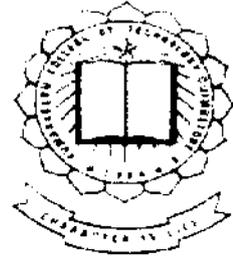


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**A STUDY ON UNIFORMITY OF RING SPUN YARN**

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**KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE -6.**

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**BONAFIDE CERTIFICATE**

Certified that this project report titled “ **A STUDY ON UNIFORMITY OF RING SPUN YARN** “ is the bonafide work of Mr. V.S.ELANGO VAN who carried out the research under my Supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this for any other candidate.



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## A STUDY ON UNIFORMITY OF RING SPUN YARN

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## **ABSTRACT**

The unevenness in linear density along the length of the yarn influences its appearance and behaviour in processing distributing productivity. Measure of this property is an indication of yarn quality. Yarn imperfections are visual defects, which affects the quality and appearance of the yarn. This includes neps, thick, thin, and similar protuberances which extend over short length of the yarn. Counting of these imperfections in the yarn is more meaning full with respect to the end product quality.

Yarn irregularity and imperfections are influenced by fibre properties and process parameters. The present work is an analysis of yarn uniformity carried out with the aim to establish a prediction model for yarn unevenness and to develop software for yarn uniformity characteristics.

A method is developed where feeding a single input parameter of number of fibres in the cross section predicts thick, thin places, neps in the yarn.

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## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 OUTLINE OF PROJECT WORK**

It is a well-known fact that some varieties of cotton draft better than others leading to the production of a more uniform yarn. Considerable amount of work has been done by several research workers on the effects of various fibre properties on yarn irregularity. Studies have clearly established the influence of fibre properties on yarn irregularity. In addition, the type of drafting and the condition of the ring frame could also be expected to contribute to yarn irregularity.

Foster and his co-workers at the Shirley Institute have done the pioneering work in the study of yarn irregularity from 1930 onwards. The work done by them and the theories they have developed are generally accepted as providing an overall picture of the relations between yarn irregularity and processing variables such as yarn count, draft and roller settings.

The unevenness in linear density along the length of the yarn influences its appearance and behavior in processing disturbing productivity. Measure of this property is an indication of yarn quality. Yarn imperfections are visual defects, which effect the quality and appearance of the yarn. These include neps, thick places, thin places and similar protuberances which extend over short lengths of yarn. Counting these imperfections in the yarn is more meaningful with respect to the end-product quality.

Yarn imperfections have a significant influence on the performance of yarns in post spinning operations and on the appearance of woven and knitted fabrics. Hence, to produce cotton yarns with a definite number of imperfections, it is of paramount importance to know the relation existing between yarn imperfections and fibre properties.

Though studies on irregularity have clearly established the influence of fibre properties on yarn irregularity, there appears to be no evidence in the literature for the overall contribution of fibre quality to yarn irregularity. Similarly, even though the fibre properties affecting yarn imperfections (measured by Uster evenness Tester) are generally explained in various articles, no quantitative expression connecting random fibre distribution with imperfections has since been proposed.

Evolving workable prediction model to yarn quality has been an interesting field of study by several research workers for more than three decades. However during the last decade there has been a spectacular improvement in the technological performance of spinning machinery, such as improved opening and effective separation of heavy particles in modern blow room lines, better carding plus efficient fibre control during drafting in preparatory and spinning machinery.

Hence the present study has been undertaken to establish prediction model for imperfection of yarns cotton currently in use.

## CHAPTER 2

### LITERATURE REVIEW

Any mass manufacturing technique has what may be termed a process capability in terms of the minimum variability between individual units of production. In the case of yarn quality the process capability is best measured in terms of the co-efficient of variation of the weight per unit length, which indicates the evenness of the yarn. Which ever terminology we prefer of, evenness or regularity, unevenness or irregularity, it all concerned with the degree of uniformity in the product, say, yarn, invariable, in the quality assessment of any drafted material like yarn the measurement of hank number or count and the measurement of irregularity are of utmost importance.

#### **2.1 what is irregularity?**

Suppose a considerable length of yarn is cut into short equal lengths. The weight of each consecutive length could be found and plotted on a graph taking weights of the individual pieces of yarn along Y-axis and the distance of the piece along the X-axis. This graph shows how the weight varies along the length of the yarn. In this graph the height of each point above the base line is proportional to the weight of a half-inch length and, in order to make the variations more clearly apparent, the points are joined by straight lines. The graph therefore represents the way in which the yarn varies in weight along its length. The dotted horizontal line is at a level equal to the average or mean weight of the yarn, and is the graph, which would be obtained for a perfectly regular yarn.

## 2.2 Yarn importance of irregularity

Irregularity as three effects:

1. Since a length of yarn tends to break its weakest place, which is nearly always the thinnest place, and since the more irregular the yarn, the thinner is the thinnest place, irregularity causes the yarn to be much weaker than a regular yarn of the same average count would be.
2. The yarn, roving or sliver may break at the thin, weak places during the passage through the machines, so making it necessary to join or piece the broken ends before production can be resumed.
3. Irregularity in the yarn leads to irregularity in the cloth, which when excessive may spoil the appearance of the cloth.

The test for irregularity is therefore perhaps the most important to which drafted materials can be subjected, and one of the chief objects of the adjustment and maintenance of drafting machinery and of the invention of new machines is to keep the irregularity under control, and nearly always to make it as small as possible.

## 2.3 Classification of Yarn Irregularities

The irregularities in the yarn can be classified in two ways:

1. According to wave length, and
2. According to type, i.e. according to whether they are drafting wave or periodic variation.

### 2.3.1 Classification according to wavelength

This classification is convenient when discussing irregularity and it corresponds approximately. With the effects which the irregularities have no cloth appearance.

Short term variation : 1 to 10 times fibre length

Medium term variation : 10 to 100 times the fibre length

Long term variation : 100 to 1000 times (or more) the fibre length

The short-term variation would be confined to those irregularities occurring over distance not greater than ten times the fibre length, medium-term variation to irregularities occurring over distances from ten to one-hundred times the fibre length, and long-term variation would be irregularities occurring with a frequency equivalent to or greater than one-hundred times the fibre length/ other suggestions concerning the classification of variation include only short-term and long-term where the short-term is variation equivalent to approximately the draft of the drafting element, and long-term variation is any variation greater than the immediate preceding draft. In any event, the long-term variation includes such non-uniformity as is found from inside to outside of a package or between packages from the same producing agent. Where drafts are high, short-term variation in the materials fed tend to become long-term variation in the material delivered. This also means that the short-term variation in the preparatory operation such as picking and carding become long-term variation in the yarn.

### **2.3.2 Classification according to type**

In each of the irregularity range of the previous classification as short, medium or long-term, the irregularity may be either periodic or of the drafting wave type. The distinction is as follows. A periodic variation has a constant wavelength, and its amplitude is either only slightly variable or varies so slowly along the yarn that it remains fairly steady over many waves. The amplitude and wavelength of a drafting wave, on the other hand, vary considerably from one wave to next.

### **2.4 The amount of Irregularity**

It has already been seen that the amount of irregularity is represented by the extent to which the trace swings up and down the chart, i.e. by the extent to which the material departs from the perfectly uniform material whose trace would be a horizontal straight line, and that this amount can be judged moderately well

by eye provided that the making of traces is standardized. Much more results can, however be obtained if the amount of irregularity is measured and expressed as a number. This can be done in the following way.

#### 2.4.1 Coefficient of variation

Another measure of the amount of irregularity is often used; this is the coefficient of variation. It is calculated in the same way as the mean deviation except that the deviations are squared before taking their mean. This gives the mean square deviation. Thus,

Mean square deviation

$$= \frac{\{(Y_1 - M)^2 + (Y_2 - M)^2 + \dots + (Y_n - M)^2\}}{n} = S \text{ (say)}$$

The coefficient of variation is obtained by taking the square root of S and expressing it as a percentage of the mean.

$$\text{Coefficient of variation} = \frac{100 \sqrt{S}}{M}$$

It does not matter very much of these measures is employed as long as it is clearly stated which is being used because in nearly all regularity tests the mean deviation is proportional to the coefficient of variation, and, in fact,

$$\begin{aligned} \text{Coefficient of variation} &= 1.25 \times \text{Percent Mean Deviation} \\ \text{Or Percent Mean Deviation} &= 0.80 \times \text{Coefficient of variation} \end{aligned}$$

It should be noted that when either of the above two quantities is to be calculated it is not essential that the magnification of the trace should be standardized as it when the irregularity is to be judged by eye. If, for example, the magnification is halved, the deviations are halved, but so is the mean height; consequently after the percentage has been calculated the final result is unchanged.

## 2.5 Limit Irregularities or Basic Irregularity

It has been shown that the most uniform strand of material, which our present are laid in a random order in the sliver, Roving or yarn. For such a strand of material the irregularity is given by the formula

$$V_r^2 = \frac{100^2}{N} + \frac{V_m^2}{N}$$

Where  $V_r$  = Co-efficient of variation of weight per unit length.

$N$  = The average number of fibre in a cross section of the strand.

$V_m$  = Co-efficient of variation of the fibre weight per unit length.

Thus for a particular fibre and count length there is a limit or basic irregularity upon which present machines cannot improve. For cotton fibres the limit irregularity formula may be reduced to

$$V_r^2 = (106)^2 / N$$

## 2.6 Factors Influencing Irregularity

There is almost an unlimited source of variables, which may contribute to the unevenness of a textile yarn. Among these are the fibre properties of length and fitness. Fibre length distribution have a direct bearing on fibre control during

the drafting operations, and influence directly the evenness of the finished yarn. This particular aspect of evenness has been studied very extensively, and the behaviour of these variables has been entitled "drafting waves".

Fibre fineness influence yarn evenness, for fineness determines the number of fibres in the average cross section for any given size of yarn. Thus, a yarn made from cotton of a 4.0 microgram per inch fineness will average 25 per cent more fibres in a cross section than the same size yarn spun from cotton of 5.0 micrograms per inch fineness. According to the Martindale theory to be discussed later, uniformity is a function of number of fibres in the section of sliver, roving, or yarn.

In addition to fibre properties, there are many machinery defects that may contribute to the variation in laps sliver, roving and, yarn. In fact, improper adjustment and poor maintenance are the chief causes of abnormal unevenness.

### **2.7 Fibre per cross section, cotton yarns**

The fibres per cross section,  $N$ , are calculated by the following relationship for cotton yarns:

$$N = (\text{micrograms} / \text{gram}) (\text{grams} / \text{pound}) / (\text{hanks} / \text{pound}) (\text{yard} / \text{hank}) \\ (\text{inches} / \text{yard}) (\text{micrograms} / \text{fibre inch})$$

$$= (1,00,000) (453.59) / (\text{yarn no.}) (840) (36) (\text{fineness})$$

$$N = 15,000 / (\text{yarn no.}) (\text{fineness})$$

For a fineness of a 4 micrograms and a yarn count of 40/1, the number of fibers per cross section would be:

$$N = 15,000 / (40) (4) = 93.7$$

For a 40/1 made from a 3-microgram cotton, the fibers per cross section would be

$$N = 15,000 / (40) (3) = 125.$$

## 2.8 Expected Coefficient Variation, Cotton Yarns

The simplified version of the Martindale theory is based on the assumption that the random distribution of fibers in a yarn follows the poisson type. Since the standard deviation for this type of distribution is estimated by the  $(N)$ , and the coefficient of variation is

$$\frac{\sigma}{\bar{X}}(100)$$

-----

X

The coefficient of variation for the fiber distribution in a yarn becomes:

$$V = \frac{1}{\sqrt{N}}(100) = \frac{1}{\sqrt{N}}(100)$$

Where N = Number of fibers per cross section.

For the 40/1 spun from 4-microgram cotton, the expected coefficient of variation would be :

$$V = \frac{1}{\sqrt{93.7}}(100) = 10.4\%$$

For the 40/1 spun from 3-microgram cotton, the expected coefficient of variation would be:

$$V = \frac{1}{\sqrt{125}}(100) = 9.0\%$$

By comparing the expected variation for the 40/1 made from the two cottons, the influence of fibre fineness on yarn variation becomes apparent.

In combining the relationships of

$$N = \frac{15,000}{(\text{yarn no.}) (\text{fineness})}$$

(where the fineness is in micrograms per inch), and

$$V = \frac{1}{\sqrt{n}}(100)$$

By substituting for N, the relationship becomes

$$V = 1 * (100) / 6 (15,000 / (\text{yarn no.}) (\text{fineness}))$$

$$= 0.82 ^{(\text{yarn no.}) (\text{fineness})}$$

using the previous example of a 40/1 with a cotton having a fineness of 4 micrograms, the expected coefficient of variation is

$$V = 0.82 ^{((40) (4))} = 10.4\%$$

## 2.9 Fibre Per Cross Section, Staple Synthetic Yarns

The number of fibers per cross section, N, of a yarn manufactures from staple synthetic fibers is calculated by dividing 5315 by the yarn number times the average denier of the staple , i.e.,

$$N = 5315 / (\text{yarn no.}) (\text{ave. denier})$$

The yarn number is on the English system. The value 5315 is the conversion constant to go from denier to cotton number. Thus 345 / 1 cotton yarn is equivalent to  $5315 / 35 = 152$  denier. By dividing the total denier of yarn by the average denier per fibre, the result is the number of fibers in the cross section.

## 2.10 Expected coefficient Variation, Staple Synthetic Yarns

Make a similar substitution to the one used for cotton to calculate the coefficient of variation.

$$V = 1 / (100)^N$$

$$V = \frac{1}{\text{-----}(100)}$$

$$^ {5315 / (\text{Yarn no.}) (\text{Ave .denier})}$$

Simplified, the relationship becomes:

$$V = 1.37 \wedge (\text{Yarn no.}) (\text{Ave. denier})$$

For a 20/1 yarn spun from 2.0 denier staple, the coefficient of variation is:

$$V = 1.37 \wedge (20) (2) = 8.6\%$$

### 2.11 Index of Irregularity

Two expressions for irregularity have been given: The percentage mean deviation and the coefficient of variation. Uster evenness tester made by the swiss firm zellweger Ltd measures the P.M.D, generally and it is popularly known as U%.

By calculating the limit irregularity and then by measuring the actual irregularity, there is a means of judging the spinning performance.

Let  $V_r$  = the calculated limit irregularity, and

$V$  = the actual irregularity

Then, the index of Irregularity is given by

$$I = V / V_r$$

A value of unity corresponds to the best possible yarn; the higher the value of  $I$  the more irregular the yarn.

### 2.12 The Law of Addition of Irregularities

Suppose that a drafting machine is producing a material whose coefficient of variation is  $V_1$ , and that a mechanical defect occurs in the machine which by itself would cause a coefficient of variation  $V_2$ , the question arises, what will be the coefficient of variation,  $V$ , of the material after the mechanical defect has occurred? At first sight it might seem right to add  $V_1$  and  $V_2$ , but this incorrect, and the correct value of  $V$  is obtained by squaring  $V_1$  and  $V_2$ , adding the squares and taking the square root of the sum.

$$\text{Thus } V = \wedge (v_1^2 + v_2^2)$$

This is the law of addition of irregularities. It is true for irregularities of any kind subject to the condition that the irregularities must be independent of one another, i.e., there must be no tendency for the thick places of the second irregularity to come on top of the thick places of the first except by chance.

If both sides of the above equation are squared we get

$$V_2 = V_1^2 + V_2^2.$$

The square of the coefficient of variation is called the relative variance, and the law may be stated thus: when there are two ( or more) independent causes of irregularity, the resulting relative variance is the sum of the relative variances which each of the causes would produce if acting by itself. Because relative variances can be added in this way, It is often more useful to use them instead of coefficient of variation.

The law of addition can be used to calculate the amount of irregularity added by the drafting at one frame. For example, if the coefficient of variation of a slubbing is  $V$  and that of the sliver being fed to the slubbing frame is  $V_1$ , then the coefficient of variation  $V_2$  of the irregularity added during the drafting is given by

$$V_2^2 = V^2 - V_1^2$$

The effect of doubling is to divide the coefficient of variation by the square root of the number of slivers or rovings, which are combined. Expressed in terms of relative variance the law of doubling is simply that the relative variance is divided by the number of ends.

The law of addition of irregularities may be used for mean deviations instead of coefficients of variation, but it then becomes a little inaccurate when large periodic variations are present.

### **.2.13 Methods of Measuring Irregularity**

The equipments used in the measurement of irregularity varies from simple tools like a black board to highly sophisticated electronics of computerized testing installation like Uster tester (VTS). A short list of the more important methods available is given here.

1. Visual methods.

Black board, Drums, Photographic devices, Projection, Patterning predicator, Lap meter.

2. Cutting and Weighing Methods

Lap scale, Lap meters, Sliver Hank tests, Hank wrapping, Count variation Short cut length.

3. Variation in thickness under compression

WIRA roving evenness tester, LINRA roller yarn diameter tester

4. Electronic capacitance testers

Fielden – Walker, Uster Tester

5. Miscellaneous Methods

Air Flow , Mercury Displacement.

### **2.14 Causes and effects of irregularity**

A knowledge of the mechanism and functioning of the various types of irregularity testing instruments is important, but perhaps more important is a clear understanding of the reasons why these techniques testing can best serve the spinner, the manufacturer, and the customer. Apart from this value in research and development irregularity testing may be looked at from two angles: Firstly, to answer the question ' what has caused this Fault?' and secondly ' How can such faults be prevented?'. Chronologically, the cost comes before the effects, but often a yarn fault remains undiscovered until the fabric is made and

sometimes until it has been dyed or finished. The Technologist, then, has to work backwards, retracing the history of the faulty yarn and using the testing methods at his disposal to track down the probable cause of the trouble. He must therefore have a sound understanding of the process of spinning and fabric manufacture. Even so, the help of the mill technician is often invaluable since he has an intimate knowledge of the machinery under his supervision. For this reason it is essential that the relations between the laboratory and the machine rooms should be cordial, a state of affairs to be encouraged but not, unfortunately, always found. When causes of faults have been found it is logical to design control systems which will prevent them from occurring again, or at least reduce the chances of repeat faults.

#### **2.14.1 Causes Of irregularity**

A broad classification of the causes of yarn irregularity has been given by Martindale:

- (1) Properties of raw materials.
- (2) Inherent shortcomings in yarn making and preparatory machinery.
- (3) Mechanically defective machinery.
- (4) External causes due to working conditions and inefficient operation.

##### **2.14.1.1 Properties of raw materials**

The design and adjustment of spinning machinery is in effect a compromise which aims at processing at an optimum efficiency the majority of fibers in a Particular mixing. Natural fibers have variable properties and set the spinner a Variety of problems. A major variable is the fibre length, of course. However, other variables such as surface character, fineness, shape of cross-section, maturity, crimp, etc., have some effect on the yarn properties. Much work remains to be done before the individual parts played by the different variables can be isolated. The old spinners dream of fibres of uniform length, fitness, etc., has come to pass but the modern spinner of staple rayons still has his problems of irregularity.

### **2.14.1.2 Inherent shortcomings of machinery**

In many engineering process the units from which the final product is assembled are positively controlled by hand or machine and positioned with only a few thousandths of an inch tolerance. In spinning it is surprising how often the individual fibres are only negatively or jostled along by surrounding fibres, or they are held in position by friction and twist.

Fibre manipulation by rollers, aprons, gills, and other machine parts is hampered by fiber variation, and the machines can only be set to give the best results within the limitations imposed by the materials.

The 'drafting wave' is one example of irregularity due to the inability of a drafting system to control each fibre. Where roller drafting is used, the distance from one nip to the other is greater than the length of the shorter fibres. The short fibres flout in the drafting zone and move forward in an irregular but cyclical manner which results in the drafted strand having thick and thin places. The wave length of this type of irregularity is about 2.5 times the mean fibre length but it is not necessarily constant for the particular strand. In addition to a varying wavelength, the amplitude of the drafting wave is also variable. Spinning students in particular are recommended to read Foster's book THE PRINCIPLES OF ROLLER DRAFTING, where an excellent account of the drafting wave mechanism is given in Chapter 4.

Not all spinning systems use drafting rollers. In condenser spinning, for example, the key machines are the cards. The roving produced by the cards is converted to yarn on the mule or ring frame without any doubling, and only a small draft is used. Thus, drafting waves do not arise but other variations peculiar to the system are found. For example, there is usually bobbin-to-bobbin variation due to uneven splitting of the card web by the tapes and the variation in web density across the card.

### **2.14.1.3 Mechanically Defective Machinery**

Since machines even in good condition produce irregular yarns, it is reasonable to assume that defective machinery will increase the amount of irregularity. The implementation of an efficient maintenance system is essential if the level of irregularity is to be kept within bounds. Machines drift out of adjustment, bearings become worn, components get damaged, lubrication systems clog, and dirt works its way into the mechanism.

Many spinning machine mechanisms are based on rollers and their associated drives. Faulty rollers and gear wheels usually produce periodic variation, a fact which helps the technologist to track down the probable cause by analysis of the traces made on the evenness tester. The methods of analysis will be dealt with shortly.

### **2.14.1.4 External Causes**

A mill is not merely a building containing machinery and materials – men and women are necessary to ‘keep the wheels turning’. To achieve a first-class product, a first-class team of Managers, Technicians, and Operatives is essential. Schemes of maintenance technicians, and quality control which look good on paper will soon become second-rate if the men and women who operate them neglect their duties. Operatives, too, can spoil yarn by poor piecings, careless oiling and cleaning, and general slack work; sound training can help a great deal in the spinning of good yarns.

In modern mills it is usual to have control over the atmospheric conditions of the various sections of the spinning plant. Optimum temperature and relative humidity limits can be established both for the process and the operatives. Also, good lighting and an accent on cleanliness encourage good work.

### 2.14.2 Influence of Fibre Properties

Raw materials selection and preparation of right mixing out of available cottons therefore plays a critical role in achieving the desired quality of yarn and fabric. Further, proper raw material selection also ensures satisfactory performance at different stages of manufactures. As brought out by earlier theoretical analysis, fibre length, fineness (micronaire value) and bundle strength are the most important fibre characteristics influencing yarn strength and spinnability of a cotton.

Short fibre content and maturity of the cotton are other fibre characteristics which have also influence on yarn strength though of a lesser order. A single index known as fiber quality index (FQI) is also sometimes used to characterize the cotton by combining the three fibre characteristics. Though several equations are proposed for predicting yarn strength from fibre properties, the one relating lea CSP of yarn to FQI developed by SITRA is more commonly used. The relationship is,

$$FQI = \frac{l \cdot u \cdot s \cdot m}{f}$$

where,

$l$  = 2.5% span length in mm

$u$  = uniformity ratio

$s$  = bundle strength at 3mm gauge length (Stelometer) g / tex.

$M$  = maturity coefficient

$F$  = micronaire value

The achievable yarn lea CSP for a given FQI is found to be given by the following empirical relationship (development by SITRA)

$$CSP = (310 - Ne)^{\wedge} FQI$$

### 2.14.2.1 Measurement of the Fibre Properties:

Fibre length of cotton is determined primarily by the digital fibrograph and bare sorter though several other methods have been proposed from time to time. In the Baer sorter fibre are aligned at one end and laid side by side in descending order in the form of an array from the longest to shortest fibre length. From the diagram, mean fibre length, effective length and short fibre content can be estimated. The method is time consuming (about 2 hrs per sample) and calls for considerable skill on the part of the operative in preparing the diagram. The sampling, testing method and skill of the operative influence the results. In Fibrograph, the fibres are clamped randomly at any point along their length on a comb and the beard thus made after combing out the loose fibres is optically scanned for density from which 2.5%, 50% span lengths and uniformity ratio are obtained.

The outline of the fibre beard in Fibrograph is therefore nothing but a cumulative distribution of baer sorter curve. The shapes of the baer sorter diagram and fibrograph are given in figure 1a and 1b respectively. Fibrograph curve can be derived from Baer sorter diagram as shown below;

$$r(1) = \frac{\int Q(1).d1}{\int q(1).d1}$$

Thus there should be one to one correspondence between estimates of fibre length from Fibrograph and Baer sorter. But in actual practice, the correspondence is not that perfect because,

1. Measurement of density of beard in fibrograph is done not at the clamping point but 3.8 mm away from it,

2. Fibre breakages occur during combing of beard for removing loose fibres in Fibrograph and,
3. Optical scanning is done to determine density of tuft in Fibrograph and as a result crimp present in the fibre affects the light absorbed by the tuft.

#### **2.14.2.2 Fibrograph has the merit that,**

1. It simulates the beard formed by fibres held by front or break roller nip and from any cross-section in sliver or yarn,
2. Test is very rapid (about 15 min per sample) and,
3. Results do not depend much upon the operator skill.

Further there is a close correlation between 2.5% span length by fibrograph and mean fibre length by Baer sorter. Correlation however of a lower order is found between 50% span length by fibrograph and mean fibre length by Baer sorter. Uniformity ratio by fibrograph has however a poor correlation with short fibre content by the Baer sorter. Though several equations have been proposed, the one given below is found to give a reasonably accurate estimate of effective length from 2.5 % span length.

$$\text{Effective length (Baer sorter)} = 3.8 + 1.03 * 2.5\% \text{ span length.}$$

Fibre fineness of cotton is universally determined by the micronaire. Micronaire measures the rate of flow of air through a known mass of fibres packed in a cylinder of known dimensions under constant pressure. It varies inversely as the square of specific surface area and therefore depends not only on the maturity of the fibres. The micronaire value M is given by,

$$\begin{aligned} Mc &= k_1 / S^2 \\ &= k_2 M H \end{aligned}$$

where,  $M$  = Maturity Ratio

$H$  = Fibre weight per unit length (fineness)

$K_1, K_2$  = Constants

$S$  = Specific surface area.

Micronaire is therefore determined by both fibre fineness and maturity. Cottons of low micronaire value. Such cottons being prone to rupture, nep generation and lapping during processing may not improve yarn strength in spite of having a low micronaire value.

Bundle strength is determined either by stelometer or pressley at zero or 3 mm gauge length is preferred because of its closer association with yarn strength as it takes into account the presence of weak places in the fibre. There are however some factors affecting the association between bundle strength of fibre and yarn strength such as,

1. The number of fibres in the bundle is much different from the number of fibres in yarn cross-section. The bundle effect which determines the loss in strength from single fibre to bundle is therefore much different in bundle strength and yarn strength tests and,
2. Rate of loading and gauge length in bundle strength test are much different from the yarn strength test.

The measurable fibre properties therefore account for only 70% to 75% the variation in yarn strength from cotton in a given spinning plant. Other factors affecting yarn strength includes inter fibre friction, fibre breakages during spinning and drafting and processing behaviour of fibres and lapping tendency. Further relative contribution of different fibre properties on yarn strength varies with the count, which renders prediction of yarn strength from properties very difficult.

#### **2.14.2.3 Measurement of yarn strength**

Lea CSP and single thread tenacity are common measures used to represent the strength of yarns. Lea CSP is more commonly used in the industry and has the merit that it is less time consuming and less affected by sampling variations. Moreover, lea CSP is influenced to a greater extent by the variability

of yarn and therefore should provide a better indication of the performance of the yarn in subsequent stages. Single thread tenacity on the other hand is a more widely used in the international market. Standards for RKM hich is nothing but single thread tenacity (expressed as g/tex or cn / tex) are often prescribed in export trade particularly in eastern countries. Optimum twist multiplier from the point of view of strength is different for single thread tenacity and lea CSP. Optimum TM is higher by 0.3 to 0.5 units for single thread tenacity than for lea CSP. Lea ratio represents the ratio of actual lea strength to predicted lea strength from single thread and is given by,

$$\begin{aligned} \text{Lea ratio} &= \frac{\text{Lea strength (in lb)} \times 100}{160 \times \text{mean single thread strength (in g)}} \\ &= \frac{283 \quad \text{lea strength (in lb)}}{\text{Single thread strength (in g)}} \end{aligned}$$

Lea ratio provides an estimate of the variability in the yarn and normally ranges between 70% and 80%. Therefore, single thread strength in g is approximately 3.5 to 4 times lea strength in lbs.

#### 2.14.2.4 Gauge length

Yarn strength is also critically influenced by the gauge length used in testing. This is because strength of a specimen is determined by the strength of the weakest element in it. With increase of specimen length there are greater chances of finding weak places in the yarn and weaker will be the weak place. This is why in wrapping where a long length of yarn is subjected to tension breaks are very sensitive to the irregularity on yarn strength will also be clear from the above is increased and since thin place usually weak, strength is reduced.

#### **2.14.2.5 Influence of fibre properties on yarn irregularity**

Fibre properties of cotton exercise considerable influence on yarn irregularity since drafting irregularities at each stages of processing are influenced by the fibre properties. Fibre length, short fibre content and fineness are the major fibre characteristics influencing irregularity though other factors like drafting behaviour of fibre, level of neps and trash in the material also affect the irregularities. With cottons of lower fibre length and higher short fibre content, higher level of irregularities are encountered at all stages because over the fibres in the drafting zone.

Micronaire value has however a complex relationship with yarn irregularity. Too high a micronaire value arises from coarseness in the fibre and can increase yarn irregularity especially in fine counts because of reduction in number of fibres in yarn cross-section. Too low a micronaire for a given variety usually arises because of immaturity and this will lead to more fibre breakages, nep generation and unsatisfactory carding which will ultimately increase irregularity. Thus micronaire value should be maintained at the optimum level depending upon the type of cotton.

#### **2.14. 3 Influence of fibre properties on imperfections**

Micronaire value, trash content and short fibre content are the short fibre content are the three important fibre characteristics on which utmost care is required in selection for minimizing imperfections in the yarn. Lower micronaire value than the normal level for a given variety means that the cotton is immature. In addition lower micronaire also means that the cotton is inherently fine and susceptible to damage. Thus, low micronaire cottons are highly prone to nep generation and fibre rolling and cluster formation. Cleaning of these cottons without causing damage to fibres is also a higher sticking tendency leading to lap licking, cylinder loading and roller lapping which in turn results in higher imperfections. Short fibre contents increases irregularities and thick and thin

places introduced during drafting and also contributes to fly liberation at different stages of processing. Trash level and the nature type of trash have a profound influence on the imperfections. The bearded seed coats are not easy to remove in blow room and contribute to thick places. The broken and powdered seed coats often form the nucleus for neps. A single index known as fibre propensity for imperfections (FPI) was developed by BTRA to assist in the selection of right cottons for minimizing imperfections. FPI is given by,

$$\text{FPI} = \frac{\text{Trash content percentage} \times \text{short fibre percentage}}{\text{Micronaire}}$$

-----  
Micronaire

Studies by BTRA have shown a significant correlation between total imperfections and FPI. FPI is therefore a useful tool in selection of cottons and should be maintained below 16.

The imperfections are made out of thin and thick places and neps. The thin and thick places are in general to a greater extent influenced by drafting processes while neps are influenced more by blow room, carding and combing processes. Further the yarn irregularity as determined by  $u\%$  is better correlated with thin places. This is because generation of thick places is also influenced by the opening and carding processes.

#### **2.14.4 Effect of count**

The influence of fibre properties on yarn quality varies with the count spun. Micronaire value has a different influence on thick and thin places on the one hand and neps on the other. The number of fibres in the cross section influences drafting irregularities. The influence of number of fibres in the cross section on  $u\%$  value and thick and thin places becomes more critical in finer counts because of the fewer number of fibres. As a result the yarn from finer variety of cotton has a lower  $u\%$  value and thick and thin places becomes more

critical in finer counts because of the fewer number of fibres. As a result the yarn from finer variety of cotton has a lower u% and fewer thick and thin faults than from a coarser variety of cotton. For the same reason, the drop in CSP with increase of count is much more steeper in coarser cotton than in finer cotton. Nep level in the yarn is however, higher with finer cotton than the coarser variety and this is because of fineness (i.e. lower micronaire value) means proneness to nep generation.

The influence of different fibre characteristics on yarn evenness and strength do not always go hand in hand and as a result such situations do occur where only one of the yarn properties is affected while other is not. The critical influence of fibre length of the cotton on irregularity of material at different stages and the differential influence of fibre characteristics on yarn strength and irregularity are made clear from several case studies.

The importance of minimizing cottons with lower micronaire value and higher short fibre content in the mixing for getting lower imperfections and better appearance in the yarn is brought out from studies.

## **2.15 Fibre Quality Characteristics**

### **2.15.1 Fibre Length**

The unit from which complicated textile structures are built is the single fibre. To evaluate the quality of raw material, two important dimensions namely fibre length and fineness are required. When natural fibres are considered. When man made fibres are considered both length and fineness can be controlled. But in the case of natural fibres between varieties of cotton, between the samples of same variety length and fineness vary. Any sample of cotton will contain fibres varying in length from 2mm onwards, the upper limit being decided by the variety of cotton under consideration and the condition under which it has been grown.

### 2.15.1.1 Importance of Fibre length

The fibre length of cotton is directly related to its spinning performance. Generally speaking, longer cottons can be spun into finer counts. When the processing of fibres is considered, the machinery arrangement, the speeds and the settings at various stages have to be designed based on the length characteristics of the fibre. The mill technician is guided by the staple length in the setting of the machineries at the stages of opening, Carding, drafting and twisting. Further, the number of cleaning points in the blow room, the settings between the grid bars, between the feed roller and the beaster depend upon the staple length.

For a card value of staple length is more critical cards have to be worked slower with open settings for longer cottons and faster with close settings for short staples. In some of the cards, design of the feed plate nose also depends upon the length.

### 2.15.1.2 Determination of Fibre Length

The determination of fibre length is of a greater importance both for the trader and technician. The word staple itself is an element to trade. Because of the variation in the length of fibres. It is aimed to obtain a measure of fibre length which can be considered as averages for the whole sample or which is likely to influence the spinning performance most. In the trade the fibre length is estimated by the hand stapling method. Several instruments are available for determining the fibre length characteristics of cotton. However, each instrument is based on a different principle and hence various length parameters are obtained depending on the type of instrument and the method for working out the results.

### 2.15.1.3 Span Length

It is the distance from a line where the fibre are randomly caught to a point where only a certain percentage of fibres are extending.



- a) 2.5% Span length : 2.5% span length is defined as the distance from the clamp randomly caught on a fibre beard to a point upto which only 2.5% of the fibres extend.
- b) 50% Span length: It is defined as the distance from the clamp on a fibre beard to a point where only 50% of the fibres extend.

#### **2.15.1.4 Uniformity ratio**

It is defined as the ratio between 50% span length and 2.5% span length measured by the instrument Fibrograph.

### **2.15.2 Fibre Fineness**

#### **2.15.2.1 The importance of Fibre fineness**

The determination of the suitability of a material for spinning is based upon the fibre length, where as for many purposes the fineness of the fibres is of equal and sometimes of more important than the length. It is an important quality characteristic which plays a prominent part in determining the spinning performance of cotton especially the long staple varieties. When irregularity is considered the best yarn that can be produced is one in which the fibres are distributed along the strand in a random order. The irregularity in the strand is depend upon the average number of fibres in the cross section for a given count of yarn, will depend on the fibre fineness. If the fibres are fine, the number of fibres in the cross section is more and the irregularity is less. If the same count of yarn is spun from two varieties of cotton, having identical fibre properties other than finess, the yarn spun from the variety having finer fibres will have a larger number of fibers in its cross section is more and the irregularity is less. If the same count of yarn is spun from two varieties of cotton, having identical fibre properties other than finess, 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. Generally, short cottons are coarser than long staple varieties.

When the given material is spun and finer yarns, the number of fibres in the cross section diminishes and the irregularity increases until a point is reached when spinning of further finer yarn is impracticable. This point or limit is known as spinning limit is reached very soon.

From the above facts, the following points can be noted:

1. If a given count is spun from a fine and coarse fibre, a more uniform and stronger yarn can be produced from the fine fibre.
2. A fine fibre can be spun to finer counts than a coarse fibre.

Broadly speaking, the finer the fibre, the greater the total surface area available for inter fibre contact and consequently less twist is needed to provide the necessary cohesion or inter fibre friction. This is reflected in the twist factors used for spinning different types of material.

The fineness of the fibre also affects several mechanical properties and therefore influences the behaviour of the fibre during processing and the properties of the resultant yarns and fabrics. The following are the two most important fibre properties which are affected by the fibre fineness :

1. The Torsional rigidity – resistance of twisting .
2. The stiffness – resistance to bending.

It may be noted that a fibre which is difficult to twist will be difficult to spin because spinning necessarily involves the twisting the fibre. Stiff fibre affect the ability of the fabric to drape and hang gracefully. The fineness of the fibre can often play a more important role in the behaviour of the material than its inherent properties. For example, if the diameter is doubled its rigidity is quadrupled, if increased ten times its rigidity is increased a hundred times. Even materials like glass, which are basically brittle can be quite flexible if made sufficiently fine.

### 2.15.2.2 The Definition of Fibre Fineness

Fibres exhibit a variety of cross sectional shapes and they also vary in section along their length and vary from fibre to fibre. Fineness denotes the size of the cross-sectional dimensions of the area of cross section is difficult and laborious. Some dimensional features such as swollen diameter, ribbon width etc., can be determined directly and sometimes used to specify the fineness of the cotton fibres.

The linear density or weight per unit length of the fibre is the more commonly used index of fineness. The unit in which this quantity is expressed varies in different parts of the world and is dependent on the type of fibre handled.

In England, the linear density is called either the fibre weight per centimeter or the hair weight per centimeter, H, and usually expressed in units of  $10^{-8}$  mg/cm or  $10^{-5}$  mg/cm. The unit commonly used in America is micrograms per inch ( $10^{-5}$  q/inch). After introduction of tex system, the linear density of cotton fibres is expressed in terms of milli tex. Which is the weight in identical with the unit of  $10^{-6}$  g/cm.

### 2.15.2.3 Micronaire Value and Nep

Micronaire value in itself is not a measure of maturity. The growth of the fibre also must be taken into consideration. Micronaire value is a combination of fineness and maturity. For example, coarse Indian cottons generally have higher micronaire values than American cottons, irrespective of maturity. If American cotton is very immature, it will give a lower micronaire value than a finer but mature Egyptian cotton. Cottons of lower maturity. If their micronaire value falls below the average further, the lower is their maturity and the greater the chance of nepping and dyeing.

### **2.15.3 Fibre Maturity**

Fibre maturity is another important characteristics of cotton and is as index of the extent development of the fibres. The maturity of cotton fibre varies not only between fibres of different samples but also between fibres on the same seed. Thus a ripened, full mature cotton boll contains fibres both mature and immature. A cotton fibre consists of a cutice, a primary layer and secondary layers of cellulose surrounding the lumen or central canal. In the case of mature fibres, the secondary wall thickening is very high and in some cases, the lumen is not visible. In the case of immature fibre, due to some physiological causes, the secondary wall thickening is practically absent, leaving a wide lumen throughout the fibre. Hence to a cotton breeder, the presence of excessive immature fibres in a sample would indicate some defect in plant growth, either varietal or environment. To a technologist, the presence of excessive percentage of immature fibre 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.

The determination of fineness of a cotton is affected by maturity of the sample. An immature fibre will show a lower weight per unit length than a mature fibre of the same cotton, as the immature fibre will have less deposition of cellulose inside the fibre. 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.

#### **2.15.3.1 Importance of Maturity**

The maturity of the fibre is concerned with development of the cell wall. The cell wall thickening is highly sensitive to growing conditions. Adverse weather, poor soil. Plant disease and pests etc will increase the proportion of immature fibre and leads to trouble in processing.

One of the main troubles caused by the presence of these thin-walled immature fibre is nepping. Apart from maturity, causes like small bits or fragments of seed particles attached to the fibre also forms neps. Neps are created during processing starting at the ginning stage. Further when rubbing of surfaces takes place as in carding, minute knots of tangled fibres are caused and the immature fibres are more prone to this nepping effect. When fine cottons are being processed, the danger of nepping is even more acute, since the mature fibres 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 fine yarn.

Immaturity also affects the shade affects the shade after dyeing. As the response of the primary wall to certain classes dyestuffs is less intense the thinner the secondary wall lighter in shade than coarse cotton. Apart from this the reflecting surfaces of the fibres of the immaturity is with respect to the patches being shown or the weft bars seen in the fabric when yarn made of immature fibres or yarn spun from cotton of different maturity is used as warp and weft. 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 appear as specks in the dyed cloth. So summarizing the maturity, the following points are noted:

1. Maturity affects the quality of the yarn and also the processing. The effect of immature fibres are seen especially in the spinning process.
2. The large number of ends down in a ring frame is due to the immature fibres.
3. The loss in yarn strength, the dyeing troubles are all due to the presence of immature fibres.

#### **2.15.4 Fibre Strength**

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

#### **2.15.4.1 Tenacity**

It is defined as the force required to break a specimen of fibre or filament having a linear density of one unit. Generally it is expressed in grams per denier (gpd) or grams per tex.

#### **2.15.4.2 Breaking length**

The breaking length is the length of the specimen, which would break under its own weight, when hung vertically. The unit for breaking length is kilometer. It is called RKM value.

#### **2.15.5 Trash Content**

The quality characteristics of cotton which are of importance in assessing the merit of the cotton are fibre length, fibre fineness, maturity, uniformity and trash.

Trash content in a cotton is a measure for the amount of trash present in the cotton expressed as a percentage.

### **2.16 HVI Testing of Cottons**

The efficiency of manufacturing and the quality of textiles is largely determined by the physical properties of fibres. Till 940 cotton quality continued to be evaluated mostly on the basis of hand stapling and visual grading; decisions on when to purchase were taken on the basis of intuitive judgment. The type and proportions of the cottons that are to be used in mixing were decided upon by taking into account the cotton prices as well as the previous experience of the mill with the working of different cottons.

Only in late 50s, the importance of improvement in the method of evolution, purchase of cottons and formulation of mixings was felt in the industry and accordingly instrumental evaluation of cotton quality was introduced slowly and steadily in the industry. The types of instruments commonly used for fibre quality evaluation include:

1. Baer sorter or fibro graph for measuring length and related parameters.
2. Pressley or Stelometer for fibre strength and related aspects.
3. Caustic soda swelling test for assessing micronaire.
4. Trash analyzer

In the year 1973, the performance of conventional testing instruments and the existing technology made it possible to incorporate all the conventional testing unit known as HVI, High Volume Instrument Test System. At present, there is only one company in the world market (Zellweger Uster) who supplies test system,

HVI test system is widely developed countries at various classing / marketing centers and textile mills/ research laboratories.

In India, more than about 60 mills acquired this system to get optimum mixing for producing quality yarns for export market.

#### **2.16.1 Relevance of HVI Testing**

HVI test enables testing of large volume of samples and arrive at a correct estimate of the fibre properties with a short time, so that appropriate mixing can be prepared. Besides, quality of all individual bales and within bale and between bale variations can be assessed. The bales can be categorized into different lots depending on the actual fibre properties. The mills can subsequently evolve a bale

management system, which would enable them to maintain the quality at a consistent level at minimum cost.

### **2.16.2 Properties Assessed and Speed of Test**

Zellweger Uster HVI test system measures seven important characteristics of cotton and they are:

- Length
- Length Uniformity
- Micronaire
- Strength
- Elongation
- Colour and Reflectance
- Trash Content (Optical Determination)

As per manufacturers claim, about 180 samples (each sample –1 test) could be tested for all the above seven properties / hour with two operatives manning the instrument.

However, as per practical experience in Indian laboratories, about 100 samples / shift of 8 hours (each sample – 4 tests) could be conveniently tested using HVI. Because of the high speed of the testing, now technicians are in a position to determine the raw material characteristics with reference to a large enough sample.

In addition, automatic testing systems offer the following advantages:

- The results are practically independent of the operator.
- The results are based on large volume samples and therefore more significant.
- The respective fibre data are immediately available.
- The data are clearly arranged in summarized reports (HVI test system as microprocessors to format the test data for analysis, storage and retrieval).

- The make possible best utilization of the raw material data.
- Problems as a result of the fibre material can be predicted and corrective measures instituted before such problems can occur.

## 2.17 Evenness Testers

Nearly all evenness testers currently in use in the textile industry may be classed as either capacitance or mechanical types, or a combination of these two. The testers most commonly used the Uster testers.

### 2.17.1 Uster Evenness Tester

The uster evenness tester one of the first capacitance type of tester developed, is manufactured by the Zellweger company of Switzerland, and sold in this country by the Uster Corporation of Charlotte, North Carolina. The Uster tester operates on the principle that a change in the mass of the dielectric (non conducting material) in the condenser will change the capacitance. The measuring comb of the tester is actually a set of condensers with an air dielectric. When some material other than air is placed between the plates of one of the condensers, the capacitance is changed in proportion. The shape of the material must also be considered. As long as the cross section of the material is approximately round, the theory outlined above is true. If the material is ribbon-shaped, as for instant low twist, continuous filament rayon yarn, considerable error will result unless auxiliary equipments such as a "Rotfil" is used. The Rotfil simply inserts a false twist in the yarn. So that the ribbon-effect is eliminated.

The method used to determine the amount of capacitance is to measure the change in frequency of an oscillator in which the condenser is the part of the circuit. In the Uster tester, two oscillators are balanced against each other with an adjustment knob provided on the panel to manually equalizes the frequencies. Inserting material in a slot changes the frequency of one oscillator. This oscillator is compared then with other base oscillator by a mixture, which determines the mass of material in the slot at the instance. The result is then

amplified send through the range dividers, gain control, amplified again, and send to the integrator and recording device. The Uster testers has proven to be a versatile instrument for measuring the uniformity of materials ranging from extremely heavy silver to very fine yarns.

### 2.17.2 The imperfection indicator

This is an additional attachment to the instrument and it offers the quality control department greater opportunities for detailed analysis of faults in yarn. Signals from the main unit are fed to the imperfection indicator, which simultaneously measures neps, thick places and thin places. A count of all three types of faults are made and the results shown on separate counters. It is possible to adjust the sensitivity of the system so that a chosen size of fault is counted and smaller faults ignored.

For the sake of classification the faults are defined as follows for Uster tester.

**Neps** : A fault length of 1 mm having a cross section 200% of the average value. This corresponds to a sensitivity settings of '3' on the 'neps' knob of the imperfection indicator.

**Thick Places:** A fault of approximately the fibre length, having a cross section of 50% over the average value 'Thick Places' knob set to '3' corresponds to this definition.

**Thin Places:** A fault length of approximately the fibre length having a cross section approximately 50% less than the average value. The 'thin places' knob sets to '-50%' corresponds to this definition.

## CHAPTER 3

### AIM OF PRESENT WORK

The aim of the current project work is to establish prediction model for yarn unevenness and to develop an software for yarn uniformity characteristics.

The specific objectives of this project work is:

It is a well-established fact that fibre properties influence yarn irregularity and yarn imperfections. This present study of fibre properties and yarn unevenness and imperfections has been undertaken with the following objectives:

- Statistical theoretical models for yarn uniformity characteristics.
- Improvement of model for yarn characteristics.
- Theoretical estimations of imperfections.
- Theoretical estimation of classi-mate faults.

Advantage of this method is, when we give input of mean number of fibres in cross section of yarn, in no matter of time, we would able to calculate the thick, thin, neps in the yarn.

## **CHAPTER 4**

### **METHODOLOGY**

The detailed experimental procedure includes the following steps in sequences:

1. Development of Software.
2. Calculating the number of fibres in the cross section and evaluation of the test results in comparison with the existing Uster and SITRA Data's.

#### **4.1 Development of Software**

Software was developed to calculate the thin places, thick places and neps using the Poisson Distribution of number of fibres in the yarn cross section.

##### **4.1.1 Algorithm Used**

1. Start the process.
2. Read  $\lambda$  (average number of group of fibres in the yarn cross section) from the user.
3. Assign Probability Of Occurrence (POC) = 0.
4. Read  $x_{\min}$  and  $x_{\max}$  from the user.
5. Assign  $x = x_{\min}$ .
6. Compute  $P(x) = (e^{-\lambda} * \lambda^x) / (x!)$  where  $P(x)$  is probability of  $x$  fibres and  $x$  varies from  $x_{\min}$  to  $x_{\max}$ .
7. Compute  $POC = POC + P(x)$ .
8. Increment  $x$  by 1.

9. Repeat steps 6 to 8 until  $x > X_{\max}$ .
10. Display the Probability of Occurrence to the user.
11. Read Imperfection value for 1000 meters of yarn from the user.
12. Compute number of imperfections in 1 KM of yarn (NOI) = POC \* Imperfection value.
13. Display NOI to the user.
14. Repeat steps 3 to 13 for thick places and neps of fibre.
15. Terminate the process.

## 4.2 Computation and Evaluation of the Test

### 4.2.1 General notions

#### 4.2.1.1 Fundamental formulae

When the probability  $p$  of a binomial event occurring is very small but the number  $n$  of trials is sufficiently great for the product  $np$  to maintain a finite magnitude, it can be demonstrated that the binomial distribution tends towards a limit form known as the poisson distribution;  $p_k$  is given by the equation:

$$P_k = (\mu^k/k!) e^{-\mu}$$

With

$$\mu = np$$

The corresponding urn scheme is that in which the proportion of white balls is very small (e.g.  $p=0,001$ ), but the extracted sample is sufficiently large (e.g.  $n=10000$ ) for a number of white balls to be found in it (on average  $np=10$ ). A textile example (that can easily be generalized for other productive sectors) could be that of the faults of a certain fabric: the probability that a fault might be produced in a certain point is very small but the points in which it might occur are very numerous and in fact, a piece often has a certain number of faults.

Poisson distribution is defined by only one parameter,  $\mu$ ; it can be demonstrated that the mean and the variance of the distribution are both equal to  $\mu$ . Therefore:

mean:  $\mu$

Standard deviation :  $\sqrt{\mu}$

Coefficient of variation:  $1/\sqrt{\mu}$

#### 4.2.1.2 Practical calculation

If we know  $\mu$ , the values of  $p^k$  can be calculated by means of the formulae:

$$P_0 = e^{-\mu}$$

$$P_k = (\mu/k)P_{k-1}$$

The calculation of the terms of the poisson distribution is therefore much more rapid than that necessary with the formulae of the binomial distribution which easily justifies the recourse to the poissonian approximation when  $p$  is small.

The error committed is negligible. The recursion is obtained in the following way (with  $np = \mu = 50 \cdot 0,001 = 0,50$ ):

$$P_0 = e^{-0.5} = 0.6068; \quad p_1 = 0.5/1 \cdot 0.6068 = 0.3034; \dots$$

Because poisson distribution depends on one parameter only, it can also be easily tabulated; generally the tables contain the values of the cumulative frequencies  $\sum_{i=0}^k p_i$ .

The values of the elementary probabilities  $p_i$  are obtained by subtraction.

**Table 4.1 Values of the elementary probability**

$\mu k$	0	1	2	3	4	5	6	7	8	9	10
0.1	905	995	1000								
0.2	819	982	999	1000							
0.3	741	963	996	1000							
0.4	670	938	992	999	1000						
0.5	607	910	986	998	1000						
0.6	549	878	977	997	1000						
0.7	497	844	966	994	999	1000					
0.8	449	809	953	991	999	1000					
0.9	407	772	937	987	998	1000					
1	368	736	920	981	996	999	1000				
1.1	333	699	900	974	995	999	1000				
1.2	301	663	879	966	992	998	1000				
1.3	273	627	857	957	989	998	1000				
1.4	247	592	833	946	986	997	999	1000			
1.5	223	558	809	934	981	996	999	1000			
1.6	202	525	783	921	976	994	999	1000			
1.7	183	493	757	907	970	992	998	1000			
1.8	165	463	731	891	964	990	997	999	1000		
1.9	150	434	704	875	956	987	997	999	1000		
2	135	406	677	857	947	983	995	998	1000		
2.2	111	355	623	819	928	975	993	998	1000		
2.4	91	308	570	779	904	964	988	997	999	1000	
2.6	74	267	518	736	877	951	983	995	999	1000	
2.8	61	231	469	692	848	935	976	992	998	999	1000
3	50	199	423	647	815	916	966	988	996	999	1000

**4.2.2 Calculation of the number of fibres in cross section**

The number of fibres in the cross section is given by :

$$\begin{aligned}
 \text{Number of fibres: } n_F &= N_{m\text{Fibre}} / N_{m\text{Yarn}} \\
 &= \text{tex}_{\text{Yarn}} / \text{tex}_{\text{Fibre}} \\
 &= \text{dtex}_{\text{Yarn}} / \text{dtex}_{\text{Fibre}}
 \end{aligned}$$

Micronaire values can be converted into dtex in accordance with the formula:

$$\text{Dtex} = \text{micronaire} * 0.394.$$

#### 4.2.3 Fundamental axioms

Also the theory of bundles like that of martindale has the merit of deriving from a concrete analysis of what happens in a drafting zone, in particular at the level of the line of contact between drafting rollers.

To clarify the idea with a numerical example, let's consider a set of fibres which is fed in the first passage of worsted preparation ; as order of magnitude we could assume 12 silvers ,each of which weighs 20g/m ( $N_m=0.05$ ). Admitting that the wool being processed has a fineness (RCM) of 21.5 microns and an average(numeric)length of 50mm, known formula enable us to calculate that the feeding involves globally  $n_s=(12.971900)/(21.5^2.0.05)=500,000$  fibres per cross section and  $n=500,00/50=10,000$  leading ends of fibre for every mm ,in the direction of advancement of the material. Thus ,the leading ends of the fibres themselves ,distributed over the entire width of the drafting zone ,will on average be 1/10 of a micron (1/10000mm) distant one from other.

Now martindales postulate that the fibres were independent requires that these are accelerated due to the effect of the drafting rollers,one by one :it is therefore intuitive that they should be nipped, along the line of contact between the rollers , in a extremely small zone of width, practically according to a segment of geometrical straight line as long as the drafting the rollers and with zero dimension in the direction of fibres advancement.(fig 4.1).

Having established this, the fundamental hypothesis of the theory of bundles consists simply of denying that is physically possible and supposing ,on the contrary that the fibres are nipped by the rollers in a rectangular zone of width  $\Delta$  of the order of a few microns and a length equal to that of the drafting rollers.(fig 4.2).

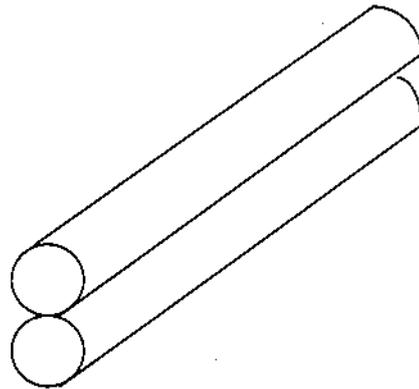


Fig 4.1

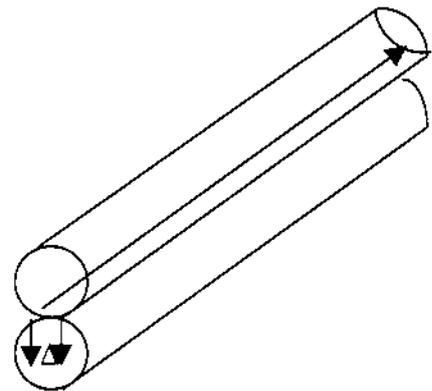


Fig 4.2

In this zone different fibre leading ends will be nipped simultaneously, and they will form a bundle, naturally, so as to allow that the structure of the set be composed of a discontinuous succession of bundles( which thus fulfill the roll of the elementary fibres in martindales model ),it is necessary to imagine that the nipped zone is not present , but animated by a vibratory movement equal to a few dozen microns.

#### 4.2.4 Calculation of Imperfection value for 1000 meter

Here we consider 25mm cut length fiber for calculating imperfections for 1KM.

$$= 1000000\text{mm}/25\text{mm} = 40,000$$

## CHAPTER 5

### RESULTS AND DISCUSSION

The results were analysed and the yarn unevenness and the prediction model of the yarns are drawn using the software.

For calculation purpose three counts were taken for consideration 20's,30's,40's using the theoretical method of calculating the number of fibres in yarn cross section ,micronaire value should be known and the value from SITRA norms where taken.For 20's micronaire value 4.1mgs/inch.For 30's micronaire value 4.1 mgs/inch.For 40's micronaire value 3.8 mgs/inch.

**Table 5.1 Number of fibres in yarn cross section.**

Count	Micronaire Value	No of fibres in yarn cross section.
20	4.1	182
30	4.1	121
40	3.8	98

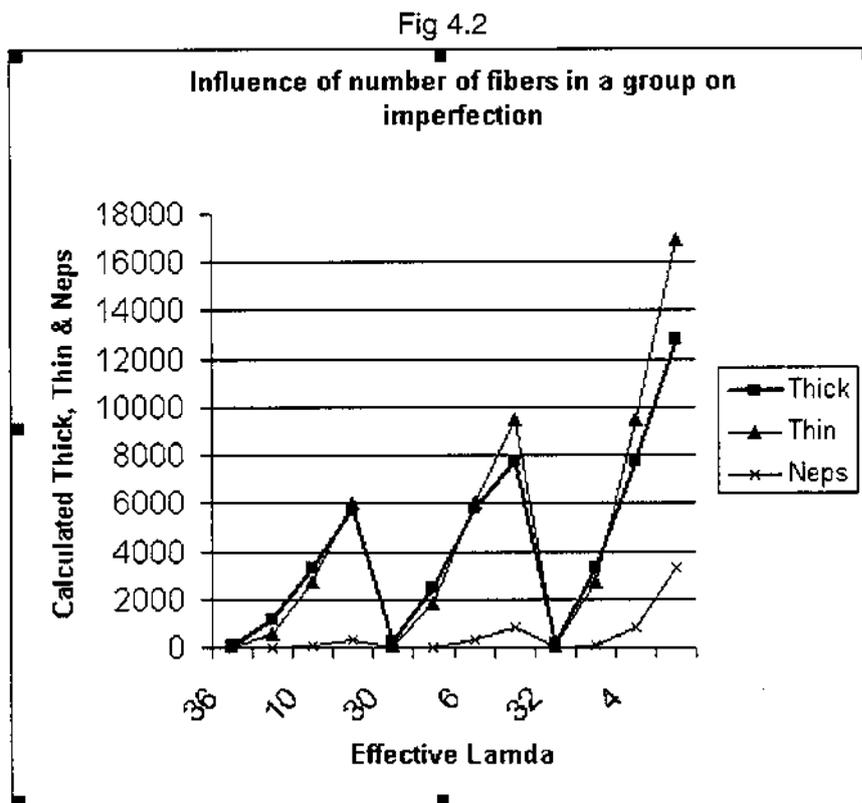
It is observe that ,the fibres are not moving individually. They are moving in groups. But nobody is observed about number of fibres in a group.so it is assumed that fibres are moving in different groups.



Table 5.3 Comparative result of Developed software with existing

Count	Micro Nair Value	No of fibres in cross-section	No of fibres in a group	Lamda	Calculated value			SITRA Norms			Uster 5% Level											
					Thick	Thin	Nep	Thick	Thin	Nep	Thick p lace			Thin place			Neps					
											20	30	40	20	30	40	20	30	40	20	30	40
20	4.1	182	5	36	121	28	0	90	10	140	60	120	200	2	5	9	30	100	250			
			10	18	1127	615	2				60	120	200	2	5	9	30	100	250			
			18	10	3275	2708	63				60	120	200	2	5	9	30	100	250			
			30	6	5757	6048	349				60	120	200	2	5	9	30	100	250			
30	4.1	121	4	30	250	78	0	175	25	300	60	120	200	2	5	9	30	100	250			
			10	12	2491	1833	28				60	120	200	2	5	9	30	100	250			
			20	6	5757	6048	349				60	120	200	2	5	9	30	100	250			
			30	4	7740	9524	853				60	120	200	2	5	9	30	100	250			
40	3.8	98	3	32	196	55	0	275	75	450	60	120	200	2	5	9	30	100	250			
			10	10	3275	2708	63				60	120	200	2	5	9	30	100	250			
			25	4	7740	9524	853				60	120	200	2	5	9	30	100	250			
			30	3	12770	16927	3312				60	120	200	2	5	9	30	100	250			

Then the calculated value is compared with SITRA and USTER 5% level standards.



When the number of fibres in a group reduces the calculated results approach towards the SITRA and USTER standards in thick and thin places, neps are still different from the standards.

## **CHAPTER 6**

### **CONCLUSIONS**

The following conclusions can be drawn from the present study:

The findings of the present work will be of great use in the future to the spinners and quality control personal to predict thick ,thin places. It's well absorbed by the trend that, if number of fibre moving in a group reduces then imperfection reduces. Further studies related to the number of fibres moving in a group and random fibre distribution will give new approach in the field of spinning.

This kind of software's will reduce the huge investment for testing.

## REFERENCES

1. K.P.Chellamani et al, "Fibre-Yarn Relationship Using HVI/FMT Measured Fibre Properties", Proceedings of the 37th Joint Technological Conference, Feb.'96, P. 33 – 47.
2. Lawrence Hunter, " Prediction of cotton Processing Performance and Yarn Properties from HVI Test Results" – Melliand Textilberite, April, '88, E – 123, 124.
3. N.Balasubramanian et al, " Measures for Meeting Quality Requirements of Cotton Yarns for Exports" – A joint project report of ATIRA,BTRA,NITRA and SITRA, March, '94.
4. S.K.Chattopadyay et al, " Influence of Raw Material / Process Factors on Yarn Faults" Indian Tex, J.,Jan. '90,P. 68 – 75.
5. Dip. Ing.Christoph Farber, "Influence of AFIS Nep and Trash Particle count in determining Imperfections Levels of Cotton Ring and Rotor Yarns" – Melliand Textilberite, Oct. '96, E 141 – 143.
6. T.V.Ratnam, et al, " Some Factors Affecting Yarn Irregularity" – J.T.I.Feb. '74, P. 61- 67
7. M.S.Parthasarthy et al, " An Analysis on the occurrence of faults in Cotton Yarns" – Asian Tex. J.May ' 95, P.17 – 20.
8. Dr. A.Basu, "The Neps – Sources and Control" – Asian Tex J., Feb. ' 94, P. 33
8. N.Balasubramanian , " Influence of Cotton Quality" – Indian Tex. J., Nov. ' 95, P. 48 – 58.10. G.A.R. Foster, " The Principles of Roller Drafting and the Irregularity of Drafter Materials", Manual of Cotton Spinning, vol. 4, Part – I (Textile Institute, Manchester, 1958).
9. Elliot B. Grover and D.S.Hamby, " Hand Book of Textile Testing and Quality Control".
10. J.E. Booth, 'Principles of Textile Testing'.

11. A.R.Garde and T.A. Subramanian, "Process Control in Cotton Spinning", ATIRA Silver Jubilee Monograph, 1978.
12. "Mathematical modeling" -.Galbraith.
13. J.G.Martindale, "A New Method of Measuring the Irregularity of Yarn with some observations on the origin of Irregularities in worsted sliver and yarns.(Journal of the Textile Institute-march 1945).
14. Textile yarns -B.C.Goswami.
15. L.H.c. Tippett,M.Sc," STATISTICAL METHOD IN TEXTILE RESEARCH" use of binomial & poisson distributions .(Journal of the Textile Institute-march 1935).T-17 to T-70.
16. A.R.Garde and T.A. Subramanian, "Process Control in Cotton Spinning", ATIRA Silver Jubilee Monograph, 1978.
17. "Mathematical modeling" -.Galbraith.
18. J.G.Martindale, "A New Method of Measuring the Irregularity of Yarn with some observations on the origin of Irregularities in worsted sliver and yarns.(Journal of the Textile Institute-march 1945).
19. Textile yarns -B.C.Goswami.
20. L.H.c. Tippett,M.Sc," STATISTICAL METHOD IN TEXTILE RESEARCH" use of binomial & poisson distributions .(Journal of the Textile Institute-march 1935).T-17 to T-70.