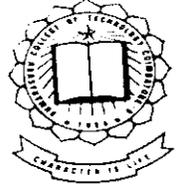
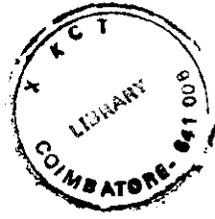


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# A STUDY OF FIBRE MIGRATION IN COMPACT YARN

By

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**A PROJECT REPORT**  
Submitted to the

**FACULTY OF TECHNOLOGY**

**In partial fulfillment of the requirements**  
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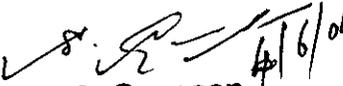
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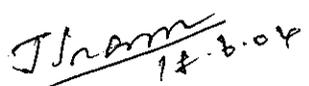
## BONAFIDE CERTIFICATE

Certified that this project report titled "A STUDY OF FIBRE MIGRATION IN COMPACT YARN" is the bonafide work of Mr.G.Ramakrishanan, 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 or any other candidate.

  
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## ABSTRACT

This project is aimed at analyzing one of the important structural characteristic namely the 'Fibre Migration' of 'Short Staple Compact Spun Yarn', while attempting to review the various researches carried out in this regard on spun yarn. The recent development of Compact Spinning Technology for staple yarns, in which the size of the spinning triangle has significantly gone down, has a decisive influence on the migratory characteristic of fibres in the constituent yarns apart from other factors. Lesser the size of spinning triangle, less gradient the tension variation among fibres and hence a lesser degree of migration expected to occur in Compact Spun Yarn than on ring yarn, a hypothesis, which is being studied experimentally in this paper. The review reveals that use of conventional methods of migration analysis with Projection Microscope (Projectina) has been sidelined with the invention of CCD Camera and on-line image processing technology, which has certain advantage in three-dimensional analysis of migration.

Combed 100% cotton yarn of 40s Ne and 52s Ne were produced on Ring and EliTe Compact spinning system. The roving used to produce the above yarns contains the tracer fibres to tune of 1.0% by weight. A Projection microscope fitted with CCD camera has been to capture the images of the tracer fibre

The paper reveals that there is a reduction of Mean Fibre Position, RMS Deviation and Mean Migration Intensity to the tune of 10 % -25 % for the Compact Yarn. The reason for higher tenacity in spite of lesser migration of fibres has been found to be better integration of fibres in the yarn body and increased packing density of yarn due to reduction in overall diameter of yarn which was revealed in testing the yarn in USTER 4 SX – OM Module Equipment.

**Key words:** Migration, Spinning Triangle, Tension Mechanism, Mean Fibre  
Migration Intensity

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## CHAPTER 1

### INTRODUCTION

The mechanical properties of staple yarns depend not only on physical properties of constituent fibres but also on yarn structure characterised by geometrical arrangement of fibres in yarn of the various structural properties for staple yarn. The relative fibre movement at the point of yarn formation (Fibre migration) and the resultant position of fibres in the yarn structure has a significant influence on yarn properties such as strength, 'CV' of strength, elongation, hairiness running performance.

The 'Fibre migration' characteristic in staple yarn is to a great extent influenced by fibre properties, spinning system adopted, (or) fibre accumulation mechanism and relative tension of fibre at the point of yarn formation.

Of the widely used systems of the production of staple yarns such as Ring, Rotor and Friction, Ring yarn exhibits highest fibre migration followed by Rotor and Friction spun the least, based on spinning tension and its variation. In 'Compact spinning systems the significantly reduced spinning triangle to the extent of 20% of conventional Ring yarn (base of triangle 2-3 from 0.5mm) which in turn leads to less variation in path distance among fibres of drafted stand. This results in less variation in tension among the fibres than in conventional Ring yarn and hence the migratory characteristic of it is expected to lie somewhere between Ring and open end spinning systems.

Inspite of a expected low migration which is in turn contrast to the theory of Morton (i.e.) in which he says that staple yarn needs migration to show strength, compact yarns possess higher strength which in turn requires

a thorough analysis of various structural parameters such as packing density, spatial orientation angle apart from the study of fibre migration.

In this project the fibre migration behaviour in short staple compact yarn spun from cotton is taken up.

## **1.1 CONCEPTS - TECHNOLOGIES**

### **1.1.1 Concept of fibre migration and its need:**

The fundamental assumption that is most commonly made is that yarn is built up of super imposed concentric layers in each of which the fibres are considered to follow simple helical path. The helix angle is zero for axial position and increases with each layer in accordance with increasing helix radius until at the surface layer where it reaches a maximum which is in turn determined by the amount of twist inserted.

For such yarns to be produced which is not practically possible, it will not survive any handling because however much twist might be present there would be nothing to prevent the successive layer from peeling off at the slightest sign of surface abrasion. Hence (Morton and Yen 1952) found that some degree of fibre entanglement is essential and it is necessary to know the form of this entanglement known as study of fibre migration.

For producing yarns of such type either each fibre would have to be delivered at a speed corresponding to its helix radius or else the leading end of each fibre would have to retract by an appropriate amount before it is gathered to form a yarn.

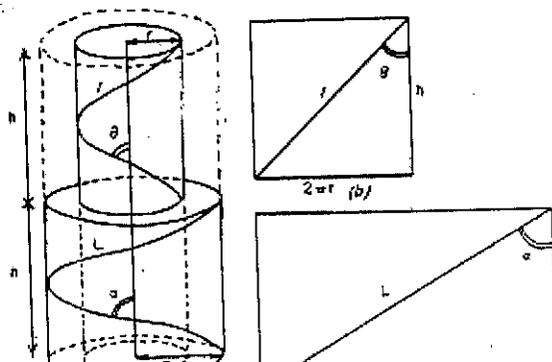
Neither of the above requirements is possible because the roller delivery is constant for all fibres and frictional grip provided by the twist insertion prevents such movements.

It follows therefore that during twist insertion the fibres must be subjected to different tensions ranging from minimum at core to a maximum at surface of yarn. This results in tendency of inner fibres to buckle out of their planes of motion and outer fibres to interchange position with inner fibres in order to equalise tensions.

The phenomenon of individual fibres exhibiting variable helix radii at different points along their length is called "FIBRE MIGRATION" and (Morton and Yen 1952) proposed this term.

### 1.1.2 Ideal migration

The fibre is set to exhibit an ideal migration if it migrates regularly and uniformly from out side to centre of the yarn and then back to outside assuming the yarn has circular in cross section through out the structure. In such condition fibres are to follow helical path around concentric layers of constant radius so that density of packing is constant throughout yarn length. The fibre, which exhibits ideal helical geometry, is shown in figure -



Consider "r" as the helix radius of fibre, which makes an angle  $\theta$  with the yarn axis, and "R" as the radius of the fibre helix at the surface making the helix angle  $\alpha$  with the axis. The length along the fibre is denoted by "q" and the yarn length is denoted by "z" (Morton and Yen, 1952).

The helix angle  $\theta$  of fibre at intermediate position will be measured by  $\tan \theta$  is equal to  $2\pi r / h$ , Where, "h" is the yarn length for one complete turn of fibre. If "l" is considered as the length of fibre for one complete turn it can be determined from the relation "l" is equal to "h" /  $\cos \theta$ .

Thus "l" increases as  $\theta$  increases and it reaches maximum for outer layer which follows longer helical path. If the yarn is divided into different zones of equal radial spacing the area increases proportionately as the radius increases. Thus there will be longer length of fibre present in outer zones in the case of idealised helical structure as shown in figure --- which indicates variation of "r" with "q".

If the pattern is divided into different zones of equal area then the distribution of fibre length in all zones will be equal as shown in figure, which indicates  $r^2$  with "q". This was discussed by Hearle et.al (1965).

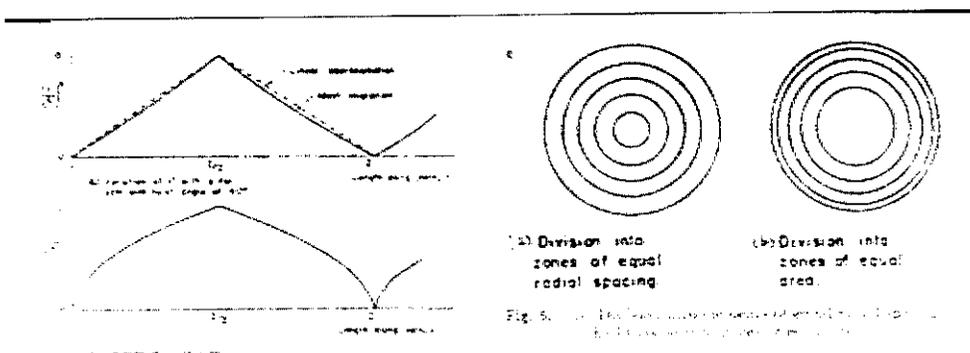


Fig. 5. (a) Division into zones of equal radial spacing. (b) Division into zones of equal area.

### 1.1.3 Concept of Ring Spinning

In the manufacture of classical or conventional Ring yarn the roving in the redrafting zone will be subjected to a small tension draft, and at the same time the roving twist to a large extent removed. In the main zone of drafting system the fibre band will be reduced to the desired yarn count. At the same time the cohesion within the fibre band is mainly lost, so that individual fibres reach the delivery clamping line in a completely open condition or flat ribbon form for twisting, which results in the formation of wrapped structure.

Immediately after the fibres have left the delivery clamping line they are twisted together to form the finished yarn in the so-called "Spinning triangle".

Since the spinning triangle is much wider resulting in higher gradient tension variation among fibres and hence a high degree of migration occurs.

The spinning triangle has a decisive influence on yarn surface (hairiness), yarn strength, and yarn elasticity, running performance and fly liberation.

Because of wider spinning triangle peripheral fibres are quite often not integrated in to the yarn. During twist insertion fibres are tensioned in longitudinal direction and this tension reaches a maximum value at the outside of spinning triangle and minimum at the centre.

In the finished yarn there are thus fibres of unequal initial tension when the yarn is subjected to tensile stress the individual fibres with maximum amount of pretension will break first. This means the fibres forming the yarn body when subjected to load will break one after other and not simultaneously which explains why the total yarn strength is lower than sum of individual fibre strength in yarn cross section.

#### 1.1. 4 Concept of Compact Spinning

In order to increase yarn strength, reduce yarn hairiness and fly liberation and to improve operating performance, it is necessary to eliminate the spinning triangle. For twist insertion the fibre should be parallel, straightened and lie as close to each other as possible

In the "Comforspin" process the fibres are compacted aerodynamically after the main draft. Thus they lie much closer together and parallel with each other. The fibre flow reaching the spinning triangle is so narrow that first the spinning triangle is reduced to a minimum and second all the fibres are caught by the spinning triangle and thus fully integrated into the yarn structure.

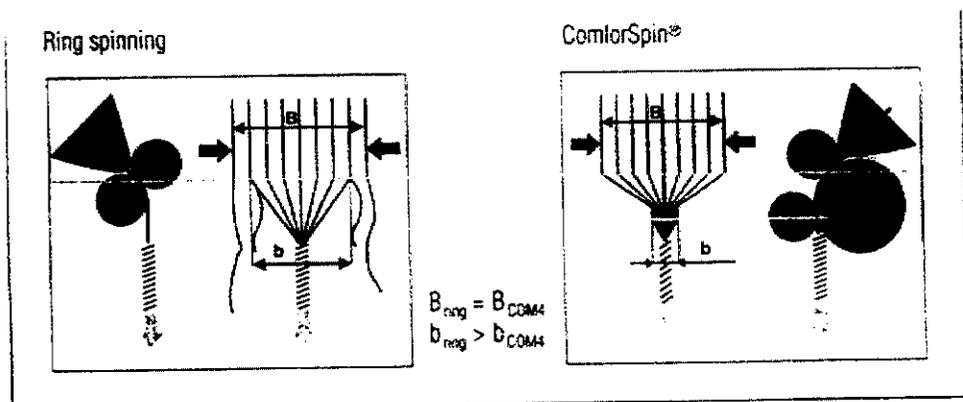


Fig 1.3 Spinning triangle for Ring and Compact systems

Because of the significantly reduced size of spinning triangle (from 2-3mm base in conventional Ring Spinning to 0.5 mm base in compact spinning) resulting in less variation in path distance among fibres of drafted strand. This in turn results in less tension variation among fibres than Ring Yarn and hence less expected migration behaviour of compact yarns but yields a more strength a hypothesis which will be studied thoroughly. In general, migration is expected to lie somewhere between Ring and Rotor yarns.

## CHAPTER 2

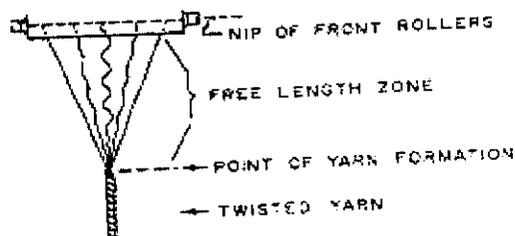
### REVIEW OF LITERATURE:

#### 2.1 Mechanism of Fibre Migration:

There are basically two different types of mechanisms viz. Tension mechanism proposed by (Morton & Yen 1952) and Geometric mechanism proposed by Hearle J.W. et.al (1965) which in turn has a decisive influence on migration behaviour of staple yarns. In staple and filament yarns, migrations occur due to combined mechanisms of both geometric and tension dependent mechanisms. In case of staple yarns tension mechanism predominates to give rapid migrations and is superimposed on a slow migration, which appears due to geometric mechanism. In continuous filament both the mechanisms play a significant role.

##### 2.1.1 Tension Mechanism:

(Morton 1956) explained the migrations on the basis of tension differences, which exists among fibre components at the point of yarn formations. These tension differences are greatly influenced by size of spinning triangles. When yarn is given some twist, fibres follow helical path with length of fibre path decreases from surface to core.



Fibers with varying amount of slack in the free-length zone.

Since twist is the main strain inducing factor, the force acting over the fibre which are forming outer layer of yarn with the larger curvature of their path will be more and corresponding force at the core region will be zero. Thus the difference in radial forces which exists among component fibres cause movement of surface layers towards the core region displacing the less highly tensioned fibres already there which are themselves displaced when their tension is fallen. Thus angle of helix envelope varies throughout the fibre length showing migrations. This is referred as "Short term migration" and is predominant.

### **2.1.2 Geometric Mechanism:**

This mechanism was proposed by (Hearle & Bose 1965), and alongwith tension mechanism to influence the migration behaviour of fibres. Geometric mechanism is based on ribbon twisting, which gives a wrapped structure. Migration period is influenced by roving twist x draft. This geometric mechanism is "long term migration " and regular.

## **2.2 Migration in Staple and Filament Yarns:**

### **2.2.1 Migration in Staple Yarns:**

In staple yarns migration of fibres is all more desirable since it is the migration that helps in radial forces developed by yarn twisting torque to produce cohesion in the yarn giving it strength and stability (B S Gupta & Hamby, 1965). Because of discontinuous nature of staple fibres, migration becomes much more complex. The twisting force together with inter fibre friction will cause the fibres to be longitudinally extended. Those forming outer layers take longer path and are highly strained than corresponding inner layers. This condition allows the highly strained surface fibres to slip between inner fibres, since they are lower tension, which can't be sufficient to make such outward movement. When the fibre end leaves the front roller nip its tension drops to zero. If the free end is following those fibres, which are

forming outer layer, it may very well go into the core region. Otherwise it will tend to move in the direction of migration and it may become a projecting hair (Morton & Yen, 1952)

### **2.2.2 Migration in Cut Staple Fibres:**

The cut staple fibres have a lower tendency to migrate than continuous filaments. It will be still low in case of short fibre materials. The high degrees of fibre angles and spinning conditions have significant controls over movement of fibres. During the yarn formations, short and coarse fibres form the outer layer, long and finer fibres occupy the core. If fibres of same staple length are blended fibres with high modulus could occupy the inner zones of the structure (Morton, 1956). Greater the number of fibre in cross section, greater will be the obstruction, which each fibre has to overcome during migration.

### **2.2.3 Migration in Filament Yarns:**

In filament yarns, the filaments, which are at the outer region, are highly strained than the core filaments, which are slack or buckled. So, highly tensioned filaments will move into core regions to ease their tension by displacing the slack one to outer place. Though a perfect geometry is expected, the pitch of fibre will not remain constant due to some degree of inequality of stress developed during radial movement because of the reason that some force is required to move the filament from one position to other (Morton & Yen, 1952).

The continuous filament twisted in the form of a cylindrical bundle also show some degree of radial movement but there could not be any large scale migration as a consequence of tension differences (Riding 1959).

### 2.2.4 Migration in Multi-Ply Yarns:

In multi-ply yarns, one-ply forms core position while the other plies follow a helical path in the outer layer when the structure is twisted. So the difference in tension develops between the plies and it initiates migration. When the central ply is in slack condition it will be easily pushed out and replaced by outer plies. If the central ply is under high tension, there will not be any migrations even if the outer plies are under much higher tension (Hearle & Merchant, 1962).

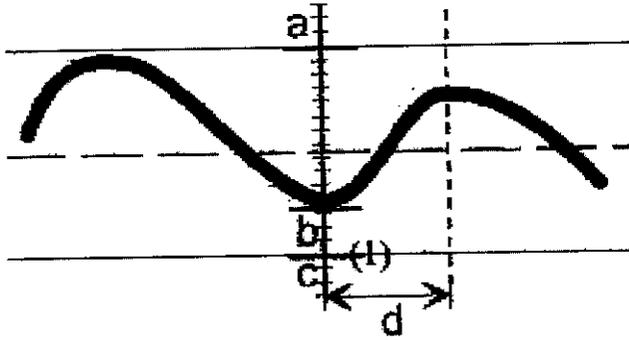
### 2.3 Characterization of Fibre Migration:

(Morton 1956) suggested few methods for characterizing the features of radial position of fibres in yarn. Since it does not yield a clear understanding on the characterisation of migration behaviour of fibre, Hearle et.al (1965) suggested some more methods to quantify the characteristics of fibre migration using an analogy with a method of describing electric current. (Riding 1964) used a different approach using a graphical method named as "**CORROLOGRAM**" to study the frequency of filament migration in continuous filament yarns.

Recently (Kim, Huh & Ryu) have defined a new parameter which can represent total migration known as "**MIGRATION FACTOR**", given by the product of R.M.S. & Migration intensity.

#### 2.3.1 Parameters for Characterization of Fibre Migration:

The following are the parameters used to Characterize Fibre Migration Proposed by Hearle et al(1965).



**Fig 2.2 Parameter for Characterising Fibre Migration**

### 2.3.1.1 Mean Fibre Position

This represents the overall tendency of a fibre to be near the surface or near the centre of the yarn. It can be calculated from the formula

$$\bar{y} = \frac{1}{z} \int_0^z y dZ = \frac{\sum y}{n} \quad (2.1)$$

Where

$$Y = \left( \frac{r}{R} \right)^2 \quad (2.2)$$

r= helix radius

R= Yarn radius

z= length along the yarn

n = number of observations

### 2.3.1.2 Amplitude of Migration:

This is the magnitude of the deviations from the mean positions and is represented by the root mean square deviations (R M S ) given by

$$D = \left[ \frac{1}{z} \int_0^z (Y - \bar{Y})^2 \right]^{\frac{1}{2}} = \left[ \frac{\sum Y - \bar{Y}}{n} \right]^{\frac{1}{2}} \quad (2.3)$$

### 2.3.1.3 Rate of Migration:

This gives the rate of change of radial position, for this mean migration intensity ( $I$ ) is used.

$$I = \left[ \frac{1}{z} \int_0^z \left( \frac{dY}{dZ} \right)^2 dZ \right]^{\frac{1}{2}} = \left[ \sum \left( \frac{dY}{dZ} \right)^2 / n \right]^{\frac{1}{2}} \quad (2.4)$$

The modified form the above formula is

$$I = \left[ \frac{\sum \left( \frac{Y_1 - Y_2}{L_1} \right)^2}{n} \right]^{\frac{1}{2}} \quad (2.5)$$

### 2.3.1.4 Equivalent Migration Frequency:

This is derived using Migration Intensity ( $I$ ) and RMS ( $D$ ) value .

$$\text{Equivalent Migration Frequency} = I / 4D^3 \quad (2.6)$$

### 2.3.1.5 Migration Factor

The migration parameters defined by (Hearle 1965) are composed of four parameters mentioned above. It is thus confusing and since each parameter itself contains its own physical measure. In general these values can show trends different from each other for various process variables or material characteristics. Thus it is desirable to define a new parameter that can represent a measure of total migration. Basically

migration can be thought of as a phenomenon resulting from balancing different tensions in fibres exerted during spinning process and the different tensions on fibres as the cause for disturbance of fibre layers which appears as migrations. In general the disturbances can be described with two measures such as magnitude and frequency. Thus a new parameter describing total migration effect should include magnitude and frequency. It is given by "MIGRATION FACTOR" which is a product of RMS deviations (  $D$  ) and migration intensity (  $I$  )

## **2.4 Factors Influencing Fibre Migration:**

Following are the factors that influences the Fibre Migration

### **2.4.1 Fibre Factors:**

These include the physical properties of length, fineness, cross sectional shape, frictional properties, fibre substance and mechanical properties such as tensile modulus, bending modulus, torsional rigidity, elastic recovery and extensibility. Generally finer and longer fibres tend to move to the core, shorter and coarser fibre move outward and increase yarn hairiness. Fibres with high modulus and frictional properties are associated with inward displacement. Displacement due to fibre substance is complicated, but its effect on displacement is small and negligible.

### **2.4. 2 Yarn Factors:**

This group includes yarn count, roving twist, spinning twist, blend proportions and fibre entanglement. The migrational behaviour of a fibre is influenced by its mean radial position in yarn. Surface fibres show least tendency to migrate while core fibres exhibit short term but low amplitude migration. Fibres in intermediate layers tend to a more complex cycle of migration.

### **2.4.3 Process Factors:**

This includes machine geometry and setting, drafting system, amount of draft, spinning tension and the position of fibres emerging from delivery rollers. Spindle speed and spinning tension influences the migration to some extent. The degree of fibre migration in open end yarn is much lower than that of ring spun yarn because the fibres do not form a flat ribbon immediately before the twist is inserted.

## **2.5. Migration in Various Spinning Systems:**

### **2.5.1. Ring Spinning:**

In Ring Spinning, a flat ribbon like fibre assembly delivered by a roller pair is twisted into a yarn. As the nip of front roller restrains fibre movement there is wide range of fibre tension variation generated across the fibre bundle which causes the fibre to migrate.

### **2.5.2 Rotor Spinning:**

In open-end rotor spinning, fibres accumulate in rotor groups and are twisted into yarn under very low-tension variation within a strand. The yarn core has almost the same structure as the Ring spun yarn but the yarn sheath consists of fibres experiencing "Different Twist" and almost no migration. Therefore the fibres in rotor spun yarn take part in migration to a lesser extent than in Ring Spun yarn.

### **2.5.3. Friction Spinning:**

The friction spun yarn is made from fibres transferred onto cone shaped partial yarn that is rotating around its own axis. One end of fibre comes to lie on the yarn surface and the other end in the yarn core. The

mean tension exerted on individual fibres while twisting is very low. As a result migration occurs almost in one direction and is very weak.

#### 2.5.4 Air Jet Ring Spinning:

The Air jet nozzle was kept at five different positions in between roller nip and lappet hook from the nip of front roller to study the effect of fibre migration. From the study it was found that migration factor shows the maximum value in respect of Air jet ring spun yarn with S and Z nozzles in the first positions.

Indeed, from the migration factor values representing total degree of migration the Ring spun yarn has the highest value of 1.03 and so highest migration effect. This is followed by Rotor spun yarn, which has a migration factor of 0.7. And Friction spun yarn has the weakest migration with a migration factor of 0.51. From this it is evident the spinning principle (i.e.) twist insertion, fibre feeding and spinning tension at yarn formation points seems to lead to a different migratory behaviour (You Huh, Young Ryul Kim & William Oxenham, *TRJ*, 2002)

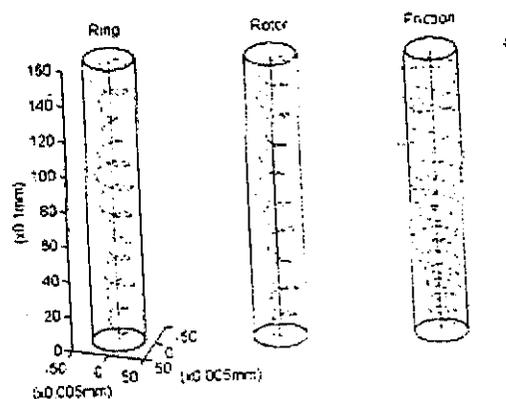


FIGURE 3. Typical fiber trajectories for yarns manufactured by various spinning methods

### 2.5.5 Migration Characteristics For Various Cotton Yarns:

The Following Table gives the migration characteristics for the various spinning system as reported by Kim Hue et al

Table 2.1 Migration Characteristics for the Various Spinning Systems

Sample Yarn	Count Ne	Mean fibre Position	Migration Factor (D x l )
RINGYARN	10	0.49	1.03(0.27 X 3.82)
ROTOR YARN	10	0.4	0.7 (0.23X 3.05)
FRICTION YARN	10	0.6	0.51 (0.23 X 2.22)

### 2.6 Techniques for Preparation of Samples for Migration Study:

Following techniques are used for the preparation of samples for the study.

#### 2.6.1 Tracer Fibre Technique:

The Tracer Fibre technique was originally developed to study the fibre arrangements in fibro sliver by (Morton & Summers 1949). Later on (Morton & Yen 1952) adopted this technique to study the radial position of fibres in the yarn.

This technique involves introduction of black dyed fibres of approximately 1% in proportion of total weight of fibres into the body of yarn and then optically dissolving the grey fibres by immersing the yarn samples in a solution of same refractive index thereby facilitating the dyed fibres to be scanned using a microscope. Using the Vernier Scale of traversing stage,

along the yarn length to construct a helix envelope for the whole length of fibre analysed (Morton & Yen 1952).

### **2.6.2 Radio-Active Fibre- Tracer Technique:**

This technique was also developed to investigate the configuration of fibres by giving the radioactive treatment to the fibres and then preparing auto-radiographs for the analysis (Hickie and Chaikan, *TRJ*, 1960).

## **2.7 Instrumentation and Analysis of Migration in Different Directions**

It was possible to view yarns only from one direction using a microscope. (Riding 1964) adopted a different procedure to view the specimen from two directions at right angles simultaneously in order to carry out a quantitative analysis.

(Hearle and Gupta 1965) pointed out that if the analysis is carried out for large number of tracers per sample (>20) then there is no need to make observations in two different planes.

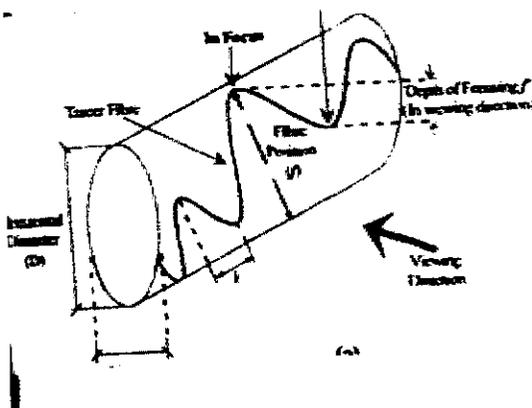
(Wray & Troung 1965) made further modification to simplify the procedure by facilitating the possibility of overall viewing of numerous yarn samples simultaneously but in one plane thereby reducing the time, labour and cost of materials.

Again (Wray 1966) introduced another simple technique, in this method for the circumferential viewing of yarn specimens. He developed a Perspex frame with a central rectangular slot running along the length to carry the rotatable glass tube which contains yarn sample and isolation liquid and rotated it to view the fibre position on a screen at all angles.

### 2.7.1 New 3-D Analysis of Migration Using Microscope:

A. Primentas (C. Iype) introduced a new 3-D analysis (JTATM 2001) using projection microscopes in which he considered the level of focussing depth as a measure of the fibre position along Z-axis with respect to the body of yarn.

With suitable reference depth it became possible to plot position of tracer fibres with reference to both screen co-ordinates and rotary position of knob.



**Fig 2.4 New 3 D Analysis of Migration**

### 2.7.2 3-D Analysis of Migration Using Image Analyser:

This system requires an image capturing system with sample mounting arrangements. This technique was used by (Youhuh, Young Ryul Kim & Woon Young Ryu TRJ 2001) to study the migration in three dimensions since the path followed by fibres in a yarn is a three dimensional one.

The equipment consists of a

- Sample mounting device including a vessel mirror
- Continuous sample feed and a delivery unit with tensioning apparatus.
- CCD camera equipped with clear distance lens.
- An image processing system controller with power supplies and light source.

### 2.7.3 Data Acquisition:

Tracer Fibre is observed in the monitor with the data acquired from CCD camera. Image for the whole length of tracer is captured in vision control system and image data stored in the computer. Each image is sequentially re-established to transform the image data in such a way has to yield the trajectory of a Tracer fibre. Image of each frame that is stored in computer contains information (X & Y co-ordinates) on location of tracer fibre in each cross section with yarn axis representing Z-co ordinate.

The information on Tracer Fibre location is extracted from each image frame in the form of Cartesian Co-ordinate system.

## CHAPTER 3

### RESEARCH OBJECTIVES

The Compact spinning system offers a lot of scope to undertake various Research studies pertaining to structural characteristic of yarn. The present study aims to

- Characterize the migration behaviour of fibres in short staple **COMPACT SPUN YARN** in relation to normal **RING SPUN YARN**
- And to correlate the improvement in the physical properties of **COMPACT YARN** with that of changes in migration & Packing density

## CHAPTER 4

### MATERIAL AND METHODS

#### 4.1 Materials for the study

Following are the details of material used for the experiments

- The Cotton variety H-4 with a 2.5 % Span Length of 30. mm and fineness 4.0 was used for the preparation of Ring and Compact yarns with tracer fibres
- A small proportion i.e. 1.0% by weight of above fibres were black dyed & used as tracer fibres, which were introduced in the Carding stage with the remaining un-dyed material.
- The linear density of roving used was Ne 1.37 The yarn count selected and spun for the study was Ne 40s and Ne 52s
- The tracer fibre incorporated roving was used in two spindles to produce compact yarn in a commercial machine. For the production of Ring yarn the same spindles with out compacting attachment was used while keeping the process parameters such as Spindle Speed, Twist Factor and Traveller Weight identical for both yarn as given below.

**Table 4.1- Experimental plan for both Ring and Compact yarn**

Particulars	40s Ne Yarn	52s Ne Yarn
Spindle Speed (rpm)	13000	18500
Ring Dia(mm)	41	36
Lift(mm)	170	160
Yarn TM ( $\alpha$ e)	4.2	3.95
Yarn TPI	26.5	28.5

## **4.2. Techniques adopted for migration study**

The standard Tracer-fibre technique has been used for the study

The yarn thus produced using tracer fibres is immersed in liquid medium (Methyl Salicylate) having the same (or) substantially the same refractive index as that of fibres concerned. The yarn being examined under a low power microscope, the un-coloured fibres disappear from view leaving the path of each tracer-coloured fibre to be clearly visible.

The tracer is seen against the faint background of yarn body as the wavy line representing the projection in one plane of helix. Ten Tracer Fibres were observed for each type and count of yarn

## **4. 3 Instrumentation used for the study**

The present study is confined to the use of Projection Microscope (Projectina) fitted with CCD Camera and unidirectional analysis of projection. A 'Projectina' consisting of a microscope with built in turret magnification of 40x is used for migration study.

## **4. 4 Procedure used for the Migration Study using ' projectina'**

A light source positioned in front of glass slide directly opposite to microscope focuses a beam of plane polarized light on yarn clamped inside the slide. The CCD camera of the 'Projectina" picks up the image of yarn and transferred to the on the PC Screen, where measurements are done. The stage carrying glass slide could be moved by screw and movements are known through a vernier scale provided. This arrangement makes it possible to study yarn structure in one plane passing through axis of yarn.

## CHAPTER 5

## RESULTS AND DISCUSSION

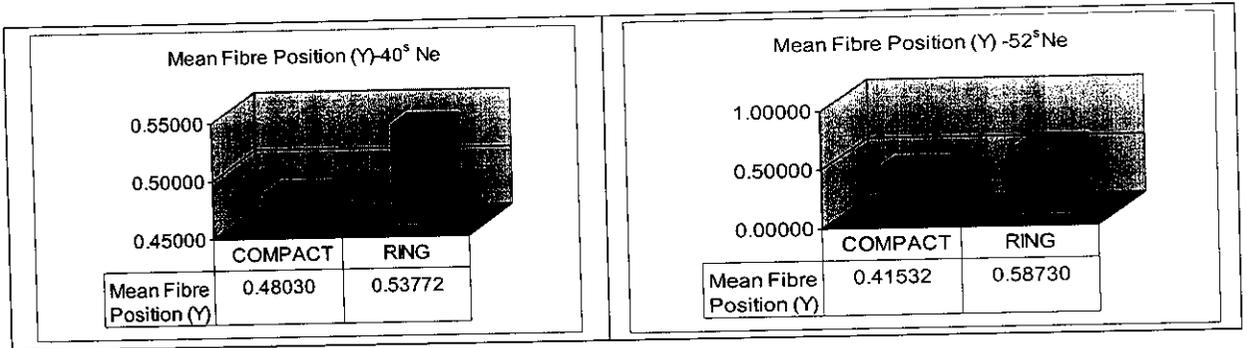
The Table 5.1 & 5.2 gives the Migration Characterization Data Summary obtained from measurements taken each on 10 tracer fibres of Ring and Compact yarn of 40s & 52s Combed Cotton yarn. The Appendix 1 & 2 furnishes the details of the data

**Table 5.1- Summary of Migration Characterization data for Compact and Ring yarn (40s Ne)**

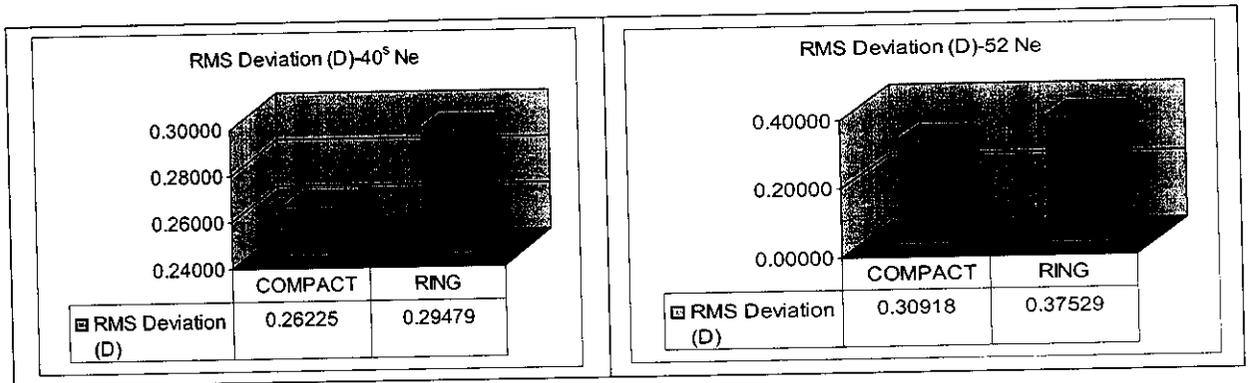
Parameters	Yarn Dia.-mm		Mean Fibre Position		RMS Devia. ( D )		Migration Intensity(I) cm <sup>-1</sup>	
	COMPACT	RING	COMPACT	RING	COMPACT	RING	COMPACT	RING
Overall Mean	0.13384	0.14995	0.48030	0.53772	0.26225	0.29479	10.46379	11.60218
S.D of Mean	0.00577	0.00601	0.10067	0.06808	0.03597	0.03253	1.79399	2.61815
c.v % of Mean	4.31471	4.00798	20.95972	12.66148	13.71671	11.03559	17.14478	22.56598
T <sub>95%</sub> /F <sub>95%</sub> & T <sub>Act</sub> /F <sub>Act</sub>	T=2.262	6.115	T=2.262	1.494	F=1.22	1.264	T=2.262	1.134
S.D. of Individl.			0.26859	0.29983				
C.V. % Individl.	8.55680	7.66796	55.92123	55.75908				
T <sub>95%</sub> & T <sub>Ac</sub> Of Individl.	T=1.96	14.033	T=1.96	2.017				
Equi. Mig. Freq. cm <sup>-1</sup>							5.7590	5.6808
Mig. Factor-cm <sup>-1</sup>							2.7441	3.4202

**Table 5.2- Summary of Migration Characterization data for Compact and Ring yarn (52s Ne)**

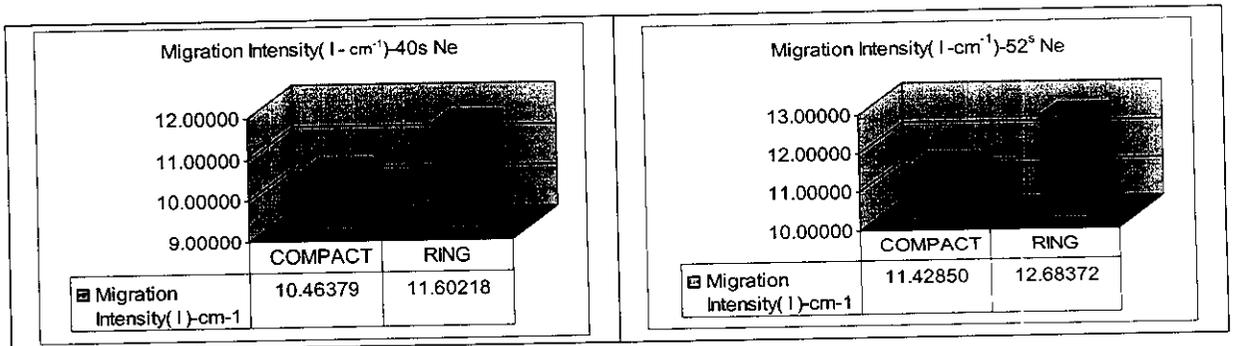
Parameters	Yarn Dia.-mm		Mean Fibre Position		RMS Devia. ( D )		Migration Intensity(I) cm <sup>-1</sup>	
	COMPACT	RING	COMPACT	RING	COMPACT	RING	COMPACT	RING
Overall Mean	0.12394	0.14382	0.41532	0.58730	0.30918	0.37529	11.42825	12.68512
S.D of Mean	0.01100	0.00964	0.12519	0.14940	0.07991	0.10394	4.13975	3.80938
c.v % of Mean	8.87818	6.70028	30.14259	25.43917	25.84597	27.69494	36.22382	30.03028
T <sub>95%</sub> /F <sub>95%</sub> & T <sub>Act</sub> /F <sub>Act</sub>	T=2.262	4.298	T=2.262	2.790	F=1.22	1.301	T=2.262	0.706
S.D. of Individl.	0.01218	0.01691	0.30695	0.37992				
C.V. % Individl.	9.82905	11.75694	75.89716	64.68918				
T <sub>95%</sub> & T <sub>Ac</sub> Of Individl.	T=1.96	19.078	T=1.96	6.985				
Equi. Mig. Freq. cm <sup>-1</sup>							5.3352	4.8788
Mig. Factor-cm <sup>-1</sup>							3.5334	4.7605



**Fig 5.1- Histogram - Mean Fibre Position**



**Fig 5.2 - Histogram – RMS Deviation**



**5.3 - Histogram - Migration Intensity**

P-1783  
KCT  
MIGRATION

### 5.1 Mean Fibre Position (Y), RMS Deviation (D) and Mean Migration Intensity (I)

From the Table 5.1 & 5.2 and the Histogram 5.1, 5.2 & 5.3 depicted above one can observe that there are reduction in Mean Fibre Position (Y), RMS Deviation (D) and Mean Migration Intensity (I) to the tune of 10.7 %, 11.0 % & 9.8 % respectively for the 40<sup>s</sup> Ne Compact Yarn compared to Ring yarn. Similarly, there are reduction in Mean Fibre Position (Y), RMS Deviation (D) and Mean Migration Intensity (I) to the tune of 29.3%, 17.6% & 9.64 % respectively for 52<sup>s</sup> Ne Compact Yarn. T'-test values reveals that the quantum of reduction is significant at 95% Confidence level for Y and D. The reason for the reduction is best explained by proper understanding of "Tension variation as mechanism of Migration" and due to elimination of spinning triangle in the Compact Yarn Spinning.

#### 5.1.1 Tension variation as mechanism of Migration

Morton proposes that fibres twisting round a long path on the outside of a yarn would develop a high tension, while the fibres following the shorter straight path in the centre would be under low tension. Similarly in Ring Spinning due to formation of spinning triangle, the corner fibre of the drafted strand that emerges from the front roller has to travel longer path than the one at the centre before it reaches the point of yarn formation resulting in higher tension.

The difference in tension among the fibres would cause an interchange of position of fibres and thus lead to a more or less regular migration. This is apart from the Geometric Mechanism that Contribute to long term migration based roving twist and ring frame draft. The following table gives the differences in path distance due to each reason. The difference in fibre path distance of spinning triangle with 3mm base is 0.5mm only, where as the difference in fibre path distance for the fibres located at core and surface is 0.6 mm for a 25 mm length of 40<sup>s</sup> Ne yarn.

From this one can understand that difference in path experienced in spinning triangle, which gets eliminated in compact yarn, is much lesser than that of the difference in path followed by fibres at different radial position (20% only). This is the reason for the lesser differences of around 10 %-25 % in the Migration Character (Y, D, I) of Compact Yarn compared to Ring Yarn.

**Table 5.3 - Fibre Path Distance**

Yarn Count (Ne) , TPI & Dia (mm)	Path distance in Spinning triangle - mm				Fibre path distance at different radial position –mm for 25 mm Length of Yarn			
	Base W	Altitude A	Side B	Diff. C = (A-B)	Outer at R X	Centre Z	Diff. E = X-Z	(E/C)x 100
40s Ne TPI= 27.0 (0.14)	3.0	1.5-2.6	2.1-3.0	0.6-0.4	27.60	25.00	2.6	430-650 %
50s Ne TPI= 28.5 (0.13)	3.0	1.5-2.6	2.1-3.0	0.6-0.4	27.5	25.00	2.5	417-625%

## 5.2 Yarn Diameter and Packing density

From the data given in Table 5.1 & Table 5.2 and from the testing of yarn in Uster 4–SX-OM Module (see Table 5.4), one can see that there is an overall reduction of yarn diameter to the tune of 10. % for 40<sup>s</sup> Ne and 15 % in 52<sup>s</sup> Ne for the Compact yarn compared to Ring Yarn of same count, which shows that there is an equivalent increase in Overall Packing Density. This is due to pneumatic compaction that is involved in the production of Compact yarn, which is mainly responsible for increase in Strength apart from better integration of fibre. This can be visualized from in the CCD Camera photograph given below for the Compact and Ring Spun yarn

**Table 5.4 - Uster 4-SX Test Results on Yarn Diameter & Packing Density**

Ring & Compact Yarn count- Ne	Dia- 2DØ- mm	Dia- 2DØ- mm	Density- g/cm <sup>3</sup>	Density- g/cm <sup>3</sup>
	Ring	Compact	Ring	Compact
40s Ne	0.212	0.203	0.42	0.46
52s Ne	0.207	0.187	0.34	0.41



**Fig. 5.4 Longitudinal Microscopic view- Ring Spun (Left) & Compact Spun (Right) Yarn (40 Ne)**

## CHAPTER 6

### CONCLUSION

The following conclusion one can derive from the study of migration on Compact Spun and Ring Spun yarn:

- The elimination of spinning triangle in Compact Spinning Technology has reduced the migration parameters such as Mean Fibre Position, RMS Deviation and Mean Migration Intensity to the tune of 10 %- 25 % only. This is due the lesser differential path distance experienced by fibre in spinning triangle than due to differential path distance experienced by fibres at different radial position (20 %).
- Differential path experienced by fibres at different radial position is a major factor for the contribution of migration based on Tension Mechanism, which is apart from Geometric Mechanism Contribution to long term migration.
- The increase in strength of compact yarn inspite of lesser migration of fibres shall be attributed to the factors such as higher packing density and better integration of fibre to yarn body.





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