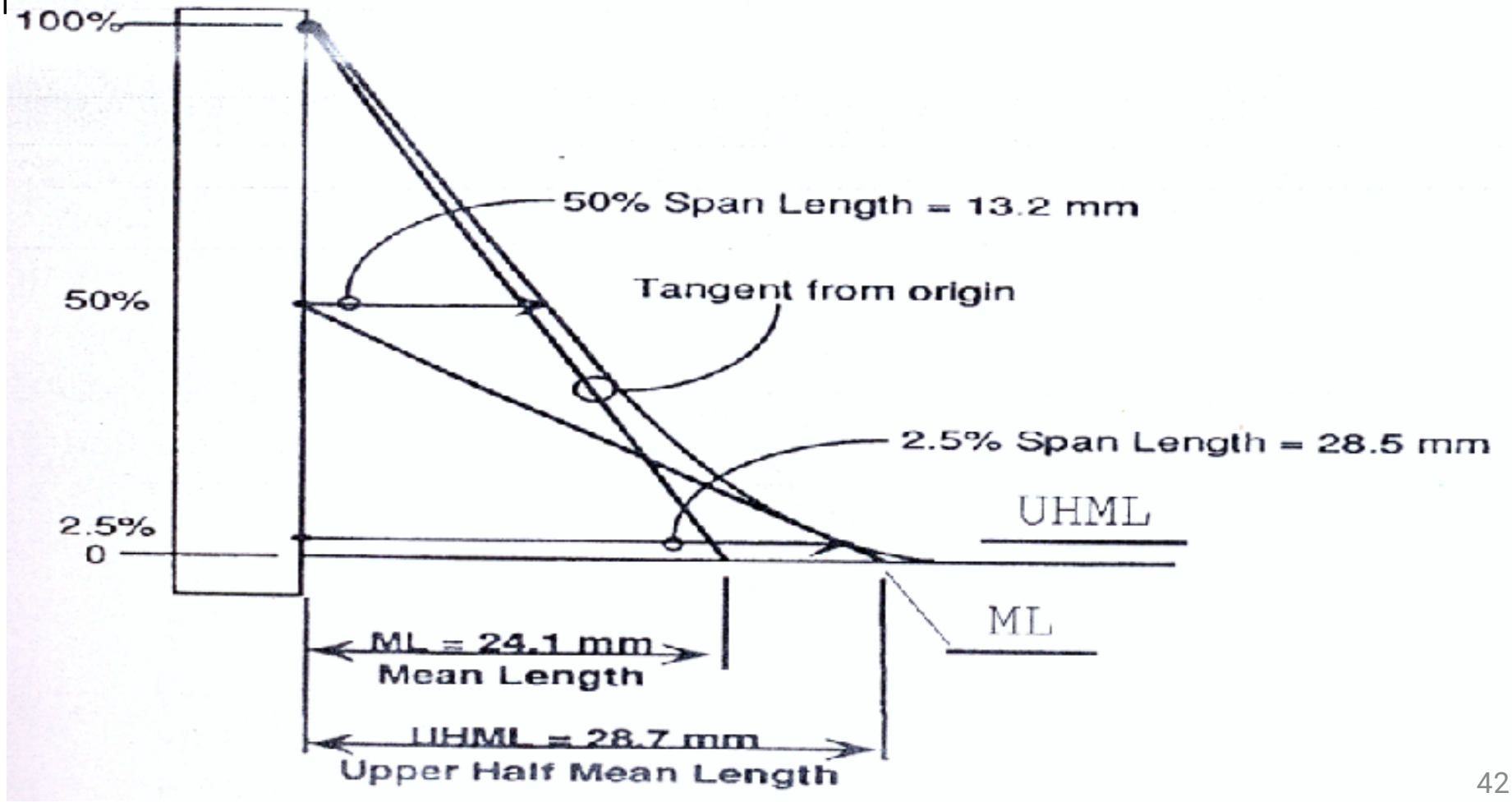


Fig… Random over lapping

Fig… The fibrogram arrangement in yarn making

Reporting Measurements of Testing

✓ There are two different kinds of fibrograph length measurement : ***mean length*** (ML) and ***span length***(SL) as shown below



✓ From these two different kinds of data, length uniformity is calculated .In order to distinguish b/n the two ,one is called "ratio"(by using span lengths) and the other is called "index"(by using mean lengths):

- ***Uniformity Ratio*** = (50%SL÷2.5SL) x100

  = (13.2÷28.5)x100 = 46.3%

- ***Uniformity Index*** = (ML ÷ UHML)100

  = (24.1 ÷ 28.7)x100 = 84 %

N.B. For normal cottons ,the uniformity ratio is in the 40% to 50% range and the uniformity index is in the 75% to 85% range.

Trash Content Testing

✓ Trash is important criteria for classification of cotton. High trash means lower grade and lower price with other things equal

✓ Bolls on plants have no trash or non-lint contamination. But when a boll opens ,it is susceptible to being contaminated by dry leaves and other plant parts

✓ Hand picked cotton is expected to carry less plant material ,while machine picked seed cotton may contain up to 1/4th of non-lint material Trash particles other than leaf are collectively called "***extraneous matter***" in cotton classing system

✓ With visual evaluation of trash content ,seven physical standards are used by the USDA to determine leaf grades designated "1" through "7"

✓ Different trash categories have different influences on the textile processing of cotton and the quality of finished products.

✓ Breakage during spinning is the biggest concern regarding trash, and statistics show that the breakage increases by approximately 60% with a 1% increase in ***bark content***

✓ Hence cotton must be cleaned during ginning ,however,

Technique that are currently available for the identification of trash in cotton include:

i. Shirley Analyzer
ii. Advanced Fiber Information System (AFIS)
iii. HVI

- ✓ The Shirley Analyzer measures the total amount of trash present in cotton sample.

- ✓ Trash measurements from AFIS include the percent content of foreign matter or visible foreign matter (dust & trash)
- ✓ The measurement is by an optical sensor and categorizes the trash objects in terms of equivalent

✓ The HVI system measures trash or non-lint content by use of Video-camera to determine the amount of surface area of the sample that is covered with dark spots.

✓ The video signal is processed by a microcomputer to determine the number of dark spots encountered (count)& the percent of the surface area covered by dark spots(area)

✓ The area and count data are used in an equation to predict the amount of visible non-lint content as measured on the Shirley Analyzer.

✓ However, the HVI measurement does not typically present the size and the type of trash particles found in a sample.

SHIRLEY TRASH ANLAYSER

A popular trash measuring device is the Shirley Analyser, which separates trash and foreign matter from lint by mechanical methods. The result is an expression of trash as a percentage of the combined weight of trash and lint of a sample.

This instrument is used;.

✓to give the exact value of waste figures and also the proportion of clean cotton and trash in the material

✓to select the proper processing sequence based upon the trash content

✓to assess the cleaning efficiency of each machine

✓to determine the loss of good fibre in the sequence of

HVI

The USTER HVI 900 system measures 7 physical characteristics defined by the United States Department of Agriculture (USDA) in its cotton marketing system

The HVI 900 system measures :

- ✓ Fiber length;
- ✓ Strength;
- ✓ Length Uniformity;
- ✓ Elongation;
- ✓ Micronaire ;
- ✓ Color & Trash

✓ The HVI 900 fiber testing system offers precise and reliable automated operation with computer controlled calibration and diagnostics (analysis) .

✓ All functions are controlled by dedicated microprocessors to simply operation & provide flexibility in testing parameters

Testing cotton samples using HVI may give variation due the following reasons:

- ✓ Natural variation in cotton and Instrument variation
- ✓ Calibration cottons
- ✓ Variation in ambient RH & Temperature
- ✓ Operator influence

❖ The following are measurements and calculations provided by the USTER HVI 900 :

- ✓Length
- ✓Length uniformity
- ✓Strength
- ✓Elongation
- ✓Micronire
- ✓Color grade
- ✓Trash content
- ✓Short fiber index
- ✓Spinning consistency index(SCI)
- ✓Count strength product (CSP)

Advantages of HVI

- ✓The results are practically independent of the operator
- ✓ The results are based on large volume samples ,and are therefore significant
- ✓The respective fiber data are immediately available
- ✓They are clearly arranged in summarized report
- ✓They make possible the best utilization raw material data
- ✓problems as a result of fiber material can be predicted, and corrective measures instituted before such problems can occur