INTRODUCTION

The quality of cotton varies considerably among the different varieties available. It is not easy to define quality in absolute terms. The most important fibre properties which determine the quality of a cotton are its fibre length, fineness, maturity and strength.

Testing is a valuable aid to those connected to the production, distribution and consumption of textiles, if the instruments and techniques are used effectively. The right course of action may be taken from the results of testing. Hence it can be said that the testing is a means to an end.

Testing is useful in the selection of raw material, in the control of process and quality of the product and in the development of the process.

The term raw material is a relative one and it will not be same for all processes. For example, the raw material of the spinner is the fibre, the raw material of the weaver is yarn and that of the finisher is fabric. All these raw materials vary in their properties. Fibres vary in length, colour, fineness and strength. Yarns vary in count, strength and twist. Fabrics vary in threads per inch, weight per unit area, strength and shrinkage etc. Therefore, to ensure a smooth running of all the production processes, testing of the available raw materials is an essential one. Also some form of testing is required at every stage of the process so that the end product will prove satisfactory to the buyer, will maintain the reputation of the manufacturer and will subsequently lead to repeat order and continued prosperity.

Testing is the application of engineering knowledge and science to the measurement of the properties of textile fibres, yarns and fabrics It involves the use of techniques, tools, instruments in the laboratory for the evaluation of the properties of these different forms of textiles.

Testing has attained an important position in the textile industry; It is just as applicable to the analysis of a finished fabric; it is as useful for the measure of a household fabric as for any army fabric; it is as necessary to a spinner in controlling the quality of his product.

In this book, the various fibre properties, their influence on processing, the properties of yarn such as count, twist, single yarn strength, lea strength and evenness, the properties of fabric such as threads per inch, strength, permeability to air and water, the methods of measuring them are discussed. Also application of statistics in textile industry, significance testing and various control charts which are used in textile industry are explained with examples.

TENSILE TESTING

TERMINOLOGY 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.

SAMPLING

TYPES 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.

SAMPLING

FIBRE SAMPLING FROM BULK:

CONTENTS

ii) FIBRE FINENESS :

Importance of fibre fineness - Definition - Methods of measuring fineness - Gravimetric method, Micronaire, ATIRA Finess tester, Arealometer .

iii) FIBRE MATURITY :

Introduction - Importance of maturity - Methods of determination of maturity - Caustic soda - swelling method. Differential dyeing method, Causticaire method. comparison between different measures of maturity.

iii) FIBRE MATURITY :

Introduction - Definition of the terms - Load, Breaking load, Stress, Mass stress, Tenacity, Breaking length, Strain, Extension. Breaking extension, Load - Elongatin curve, Stress - Strain curves of different materials, Initial Young's Modules, Yield point, Work of rupture, Work factor, Elastic recovery. Time and elastic properties.

Factors influencing strength test results - Methods of measuring the strength of fibres - single fibre strength, Bundle fibre strength - Pressley tester, Stelomeeter - Single fibre strength Vs Bundle fibre strength.

iv) TRASH CONTENT IN COTTON FIBRES

Grading of cotton - Fibre quality index - Determination of trash content in cotton - The Shirley trash analyser.

3. TESTING OF YARNS :

i) COUNT OF YARN

Introduction - Systems of yarn numbering - Merits and demerits - Definition of count in different systems - conversion of count from one system to another - Measurement of length, Measurement of weight - Instruments used for count determination - Analytical balance, Knowles balance, Quadrant balance. Beesley balance. Stubb yarn balance.

ii) - TWIST IN YARN

Introduction - Definition of twist - Twist on twist, weft on twist - Balanced twist - corkscrew twist - Amount of twist - Relationship between yarn count and twist per inch Uses of twist multiplier - Function of twist in yarn structure - Effect of twist on fabric properties.

Methods of determination of twist in yarns - Sampling, straightened fibre method. Rock bank twist tester, Continuous twist tester, Twist to break method, Optical method, Twist contraction method, Twist in doubled yarns - Take up twist tester.

Yarn diameter - Peirce's formula for cotton spun yarn diameter.

iii) SINGLE YARN STRENGTH

Introduction - Factors affecting the tensile properties of textiles and the results obtained from testing instruments - Principles of tensile testing machines - CRL and CRE principles - The pendulum lever principle with constant rate of traverse, Inclined plane principle - Single thread strength tester of CRT Principle - Single thread strength tester based on inclined plane principle, - Uster single thread strength tester, - Instron tester.

iv) LEA STRENGTH

Lea test - Drawbacks of the lea tester - Count strength product or Break factor - correction for nominal count) - Determination of lea strength using lea tester, - Comparison of lea and single thread strength test results. Ballistic Principle or the Impact principle - Ballistic tester. The merits of the Ballistic test. Comparison of single thread strength, lea strength and work of repture.

iv) EVENNESS OF YARNS

Introduction - classification of variation - Methods of measuring yarn evenness - Visual examination method. cutting and weighing method, Electronic capacitance testers - Fielden Walker Evenness tester, Uster Evenness tester - Analysis of periodic variation - Spectrogram analysis Causes of yarn irregularity - Interpretation of the results of irregularity tests.

Uster classimat, yarn hairiness - effects, Shirley hairiness tester, Textured yarns - Tests for textured yarns. Dynafil tester.

4. TESTING OF FABRICS

i) QUALITY PARTICULARS OF FABRIC

Introduction - Sampling of cotton fabrics - Dimensional characteristics of fabrics - Measurement of fabric length and width, Fabric thickness, threads per inch - Determination of threads per inch, fabric weight, yarn crimp - Influence of crimp on fabric properties - The measurement of crimp percentage - Shirley crimp tester, Load - Elongation curve method. cover factor - warp, weft and cloth cover factors.

ii) FACRIC STRENGTH

Introduction - Tensile strength testing - preparation of test samples - Methods of measuring tensile strength - Ravelled strip method, cut strip method, Grab method - Tearing strength testing - Methods of measuring tearing strength - The tongue tear test, The tongue double rip test, Trapezoid tear test, Ballistic tear test, Wing rip tear test, The Elmendorf tearing tester. Bursting strength testing - Method of measuring bursting strength.

iii) FABRIC ABRASION RESISTANCE, HANDLE

Serviceability - Purpose of serviceability testing - wear, abrasion. Testing of Abresion resistance. Factors affecting abrasion resistance testing - Assessment of Abrasion damage - The interpretation of the results - The B.F.T. Abrasion testing machine, - Martindale abrasion tester, Pilling of fabrics - I.C.I. Pill box tester.

Fabric stiffness, Handle and Drape - Measurement of drape - Drapemeter, stiffness - Cantilever test - Shirley stiffness tester - The Heart loop test. Crease resistance and crease recovery - Measurement of crease recovery - crease recovery tester.

iv) AIR AND WATER PERMEABILITY :

Introduction - Air permeability, Air resistance, Air porosity - Permeability to air, Measurement of air permeability and air resistance - Shirley air permeability tester - Air permeability and fabric properties - Water permeability - Absorbability, shower proof, water proof, water repellent, Basic concept of wetting and water repellency - Methods of testing - Wetting time test, Spray test, Drop penetration test, The Bundesmann tester, The penetration of fabrics by water under pressure - The hydrostatic head test.

5. STATISTICAL QUALITY CONTROL

Introduction - Classification and tabulation of data - Frequency distribution - Graphical representation of data - The frequency curve - Application of frequency diagrams - statistical measures - Mean, Median and Mode - The measures of dispersion - Range. Deviation, Co-efficient of variation - calculations.

Normal distribution - The normal curve - Practical usefulness of the normal distribution - Population and samples - Selection of sample - Random samples - Standard error - significance tests - significance testing of means, significance testing of dispersion.

Quality control charts - concepts - control limits - specification limits Types of control chart - X and R chart, Control chart for Fraction defectives (P), Control chart for Number of defectives (np), Control chart for Number of defects (c) - Control chart for Defects per unit (u) - Interpretaion of control charts - Exercises.

Humidity

Humidity is a term used to describe the amount of moisture present in the atmosphere. This can be described in terms of either **Absolute Humidity or Relative Humidity.**

Absolute Humidity (AH)

It is the weight of water present in a unit volume of moist air. It is the actual density of water vapour in the atmosphere and it can be expressed interms of grains per cubic foot or grams per cubic metre.

Relative Humidity (RH)

It is the ratio of the actual vapour pressure to the saturated vapour pressure at the same temperature, expressed as a percentage.

$$\text{i.e., RH} = \frac{\text{Actual vapour pressure}}{\text{Saturated vapour Pressure}} \times 100$$

The changes in the relative humidity will change the amount of moisture in a sample of material which may be expressed in terms of moisture content and moisture regain.

Moisture Content (M)

It is defined as the weight of water in a material expressed as a percentage of the total weight of the material or As is State.

$$\text{i.e., Moisture Content M} = \frac{\text{Weight of water}}{\text{Total weight of the material}} \times 100$$

The moisture content of a textile material at any given humidity will depend on whether the material has been brought to that humidity level from an atmosphere of lower humidity (absorption process) or from one of higher humidity (desorption process).

Moisture Regain (R)

It is defined as the weight of water in a material expressed as a percentage of the oven dry weight of the material.

$$\text{i.e., Moisture Regain R} = \frac{\text{Weight of water}}{\text{Oven dry weight of the material}} \times 100$$

The oven dry weight is defined as the constant weight obtained by drying the material at a temperature of 105° ± 3°C, till all the moisture is expelled.

If oven dry weight = D

Weight of water = W

Regain = R

Moisture content = M

Then, $R = \frac{100\,W}{D}$ and $M = \frac{100\,W}{D + W}$

also $R = \frac{M}{1 - \frac{M}{100}}$

$M = \frac{R}{1 + \frac{R}{100}}$

CONDITIONING OVEN

Principle

Regain is the weight of moisture in a material expressed as a percentage of the oven dry weight. Therefore the basic method of measuring regain must be to weigh the sample in its original condition, to dry it under a standard conditioned temperature of 105 ± 3°C and then to weigh it again. The weighings are made accurately without disturbing the sample.

Description

The conditioning oven consists of a double walled chamber. This is illustrated in Fig. 1.7.

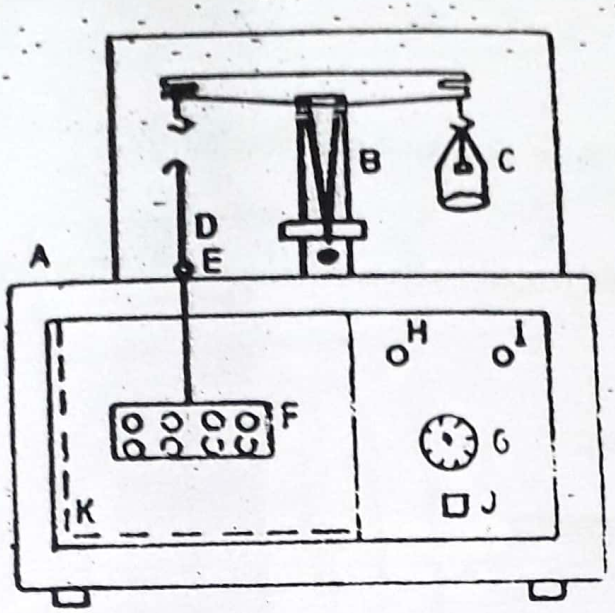


Fig. 1.7. **CONDITIONING OVEN**

A-Heating Chamber
B-Balance
C-Counterpoise weight
D-Rod
E-Knob
F-Perforated tray
G-Thermostat
H-Green light
I - Red light
J-Switch
K - Heating elements

The two walls being insulated with an insulating material like glass wool minimise the loss of heat. The bottom portion of the chamber is provided with ıe heating elements and it has a thermostat control arrangement to control the :mperature inside the chamber. The thermostat is a bimetallic rod which feels ıe temperature inside the oven and acts like a potentiometer in operating a red mp connected to it. A thermometer is provided in the chamber to record the side temperature for the initial adjustment of the thermostat. A blower fan is ·ovided for the circulation of hot air inside the chamber. The middle portion of the ıamber has sufficient space for accommodating a cage containing the sample ır which the moisture content and regain have to be determined. The upper ɔrtion of the chamber is provided with a balance, one arm of which carries a pan ır the weights and the other is connected to the cage. This arrangement helps determine the weight of the sample inside the chamber without disturbing it.

Working

A known weight of the cotton fibres, usually 50gms, is placed in the cage, inside the chamber. When the oven is switched **ON** a green light will glow. Then the heating elements will heat the air inside the chamber and the hot air is circulated through the fibres in the cage. As the temperature increases inside the chamber and when it records on the thermometer as 105°C, the thermostat is adjusted. When it is adjusted, a red light will glow and the heating elements are switched **OFF** automatically. When the temperature inside the chamber goes below 105°C, the red light is switched **OFF** and the heating elements are switched **ON** automatically. This automatic action helps to maintain the temperature of 105 ± 3°C inside the chamber.

After $1^1/_2$ hours of heating, the material is weighed by keeping the cage inside the chamber and this will be less than its original weight. Weighing is done at every 10 minutes until a constant weight in sets of two or three readings are obtained. It means that all the moisture from the sample has been expelled. The weight of the sample now obtained is called the oven dry weight or bone dry weight of the sample. The difference between the original weight and the oven dry weight of the sample gives the weight of moisture present in it.

If the original weight of the sample is W_1 and the oven dry weight is W_2, then the moisture content and regain can be calculated using the following formulae :

$$\text{Moisture Content M} = \frac{\text{Weight of moisture}}{\text{Original weight of the sample}} \times 100$$

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

$$\text{Moisture Regain R} = \frac{\text{Weight of moisture}}{\text{Oven weight of the sample}} \times 100$$

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

SHIRLEY MOISTURE METER

Principle

The electrical resistance of textile fibres varies with different regain values. When the sample is dry, practically the resistance for the flow of electrical current will be maximum and when it is wet, it will be minimum. Hence the regain values of the fibres can be determined indirectly by measuring their electrical resistance.

Description

The Shirley moisturemeter is specially designed for measuring the regain of raw cotton and grey cotton yarns. The electrodes consist of an insulating material (ebonite) in between the central and outer conducting materials. When it is pressed over the fibres, the fibres will form a bridge between the conductors and the current will pass through the fibres. The resistance to the flow of current through the fibres is measured. The indicating unit of the instrument translates this resistance value into regain value, and it will be indicated on one of the two dials. One dial covers the normal range of regain values from 7 to 11%. The other dial has two ranges, one for testing damp or wet fibres with range 9 to 15%, the other for testing dry fibres with range 5 to 9%. The indicating unit and the sectional view of electrode are shown in Fig.1.8 a and b respectively.

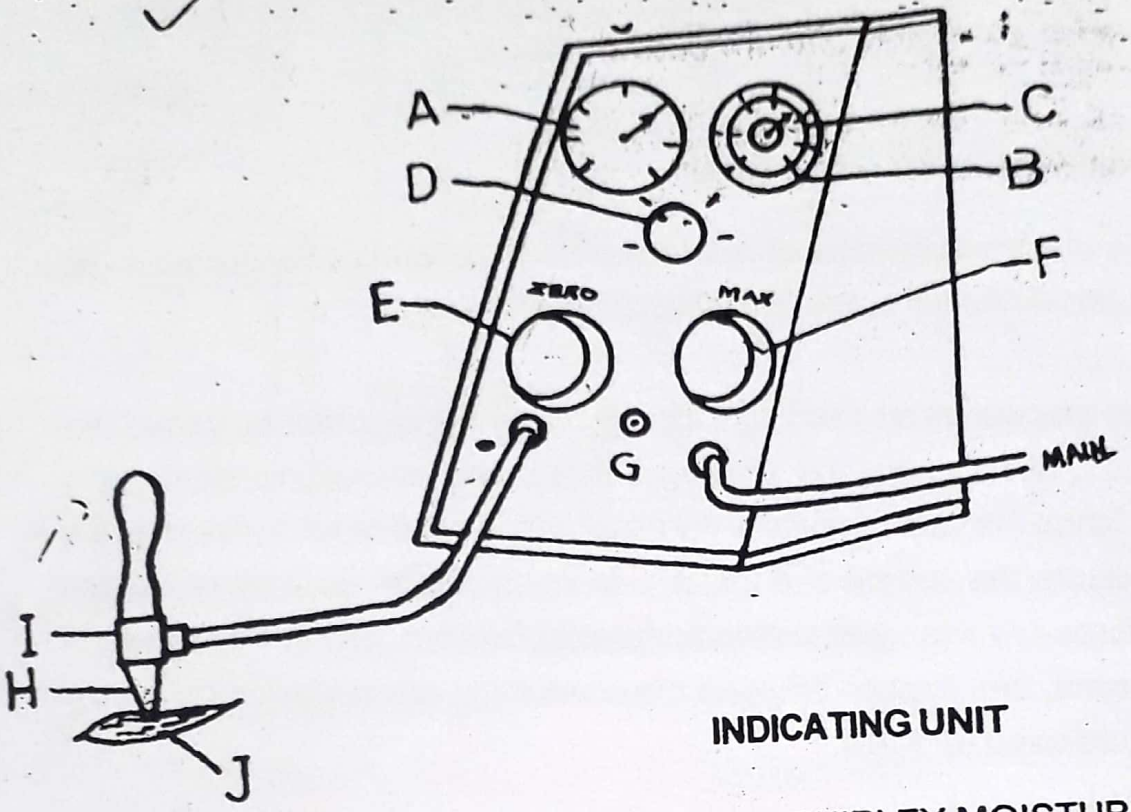
Electrodes for yarn and raw cotton

The electrode consists of two terminals in the form of concentric rings with an insulated annular space (ebonite) between them.

Two electrodes are used, one for raw cotton and the other for yarns. The difference is that for yarns, the spacing between the conducting elements is increased. Since the yarn consists of fibres arranged more or less parallel to the axis, it conducts the current at a faster rate when compared with raw cotton where the fibres are arranged in random manner. To counteract this faster rate of current in yarns, the distance between the conducting elements is increased in the electrodes used for yarns.

The proper electrode is selected and fitted into the holder. The instrument is adjusted to ZERO and MAXIMUM readings for checking the pointer indication. A firm pressure is applied over the holder in order to bring the electrode and the fibres into close contact. Then the regain value is noted from the dial directly. Instead of pressing the electrode holder by hand, a constant pressure device is available which spring loads the holder to 45 lb/sq. inch pressure. A number of readings is obtained from various parts of the material and an average value is calculated.

The disadvantage in using this instrument is that the dyeing and chemical treatments alter the electrical properties of the material and it is not possible to calibrate the instrument and draw up conversion tables with a sufficient degree of accuracy.



INDICATING UNIT

Fig. 1.8 a & b SHIRLEY MOISTURE METER & ELECTRODE

A - Dial with range 7 to 11%
B - Dial with range 9 to 15%
C - Dial with range 5 to 9%
D - Adjusting know
E - Zero adjuster
F - Maximum adjuster
G - Switch
H - Electrode
I - Holder
J - Fibretuft