MIGRATION STUDY OF RING AND ROTOR YARN MADE FROM MICRO MODAL FIBRE

A PROJECT REPORT

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BONAFIDE CERTIFICATE

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ABSTRACT

This project is aimed at studying the important structural characteristic of spun micro fibre yarns namely the fibre migration, which has a decisive influence on the mechanical and physical properties of the yarns. Fibre migration apart from being influenced by constituent fibre properties, are also influenced by the spinning systems adopted with different fibre accumulation mechanism and the process condition at the point of yarn formation. Among the modern staple fibre spinning systems open end rotor and friction spinning systems have drawn much attention. When migration is considered Ring spun yarn exhibits higher migration, followed by rotor spun yarn and friction spun yarn with least. A higher migration factor corresponds with a higher yarn breaking tenacity.

In general, yarn structure depend one side on spinning technologies and the other side on processing conditions and structural differences in staple yarn lead to different yarn properties. Thus it is very important to understand yarn structure and its effects on physical properties of yarn; because each kind of yarn manufactured by specific spinning system method exhibit unique properties.

Various works in migration that have been carried out so far are on the spun yarns made of fibres coarser than one denier (Normal Fibres), but not on yarns made of fibres finer than 1 denier (Micro fibres). Hence, an attempt has been made in this project to comparatively study the migration of Micro-Modal fibre in Ring and Rotor normal TM & high TM yarns. Traditional tracer fibre technique has been followed for making yarn samples and the equipment used is projection microscope coupled with CCD camera and an image analysis system. Parameters such as Mean fibre position, r.m.s deviation, Migration Intensity, Equivalent migration

Frequency, Migration Factor has been used to characterize the behaviour of migration. Mean Fibre Position and RMS deviation for micro-denier fibre yarns was found to follow the same trend as found in the previous studies by research worker for normal denier fibres but there is reduction of Mean migration intensity of Ring yarn than the OE Yarns. This may due to the variation in stress strain values of fine denier fibre and lower flexural rigidity for the fine denier fibres compared to the coarser fibres.

சாராம்சம்

இந்த ஆய்வு அறிக்கையானது நுண்ணிழையால் ஆன நூலின் தன்மையைப் பற்றியதாகும். நூலின் தன்மையானது அதன் இழைகள் எவ்வாறு இடம் பெயர்கிறது (Fibre Migration) என்பதை பொறுத்தே இருக்கிறது. இழைகளின் இடப் பெயர்ப்பு அதன் தன்மை மட்டும் அல்லாமல் எந்த இயந்திரத்தில் (Spinning System) நூல் உருவாக்கப்படுகிறது, இழை சேரும் தன்மை, நூல் உருவாகும் இடத்தில் ஏற்படும் பளு (Tension) முதலியவற்றையும் பொறுத்தே அமையும். நவீன நூல் உருவாக்கும் இயந்திரத்தில் ரோட்டார் (Rotor) மற்றும் ப்ரிக்ஷன் (Friction) முதலியவை மிகவும் உபயோகப்படுத்தபடுபவையாகும்.

ஒரு நூலின் உட்புறத் தோற்றம் அதன் தன்மையை தீர்மானிப்பதாக அமையும். ஆனால் ஒரு நூலின் தோற்றம் அது எந்த இயந்திரத்தில் உருவாக்கப்படுகிறதோ அதைப் பொறுத்தே அமையும். மேலும் நூல் எந்த சூழலில் உருவாக்கப்படுகிறதோ அதைப் பொறுத்தும் அமையும். அதனால் ஒரு நூலின் உட்புறத் தோற்றத்தையும் அதன் தன்மைகளையும் பற்றி ஆராய்தல் மிக அவசியமானதாகும்.

இந்த ஆராய்ச்சியில் நூலில் மைக்ரோ மாடல் நுண்ணிழைகளின் (Micro Modal) அமைப்பு இரண்டு இயந்திரங்களில் (Rotor & Ring) உருவாக்கப்பட்ட நூலில் எவ்வாறு உள்ளது என்பதைப் பற்றி ஆராய்வதாகும். ஒரு இழையின் இடப் பெயர்ப்பை ஆராய டிரேசர் பைபர் (Tracer Fibre) என்னும் தொழில்நுட்பம் உபயோகப்படுத்தப் பட்டுள்ளது.

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Last but not least, I convey my thanks to parents and friends who extended their support to complete the project.

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CHAPTER 1

INTRODUCTION

The relative fibre movement at the point of yarn formation and the resultant position of fibres in the yarn structure is described as fibre migration. The migration behaviour of a fibre in a yarn is affected significantly by the inherent properties of constituent fibre like fibre length, fibre fineness, and crimp and cross sectional shape and the inherent characteristics of adopted spinning systems. Migration has the influence on yarn properties such as

- Strength and its CV%
- Elongation
- Hairiness
- Running performance.

Of the widely used system such as Ring, Rotor and friction Ring yarn exhibits highest fibre migration followed by Rotor and Friction spun yarns based on spinning tension and its variation.

In recent time the use of micro fibre in staple yarn has come in to existence towards improving fabric handle and imparting better wicking characteristic to meet the specific end use requirement in the sports or active wear fabric. The structural of such yarn needs investigation through migration study.

CHAPTER 2

LITERATURE REVIEW

2.1. MIGRATION

2.1.1. IDEAL MIGRATION:

The fibre is set to exhibit an ideal migration if it migrates regularly and uniformly from outside to centre of the yarn and then back to outside assuming the yarn has a circular cross section through out the structure. In such condition fibre are to follow helical path around concentric layers of constant radius so that the density of packing is constant throughout yarn length. The fibre, which exhibits ideal helical geometry, is shown in fig.2.1.

Where,

"r" - helix radius of fibre, which makes an angle □ with yarn axis,

"R"- radius of the fibre helix at the surface making an helix angle with the axis.

"l"- length along the fibre

"z"- length is denoted

"h"- 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 $l=h/\cos \square$

Thus "l" increases as □ 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. If the pattern is divided into different zones of equal area then the distribution of fibre length in all zones will be equal.

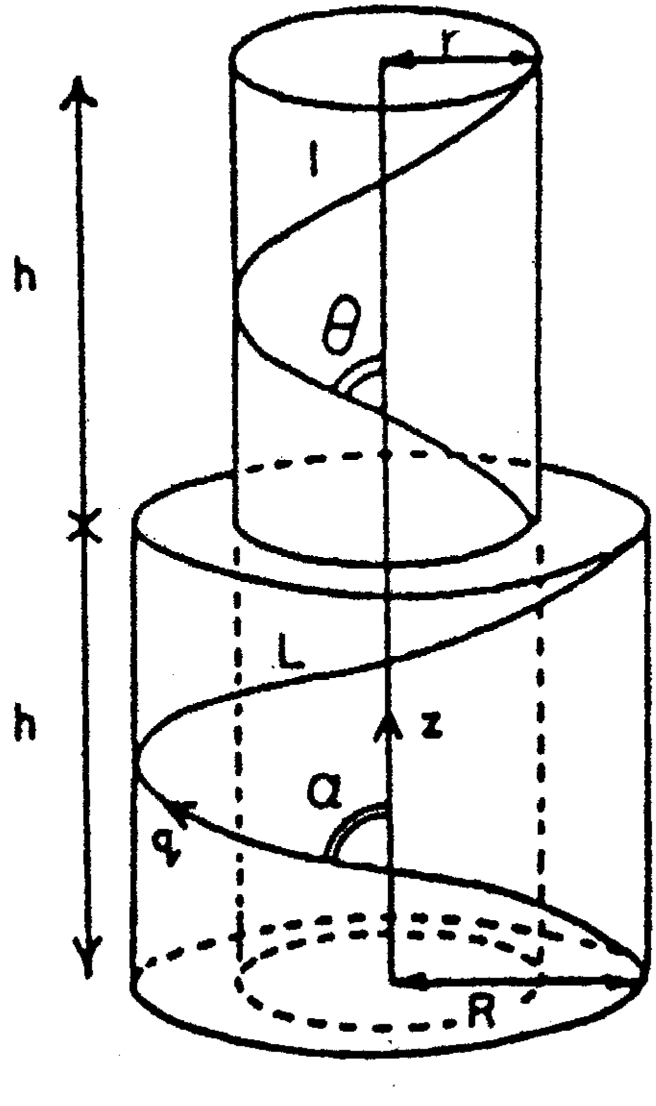


Fig.2.1.Idealised Migration

2.1.2. MECHANISM OF FIBRE MIGRATION:

There are two different mechanisms of migration. They are

Tension Mechanism

Geometric mechanism

In case of staple and filament yarns, migration occurs due to combined mechanisms of both geometric and tension mechanism. In case of staple yarns tension mechanism predominates to give rapid migration and is super imposed on a slow migration, which appears due to geometric mechanism. In continuous filament both the mechanisms play a significant role.

2.1.2.1. Tension Mechanism:

This mechanism is proposed by Morton & Yen (1952). It is based on the tension differences, which exists among fibre components at the point of yarn formations. These tension differences are greatly influenced by size of spinning triangles in ring spinning system (Fig 2.2). When the yarn is given some twist, fibres follow helical path with length of fibre path decreases from surface to core.

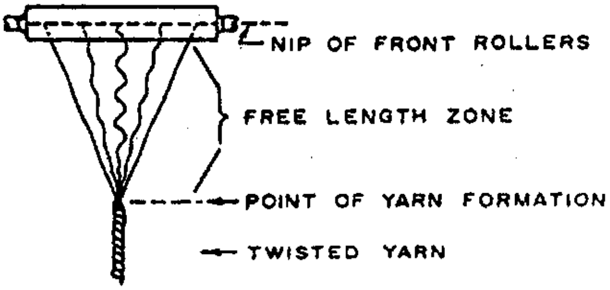


Fig.2.2.Tension mechanism

Since twist is 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 the angle of helix envelope varies throughout the fibre length showing migrations. This is referred as "Short Term Migration" and is predominant.

2.1.2.2. Geometric Mechanism:

This mechanism is proposed by Hearle J.W.S et al (1965) to influence the migration behaviour of fibres along with the tension mechanism. Geometric mechanism is based on ribbon twisting, which gives a wrapped structure. Roving twist draft influences migration period. This mechanism is "Long Term" and regular.

2.1.3. CHARACTERISATION 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 characterization of migration behaviour of fibre, Hearle (1965) suggested some more methods to quantify the characteristics of fibre migration using an analogy with a method of describing electric current. In 1964, Riding used a correlogram method to analyse the frequency of migration. A new factor known as "MIGRATION FACTOR" was proposed by Kim, Huh & Ryul (2001) which can represent total migration.

2.1.3.1. Parameters for characterisation of migration:

The following are the parameters used to characterize fibre migration as proposed by Hearle et al (1965).

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

$$\bar{Y} = \frac{1}{z}\int_{o}^{z} YdZ = \frac{\sum Y}{n} \qquad (2.1)$$

Where,

$Y = [r/R]^2$
r = helix radius
R = Yarn radius
z = length along the yarn
n = number of observations

Amplitude of Migration:

This is the magnitude of deviation from the mean positions and is represented by the root mean square deviation (RMS) given by

$$D = \left[\frac{1}{z}\int_{o}^{z} \left(Y - \bar{Y}\right)^2\right]^{\frac{1}{2}} = \left[\frac{\sum Y - \bar{Y}}{n}\right]^{\frac{1}{2}} \qquad (2.2)$$

Rate of Migration:

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

$$I = \left[\frac{1}{z}\int_{o}^{z} \left(\frac{dY}{dZ}\right)^2 dZ\right]^{\frac{1}{2}} = \left[\sum\left(\frac{dY}{dZ}\right)^2 \Big/ n\right]^{\frac{1}{2}} \qquad (2.3)$$

Equivalent Migration Frequency:

This is derived using Migration Intensity (I) and RMS deviation (D) value Equivalent Migration Frequency=I/4D√3.

Migration Factor:

The migration parameter defined by Hearle in 1965 is composed of four parameters mentioned above. It is thus confusing and since each parameter itself contains its own physical measures. In general these values can show trends in different from each other for various, spinning system, process variables and material characteristics. Thus it is desirable to define a new parameter that can represent a measure of total migration and Kim, Huh & Ryul (2001) proposed a parameter called, 'MIGRATION FACTOR' in their study Basically migration can be thought of as phenomenon resulting from balancing 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 is given by MIGRATION FACTOR" which is the product of RMS deviation (D) and Migration Intensity (I).

2.1.4. FACTORS INFLUENCING MIGRATION:

Following factors influences fibre migration

2.1.4.1. Fibre Factors:

Physical properties:

- Length,
- Fineness,
- Cross sectional shape,

- Frictional properties,
- Fibre substance.

Mechanical properties:

- Tensile modulus,
- Bending modulus,
- Torsional rigidity,
- Elastic recovery and extensibility.

Generally finer and longer fibres tend to move to the core and, shorter and coarser fibre move outward and increase the yarn hairiness. Fibres with high modulus and frictional properties are associated with inward displacement. Displacement due to fibre substances is complicated, but its effect on displacement is small and negligible.

2.1.4.2. Yarn Factors:

Yarn properties include yarn count, roving twist, spinning twist, blend proportions and fibre entanglement. The migration 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.

2.1.4.3. Process Factors:

Process factor 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. Thus 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.

2.1.5. MIGRATION IN VARIOUS SPINNING SYSTEMS:

2.1.5.1. 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 fiber movement there is a wide range of fibre tension variation generated across the fibre bundle which causes the fibre to migrate. In 2001 You Huh and Co-workers made a 3D analysis of migration. They found a parameter migration factor to asses the migration effect. They also concluded that migration reaches a saturation point as yarn twist increases. They also concluded that ring yarn has higher fibre migration followed by rotor and friction spun yarn. Higher the migration factor higher is the breaking tenacity.

In 1970, Buphender S Gupta studied the effect of roving twist and drafting ratio on migration. He found that Roving twist and drafting ratio had a significant effect on migration but drafting tenacity was found to have negligible effect on migration. Hearle in 1965 in addition to the occurrence of tension mechanism also studied geometric mechanism to influence fibre migration during yarn formation and also detailed the presence of short term and long term variations along the yarn length.

2.1.5.2. Rotor Spinning:

In open-end rotor spinning, fibres accumulate in rotor groove and are twisted into yarn under very low tension variation within a strand. The yarn core has almost the same structure as the ring yarn but the yarn sheath consists of fibres experiencing "Different twist" and almost no migration. Therefore fibres in rotor yarn take part in migration to a lesser extent than in Ring yarn. In 1972, Hearle and co workers carried out research work on fibre migration in rotor yarns. They found that low strength of rotor yarn is due to the poor alignment, inferior and shallower fibre migration with the yarn body combined with large number of folds, poor distribution of load over fibres, higher twist multiplier, different twist structure and spinning tension.

2.1.5.3. 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. In 1986, Lunenschloss and in 1991,Rust and Lord studied migratory parameters for friction spun yarn using Stereo scanned pictures and cross-section of yarn interspersed with tracer fibres and concluded friction spun yarn has stronger migration than ring yarn.

In 1994, Alagha et al and his associates concluded that differences in migration characteristic of yarn on different spinning system were due to different twisting methods and different levels of tension developed during yarn formation. They also developed an image analysis system to asses the structural characteristics of friction spun yarns.

2.1.6. MIGRATION IN VARIOUS TYPES OF YARNS:

2.1.6.1. Migration in Staple fibre 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 migration 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 tends to move in the direction of migration and it may become a projecting hair (Morton & Yen, 1952).

In 1956, Morton studied the influence of fiber reversal both by count and amount of twist inserted .He found that the interval between the reversals decreases as twist increased. As twist increases frequency of reversal increases. He suggested that in coarser yarn tension difference should be more in order to produce same effect as the finer count.

2.1.6.2. Migration in Cut Staple fibres:

The cut staple fibres have a tendency to migrate than continuous filament yarns. It will be still low in case of short fibre materials. The high degree 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.

2.1.6.3. 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 tension filaments will move to into the core regions to ease their tension by displacing the slack one to outer place (Morton & Yen, 1952). 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.

The continuous filament twisted in the form of a cylindrical bundle also show some degree of radial movement but there could be any large scale migration as a consequence of tension differences (Riding 1959).

In 1968 work was done in filament viscose rayon yarn. It was found that as yarn twist increases mean fibre position increases RMS deviation has little effect on twist, and mean migration intensity and equivalent migration intensity increases with twist. When filament size is considered no change in RMS deviation as denier is varied but EMI decreases with size. When number of filament is decreased mean fibre position is decreased. Whereas RMS deviation remained constant. When number of filaments was increased migration became more rapid.

In 1965, Treloar found the migration theory for filament yarns and stated that pitch variations can be used for measuring fibre migration.

2.1.6.4. Migration in Multi-Ply yarns:

In multi-ply yarns, one ply forms core portion while 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 will be easily pushed out and replaced by outer plies. If the central ply is under tension, there will not be any migration even if the outer plies are under much higher tension. (Hearle & Merchant , 1962)

2.1.7. COMPARITIVE WORKS DONE:

Some works have been done by comparing the migration behaviour based on different systems of spinning and also by varying the variables such as twist & tension in the same system. Following are the some of the comparative works done so far.

In 1972, J.W.S.Hearle and Co compared the migration behaviour of Ring spun, Rotor Yarns with tangential feed and radial feed.

Sample Details:

Fibre type	: Viscose Rayon
Fineness	: 1.5 denier
Staple Length	: 36.5mm
Yarn count - Tex	
Ring yarn	: 130
Rotor yarn (Tangential)	: 63.5
Rotor yarn (radial)	:52.4

They concluded from their results as follows:

- Mean Fibre Position is high for Rotor yarn compared to ring yarn.
- Magnitude of migration is as low as one-sixth of the typical values that have been observed in ring spun yarns. This affects the degree of fibre interlocking within the yarn, which in turn affects the properties of yarn.
- For very high and very low mean fibre position results in low r.m.s deviation in rotor spun yarns and not so in rings spun yarns.

Table: 2.1. Effect of Spinning Systems on Migration Parameter

Yarn Type	Mean Fibre Position	RMS deviation
Ring Spun Yarn	0.37	0.19
Rotor yarn (Tangential)	0.40	0.043
Rotor yarn (radial)	0.43	0.02

In 1965 J.W.S Hearle and B.S.Gupta studied the effect of twist on migration parameters of Rayon staple Ring yarn.

Sample Details:

Fibre type	: Staple Rayon
Fineness	: 1.5 denier
Staple Length	: 3.8cm
Yarn count	: 25s Ne

They compared the migration parameters by using Twist factors of 2.1, 3.0, and 6.0. They concluded that

- Mean Fibre Position and RMS deviation are only slightly affected by twist.
- Mean Migration Intensity increases as the twist increases rapidly and this is reflected in a corresponding increase in equivalent migration frequency.

Table: 2.2. Effect of twist on migration parameters

Twist Factor	Mean Fibre Position	RMS Deviation	Mean Migration Intensity, cm-^{1}	Equi. Mig. Freq, cm-^{1}
2.1	0.33	0.16	1.0	0.95
3.0	0.37	0.18	1.9	1.55
6.0	0.40	0.20	4.6	3.3

In 2001, You Huh and Co made three dimensional analysis of migration in staple ring yarn structure by varying the TM (3.0, 4.0, 5.0).

Sample Details:

Fibre type	: Cotton
Micronaire	: 4.2
Staple Length	: 24.2 mm
Yarn count	: 30s Ne

They concluded that,

- From the values of mean fibre position and r.m.s deviation it was fond that the samples used have more compact structure in the central area of the yarn than an ideal yarn, and as twist increases, the compactness of fibres in the yarn becomes grater near the yarn axis.

Table. 2.3. Effect of TM on Migration parameters

Migration Parameters	TM-3.0	TM-4.0	TM-5.0
Mean Fibre Position	0.58	0.42	0.36
RMS Deviation	0.26	0.24	0.27
Mean Migration Intensity, cm-^{1}	1.49	2.41	2.66
Equivalent Migration Frequency, cm-^{1}	0.83	1.45	1.75
Migration Factor	0.39	0.58	0.59

- Migration intensity increases dramatically as the twist increases. The twist seems to structurally disturb the yarn so that neighbouring fibres layers mix in the short term while spinning.

In 2002, You Huh et al analyzed the structural features of Ring, Rotor and Rotor spun yarns.

Sample Details:

Fibre type : Cotton

Micronaire : 4.2

Staple Length : 28.6 mm

Yarn count - Ne

Ring yarn : 10.2

Rotor yarn : 9.8

Friction yarn : 9.3

They concluded that

- Fibres in the rotor yarns are mostly located in the yarn axis, and those in friction spun
- Yarns mostly in the sheath. The Ring yarn has the fibres spread in the middle of the yarn cross-section.
- Both Rotor and Friction spun yarns have the migration magnitude, which is less than ring yarn.

Table.2.4.Effect of Spinning Systems on Migration Parameter

Migration Parameters	Ring Spun Yarn	Rotor Spun Yarn	Friction Spun Yarn
Mean Fibre Position	0.49	0.40	0.60
RMS Deviation	0.27	0.23	0.23
Mean Migration Intensity, cm^{-1}	3.82	3.05	2.22
Migration Factor	1.03	0.70	0.51

- Ring spun yarns have higher migration intensity followed by rotor and Friction spun yarns.

In 1975, Pillay , K.PR, Viswanathan, N and Parthasarathy M.S. anlysed the structure and properties of open -end yarns.

Sample Details:

Fibre type : Cotton
Micronaire : 4.2 (1.49 denier)
Staple Length : 24 mm
Yarn count : 20s Ne

They reported the following:

- Decreased RMS deviation in Rotor spun yarns shows that the core fibres exhibit limited deviations from the mean fibre position and do not migrate towards the surface.

- Higher rate of change of radial position of fibres in the Rotor spun yarn may be attributed to relatively higher twist as compared to the Ring spun yarn.

Table. 2.5. Effect of Spinning Systems on Migration Parameter

Migration Parameters	**Ring Spun Yarn**	**Rotor Spun Yarn**
Mean Fibre Position	0.54	0.44
RMS Deviation	0.32	0.24
Mean Migration Intensity, cm^{-1}	11.1	15.2

Likewise various works in migration that have been carried out so far are on the spun yarns made of fibres coarser than one denier (Normal Fibres), but not on yarns made of fibres finer than 1 denier (Micro fibres).

One of the most significant developments in recent years has been the technology to extrude extremely fine filaments while maintaining strength, uniformity and processing characteristics expected by textile manufacturers and consumers. These micro fibres are even finer than luxury natural fibres, such as silk. This comparison, coupled with their exceptional performance, has led some in the industry to refer to micro fibre as "supernatural". They expect to see the micro denier fabrics in virtually every type of apparel and home furnishings, rainwear, active sports, blouses, tailored suits, children's wear, lingerie's, hosiery, sheeting, upholstery and accessories. So far no migration study was carried in micro fibres. This made to do the migration study in fine denier fibres. The description of micro Fibres and Modal fibre are detailed in sub chapter 2.2 & 2.3.

2.1.8. TECHNIQUES FOR PREPARATION OF SAMPLES FOR MIGRATION:

The need for the theoretical description and interpretation of the various yarn properties has been met by both macroscopic and microscopic examinations of yarns.

2.1.8.1. Tracer fibre technique:

The observation of individual fibres in the twisted yarn structure became possible by the use of the tracer fibre technique. In applying this technique, a small proportion of dyed tracer fibres are introduced in the carding stage, with the remaining un dyed material. The resultant end product is then immersed in a liquid medium having the same or substantially the same refractive index as that of the fibres concerned. When the yarn is then examined under a low power microscope, the uncoloured fibres almost disappear from view leaving the path of each tracer coloured fibre to be clearly discerned. The tracer is seen against the faint background of the yarn body as a wavy line representing the projection in one plane of a helix. Using vernier scale of traversing stage, the measurements were made at the crests and troughs of successive waves along the yarn length to construct a helix envelope for the whole length of fibre analysed.

This method was devised by Morton and Yen for the study of staple fibre yarns. Later, Riding applied this technique for the study of continuous filament yarns.

2.1.8.2. Radio-active fibre Tracer Technique:

In 1960, Hickie and Chaiken gave radio active treatment to the fibres and developed radioactive tracer fibre technique by preparing auto radio graph for analysis. This technique was developed to investigate the configuration of fibres by giving the radio active treatment to the fibres and then preparing auto radio graphs for the analysis.

2.1.9. 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 a quantitative analysis.

Hearle& 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 modifications 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.

He again introduced a simple technique, where circumferential viewing of yarn specimens is possible. He developed a Perspex frame with a central rectangular slot running along the length to carry the rotatable glass tube which contains yarn samples and isolation liquid and rotated it to view the fibre position on a screen at all angles.

2.1.9.1. New 3-D Analysis of Migration using Microscope:

Primentas and Iype (2001) introduced new 3-D analysis using projection microscope in which he considered the level of focusing depth as a measure of the fibre position along z-axis with respect to the body of the yarn. With the suitable reference depth it became possible to plot position of tracer fibres with reference to both screen co-ordinates and rotary position of knob.

2.1.9.2. 3-D Analysis of Migration Using Image Analyser:

This system requires a image capturing system with sample mounting arrangements. This technique was used by You Huh, Young Ryul Kim & Woon Young Ryul (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 deliver unit with tensioning apparatus.
- CCD camera equipped with clear distance lens.
- An image processing system controller with power supplies and light source.

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 reestablished to transform the image data in such a way has to yield the trajectory of 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.

2.2. MICRO FIBRES:

Most micro-fibre is made of polyester; however, other polymers are used including nylon, polyacrylonitrile, polypropylene, cellulose acetate and rayon. Mixtures of polymers such as polyester-nylon and polyester-polypropylene are also used. Micro fibers are manufactured in both stable and filament forms those are chiefly made in three different ways (Arindam Basu, 2001)

2.2.1. TYPES:

The are the various technique to produce micro fibres :

- Chemical dissolution of one of the components in a bi-component fibre
- Physical splitting of a bio-component fibre and
- Direct spinning of the micro fibre

Methods 1 and 2 can be accomplished in the fabric finishing process. In Europe the route adopted is direct spinning of fine filaments, in other words spinning via spinnerets with fine diameter holes and at high draw ratios. Direct spinning produces fibre with individual filament fineness from 0.1 to 0.8 denier. The bi-component process produces super micro fibres with individual fibre fineness ranging from 0.001 to 0.01 denier. There are several technologies by which super micro fibres are produced. These methods are popular in Asia. These principles can be classified as the sea-islands (island in the sea) type, the separation type, the splitting type and multi layer type. The advantage of bi-component fibres are that the fibre fineness are 2-3 denier during processing and after the fabric are being made the micro fibres will be separated. Hence no major special process parameters need to be fixed during mechanical processing.

2.2.1.1. Sea-island type:

In this method the fibre is produced from two component polymers A (sea) and B (cores or islands). Some companies e.g., Toray arrange them in parallel, with polymers A and B in the conjugate spinning nozzle prior to spinning unit and some companies e.g., Kuraray blend them randomly in the extruder. After spinning and producing fabric, the A component (e.g., polystyrene) is being dissolved in a solvent to produce ultra fine fibres of the B component (polyester or polyamide by Toray and nylon by Kuraray). Although the initial monofilament (AB composite fibre) is rather thick i.e.,3.5 denier, the monofilament of the B component is extremely fine(less than 0.1 denier).The microfibres produced by first method due to very nature of process , are continuous and homogeneous in terms of its thickness. Whereas in second method the thickness varies discontinuously.

2.2.1.2. Separation type:

Separation type can be considered as a variation of the island type or the fibre splitting type where polyester and nylon are composite spun and then split in to their respective components. A novel .silk like, polyester fibre made from a bicomponent fibre by Toray in japan. This fibre was spun in a citrus form with triangular or trilobal sections in imitation of the triangular shape of the silk fibre. It is claimed that this unique cross section is responsible for generating the rustling sound similar to that of silk when friction occurs among the fibres.

2.2.1.3. Splitting type:

In the splitting type a hollow composite fibre of polyester and nylon is being produced. The composite fibre is split mechanically into 16 or more sections and its monofilament after splitting has a homogenous thickness. The Bellescime Department of Kanebo Ltd of japan has developed a cation-dyeable ultra fine microfibre 'Belima KX' Which achieves an ultrafine microfibre of 0.1 denier by splitting a 70% polyester/30% nylon bicomponent fibre of 17 divisions .Multi layer type can be produced using similar technique but the components will be laid side by side.

2.2.2. METHODS OF PRODUCTION OF MICRODENIER FIBRES:

There are several advantages of producing fabrics from micro-denier fibres as far as fabric properties are concerned. But due to extra fineness of the fibres there are several problems faced during processing of these fibres.

Spinning of yarn:

When fibres are subjected through a series of machines employed in spinning, they experience various types of stresses and strains of different magnitude.

As fineness of fibres reach micro level, the immediate, dimensional changes that can be foreseen is a reduction in diameter. But to what extent it gets affected can be realized if the diameter of fibre is plotted as a function of denier covering the denier range from micro level to normal level.

Due to the reduction in diameter the following properties are being affected significantly.

- Flexural rigidity
- Tensile strength and
- Surface friction.

Also it has been taken into account that increasing fineness of fibre count is associated

- greater efforts in opening the fibre stock
- lower carding performance and
- higher sensitivity to unfavourable spinning conditions.

2.2.2.1. Blowroom and Carding:

Being sensitive fibres the micro-denier fibres must be treated gently. Short machines, short pipe connections, short air transport and less number of machines rightly selected show the way for the solution of the problem. As for a good opening a self controlled stroke is necessary, the components which pull out the fibers from the fibre tuft must be so shaped that the load on fibre is minimum. The ideal components may be pins and needles on the pin roller and needle on the licker-in. There is no other gentler component as the needles which because of their fine points penetrate practically with no resistance in the lap. The round needle obstructs the sharp cutting on the edges and or blending of the fibre. Properly selected and properly processed saw teeth are harmless, especially when they only convey on take over fibres in an opened condition.

With the cleaners as well as with the cards the stresses in the fibres can be influenced through the setting. In openers and cards the machine and settings are to be selected are used in the case of finest cotton. For fine cotton the cylinder of 865 teeth per square inch are selected. Same or 1080 teeth per square inch can be used for processing of micro-fibres. Most modern cards (Trutzschler DK 760, Rieter C4 etc.,) with presently available facilities are capable of handling micro denier fibres. In 1980 s it was possible to produce 30 to 40 kgs/hr. The success can be shared by the fibre and machinery manufacturers' .The new and accurate machines, which have the modern metallic clothing, have a remarkable share in this development.

As per the results from the experiments carried out jointly by Bayer, Schlafhorst and Trutzschler the performances of cards improved with the increase in production up to a certain level and then deteriorates for 0.6 denier and 32mm Bayer Acryl fibre Dralon .At the production rate of 24 kg per hr the nep count of card silver was 7 per gm., which became 3 per gram at 44 kg/hr production rate .On increasing the production to 53 kg/hr. the nep count increased to 10 per gm., however it remained the good working condition still.

2.2.2.2. Drawing:

On modern draw frame, it may be necessary to reduce the delivery speed to 400m/min in order to reduce the incidence of roller lapping which is likely to be more because of larger area contact with the rollers and its low bending rigidity. Higher top roller load may be used (around 20-25%).More frequent grinding or buffing is required. Whenever the draw frames are stopped the pressure on the top rollers should be in released condition. Prolonged holding of fibres under pressure may cause thermal damage.

The micro fibres can be used in worsted spinning system also. For processing the micro-denier acrylic fibres some precautions has to be taken. The very high number of fibres in the top influences the draw ability. This leads to these considerations:

- Minimum three draw frame passages are required.
- Inter settings with pin drafter heads (medium pin/cm number) to get proper fibers control.
- The loading of intersecting must be optimized to prevent flame formation to irregular drafts.
- Intersecting speed must be reduced (15% ca) compared with standard acrylic hen exceeding 300m/min.
- In case of blend with wool .attention to be paid to draft regulations particularly in the passages.
- Two heads classic 'melangi' are suggested for blends with wool.

2.2.2.3. Roving frame:

Due to higher cohesive force between the fibres the twist level used may be little less as compared to normal denier fibre. Higher top roller pressure should be used .The top rollers need to be buffed more frequently. Flyer with highly polished surface may lead to more fly generation and hence a matt finish would be preferable. Flyer top with more number of ribs may be more advantageous.

2.2.2.4. Ring frame:

The sliver and drafted fibre web being very thin, care has to be taken so that proper drifting takes place. Use of softer cots may be useful as the fibres will be gripped better thereby reducing slippages. Higher break draft or wider setting may be required due to higher cohesiveness of roving. For fibres finer than 0.5 denier very high spindle speed may be avoided as that will damage the fibre. The traveler speed should be restricted to 30-35m/sec along with smaller ring and shorter lift. For 0.8 denier polyester fibre the experience shows that the yarns can be spun at same spindle speed as conventional fibres. In addition it is possible to reduce twist of the yarn due to the presence of higher number of fibres per cross section. A study carried out to investigate the spinning conditions of fine denier polyester fibres and their effect on yarn quality revealed the following:

First the back roller gauge was set at 56 mm and break draft ratio was changed from1.1 to 1.8 then the roving were fed of three different twist levels .0.5, 0.6 and 0.7 TM to spin a 13.1 tex (45s Ne).The results showed that each of three kinds of twisted roving has a peak value of the three kinds of twisted roving has a peak value of the yarn quality index. However the 0.6 TM roving has a minimum value of thin and thick places and maximum value of yarn quality index. The yarn quality index is given by:

$$\text{Yarn Quality Index (YQI)} = \frac{\text{Single yarn strength (mN/Tex)} * \text{Lea strength (N/tex)}}{\text{U \% of the yarn}}$$

When the break draft ratio is too low, the twisted roving cannot be sufficiently drafted in the back roller zone, resulting in thick places in the spun yarn. The number of thick places will increase as the roving twist increases. Too great an increase in break draft ratio will frequently cause a drafting wave in drafted roving resulting in serious thick and thin places in the spun yarn. The effect of break draft ratio was no evident on neps. So when spinning micro denier polyester in fibre into yarns, the drafting ratio should be chosen to all within the initial ascending range the drafting force curve based on the CV % of the drafting force versus drafting ratio. When CV % decreases and stabilizes, the drafting ratio of the spinning process will provide better quality.

As the roller gauge increases, the decrease in the drafting force is due to decreased inter-fibre cohesion. The rate of the decrease depends upon the number of fibre in the roving. However too great an increase in the roller guage will cause the floating fibres to go out of control. The base roller gauges were set at 56 mm and 62 mm. In both the cases the yarn quality index increases as the break draft increases and then the yarn quality increases. As compared 56 mm the yarn quality index 62 mm roller guage appears to small and peak value shifts to lower break draft side. This indicates that an increase in the roller gauge will decrease the draft force, a lower break draft is required however, the result shows that average value of yarn quality index 62 mm roller gauge decreases due to decrease in yarn strength.

It is believed that increasing top roller pressure, i.e., increasing nip point pressure .will help to control fine denier fibers and yield normal drafting behaviour. These experiments carried out at two roller pressures shows that best yarn quality can be achieved at higher roller pressure (14 kgf) due to better grip of the fibers.

The heavier roving mass requires a higher drafting force. As the number of fiber increases, there is an increase in the fibre cohesion and the draft force increases as a result. The results of the above experiments revealed that break draft of 1.3 and a 56 mm roller gauge in conjunction with a higher roller pressure are the optimum spinning condition for this particular fibre i.e., 0.8 denier polyester fibre roving of 0.6 TM and 0.354 g/m linear density.

2.2.2.5. Rotor spinning:

Micro fibres can be spun into very fine yarns on modern open-end rotor spinning machines –with rotors of small dimensions –at high speeds. The results obtained by the researchers show that both yarn and end products show that the use of micro fiber in either 100% or blended forms opens up opportunities to spin finer yarns which were not possible to achieve in rotor spinning with standard fibres. Perfect condition of the spinning elements is essential, however, in particular opening roller. Rollers with a relatively heavy nickel coating are recommended. Finer draw frame slivers similarly minimise the risk of fiber damage. Whilst sliver containing a large number of fibers in the cross –section can cause problem in fiber separation, on the other hand there may be a reduction of the amount of twist required. In the comparison of various yarns the yarn spun at TM 80 appears to have better appearance than other TM values.

In processing fiber blends incorporating cotton the quality of the natural; fiber should be compatible with the high quality generally envisaged with micro fibres One experiment shows that it is possible to spin yarns with micro fibre polyester and cotton (50/50) up to rotor speed of 1,20,000rpm. Above 1,55,000 rpm there is a greater tendency to neppiness, whilst at the same time the number of thin places is lower. Outstanding yarn quality, soft handle in the finished product and superior aesthetics can thus open up new applications for rotor yarns.

2.2.2.6. Air-jet spinning:

The US and Japanese man made fiber manufacturers carried out extensive research on the adaptability of MJS spinning machine for use with micro fibre. Based on their research they recommended spinning speeds for polyesters of different deniers with 802H MJS machine.

Results show that as denier becomes finer, strands in the cross section of the fiber increases. As denier becomes finer, strands in the cross section of the yarn increase. Contact area between fibres increases and twist propagation of false twist generated by the spinning nozzle becomes faster. All of these factors promote a faster spinning speed.

2.2.3. ADVANTAGES OF MICRO-DENIER FIBRES:

The micro-denier fibre being fine, offers various advantages over normal fibres:

- Owing to lower bending stiffness of the single fibres/filaments, micro fibre yarns impart excellent drapability of the fabrics as well as more or less pronounced softness depending on the fabric construction, blending ratio and blend components selected.
- The low absolute filament strength makes micro fibre fabrics an ideal for immersing. Yarn strength on the other hand, is on the higher level due to presence of more number of fibres per cross sectional area.
- As the filament size decreases, the yarn surface (on the equal count basis) increases.
- Roundness and bulk of the yarns combined their remarkable regularity ensure the production of knitwear of smooth and fluid appearance, comfortable, light and very soft to guarantee perfect weavability.
- The yarns made from micro denier fibre contain many more fibres/filaments than regular yarns producing fabrics with water tightness and wind proofness but improved breathability.
- With increasing fabric density using micro fibre it is possible to obtain high resistance to

slippages. The fabrics produced meet the stringent requirements of 2 non-seam opening at a load of 10 den.

- More filaments/fibers in yarns result in more surface area .This can make printed fabrics more clear and sharp as compared to normal fabrics.
- Micro denier characteristics lend themselves to production of new exciting and fashionable fabrics.
- One of the immediate advantages the spinner can foresee is that due to presence of more fibres per yarn cross-section, there would be improvement in yarn evenness and spinning performance. Technologically the spinning limit can be increased especially for unconventional spinning techniques such as rotor spinning, air-jet or friction spinning where requirement of minimum number of fibres is much more than ring spinning.

2.3. LENZING MODAL

Lenzing Modal, this incomparable fibre of natural origin from pure beech wood fulfils the demands required by fashion and performance: excellent wear properties, soft, smooth handle, absorbency, kind to the skin, dimensional stability, color brilliance and easy care. The superb properties of lenzing modal provide persuasive advantages in blends with cotton, wool, linen, silk and synthetics. The high degree of purity, the uniformity the strength and the good processing properties of Lenzing Modal at all production stages guarantee high quality yarns for high quality textiles.

Lenzing modal has proved its worth with the product groups in particular fabrics for shirts, blouses and clothing ; fabrics for men's and women's suits; terry materials for hand towels and dressing-gowns; day and night wear, pullovers, sportswear and leisure wear such as T-shirts, track suits as well as table-linen and bed –linen.

Lenzing Modal possesses all the advantages of an industrially produced fibre. It is distinguished by a high degree of uniformity, consistent quality, high purity and optimum adaptation of linear density and staple to the blending partners and meets all the requirements of the processing procedures. Because of the integrated production of Lenzings own cellulose, the high quality of Lenzing Modal is already determined to a large extent in the raw material. The blend 50/50 % of Lenzing Modal and high quality carded cotton is comparable to 100 % combed cotton.

The Lenzing Modal is an industrially produced fibre which is comparable in many aspects with high quality cotton and which is superior to cotton in same specific features. Like cotton it consists of pure cellulose.

Lenzing Modal is available in fibre linear densities of between 1.0 and 5.5 dtex, raw white, bright or from certain minimum quantities upwards also spun dyed. It can be processed to yarns using any spinning procedure. Modal proves to be particularly well suited to the highly productive new spinning technologies, like for example, OE-rotor spinning or air jet spinning .

Modal fibres must exhibit minimum values with respect to fibre tensile strength in both the conditioned and wet states .the wet modulus is the tenacity necessary to permit the individual fibres to be stretched by 5 %when wet. Lenzing Modal fulfils these requirements in all available linear densities 1.0 dtex to 5.5 dtex. Thus Lenzing Modal is defined as 'Modal' in its finished product in accordance with the European Textile Identification Regulations. Due to its excellent properties the modern textile fibre Lenzing Modal has created for itself the image of a high quality fibre, particularly in the fields of fashion and performance.(www.Lenzing modal.com)

2.3.1. CHARACTERISTICS:

2.3.1.1. The tenacity:

The high corresponding tensile strength elongation relationship between modal, cotton and polyester (See fig 2.6) makes a considerable contribution to the excellent blending possibilities of these fibres (SITRA FOCUS Nov-2002). The mechanical and technological properties of Lenzing Modal such as tenacity, elongation, wet modulus and loop strength, have been optimally tuned to one another. No property has been over developed to the determinant of another.

Table 2.6.Comparitive characteristics of Fibres

Fibre properties	**Cotton**	**Polyester**	**Viscose**	**Tencel**	**Lyocell**	**Modal**
Tenacity (cN/tex)	24-28	42-53	24-26	42-44	40-42	34-36
Elongation (%)	7-9	44-45	18-20	14-16	15-17	12-14
Tenacity Wet (cN/tex)	25-30	42-53	12-13	37-41	34-36	20-22
Rel.WetSrength (%)	105	-	50	-	85	60
Elongation Wet (%)	12-14	44-45	21-23	16-18	17-19	13-15
Natural Moisture Content(65% RH)	8	-	13	-	11.5	12.5

2.3.1.2. The shrink behavior:

On leaving the factory, Lenzing Modal fibres do not exhibit any shrinkage. During Processing, the fibres are stretched in various ways, particularly in the wet state. The stretching leads to tensions in the individual fibres.During a subsequent low-tension or non -tension wet treatment, such as washing ,the fibre will thus shrunk i.e., the increase in length brought about during the earlier stage is partly reversed .

The greater the resistance which a fibre can use to combat a mechanical loads the smaller the resulting changes in length or the shrinkage values arising from these. The textiles made from Lenzing Modal fibres are thus structurally more stable. Further improvements in dimensional stability can be achieved by finishing processes, if required, combined with an additional sanforisation.

2.3.1.3. More absorbent:

Lenzing Modal absorbs moisture more quickly than cotton and stores more moisture, even after many washes.

2.3.1.4. Higher colour brilliance:

Lenzing Modal brings color brilliance to textiles. The bright colors are still there even after many washes.

2.3.1.5. More Lustre:

The use of Lenzing Modal in its bright form gives textiles a silky, elegant luster comparable to mercerized cotton qualities, which remains intact even after much wash. If fashion so desires, Lenzing Modal are also available in matt form as well as spun dyed, from certain minimum quantities upwards. Due to its high resistance to alkali, Lenzing Modal in blends with cotton can also be mercerized .which influences not only the color affinity and luster positively, but also the dimensional stability.

2.3.1.6. Soft and pleasant handle:

Textiles containing Lenzing Modal are distinguished by a pleasant, soft handle .Blended with cotton this advantage is particularly beneficial since Lenzing Modal clearly reduces harshness after several washes. In comparison, the fibre surface of Lenzing Modal remains smooth.

CHAPTER 3

OBJECTIVE

The objectives and scope of this study are as follows:

- To Characterize the migration behaviour of fibres in Ring and Rotor Yarn made from micro-denier regenerated cellulose ~~fibre~~ fibres
- To choose high tenacity Lenzing Micro-Modal Fibre for the study ?
- To choose Ne 20 Ring Yarn, and Rotor Yarn with equal TM (of that of Ring Yarn) and Rotor Yarn with High TM for the comparative study. Why ?

CHAPTER 4

METHODOLOGY

4.1. MATERIALS:

For the study, 100% Micro-Modal fibre has been chosen for the production of Ring and Rotor yarns with the tracer fibre and its fibre characteristics are given below (Table 4. 1).

Table.4.1. Fibre characteristics selected for the study

Characteristics	Values
Fineness	0.9 denier
Length	34mm
Tenacity & CV (g/tex) and %)	33.39 & 8.30
Elongation % & Cv	14.70 & 9.60

4.2 METHODS

4.2.1. Production of yarn samples with tracer fibre:

A lap made of Micro Modal Fibre as per the details given in Table 4.2 has been procured from a standard mill and used for the production of Ring and Rotor yarns with tracer fibre. A small quantity of procured fibre (around 0.6 %) is dyed with reactive orange dye and the dyed fibre is spread uniformly on the on the lap sheet fed in to the carding machine to obtain carded sliver containing tracer fibre. This sliver is processed further in the draw frame two times and part of the out put quantity is converted in to the roving toward producing ring yarn with tracer fibre. The remaining part of sliver is used for producing Rotor yarns with tracer. The details of process parameters are given below.

Spinning Preparatory

Lap length : 45 yards
Lap weight : 13.5 kgs → Metric System.
Lap Hank : 0.0018Ne
Card sliver hank : 0.14Ne
Draw sliver hank : 0.14 Ne
Roving Hank : 1.327 Ne
Yarn count : 20s Ne

Ring Spinning:

Machine Make : TRYTEX
Ring yarn TM : 3.68
Spindle Speed : 13,500 RPM.
Break Draft : 1.3
Actual count : 19.8

Rotor Spinning:

Machine Make : BD-SD ELITEX
Rotor Yarn Normal TM : 3.68
Rotor Yarn High TM : 4.1
Rotor dia. : 42mm
Rotor speed : 71,580 RPM.
Opening roller speed : 8100 RPM.
Actual count OE-NT :19.6 s
Actual count OE-HT :20.6 s.

4.3. TECHNIQUE ADOPTED FOR MIGRATION STUDY:

The standard tracer fibre technique has been used for the study. The yarn produced using tracer fibres is immersed in a liquid medium (Methyl Salicylate) having the same refractive index as that of fibres concerned. The yarn being examined under a low power microscope, the uncolored 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.

4.3.1. 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 50x is used for the study.

4.3.2. Procedure for the Migration Study:

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 microscope picks up the image of a portion of yarn and it is transferred and stored in to the PC attached to it. The stored series of images could be retrieved and merged to obtain complete image of the tracer fibre for the measurements. 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.

4.3.3. Method used for Assessing Fibre Migration:

A typical configuration of a tracer fibre observed under microscope is shown in the fig.4.1. The diameter of the yarn in scale units was given by c-a, while the offset of the trough from the yarn axis was given by [b-(a+c)/2].In addition, the distance between the peaks, marked as z, as well as the overall extent of the tracer was obtained. With this method it was possible to track of the paths followed by the tracers in the horizontal plane. In order to avoid the effects due to the changes in the yarn diameter, the radial position of the fibres are expressed in terms of ratio r/R.

$$r/R = \frac{[(a+c)/2-b]}{(a-c)/2} \qquad (4.1)$$

From the projected image, measurements at each crest and troughs of successive waves along the yarn length to contact a helix envelope for the whole length of fibre analysed.

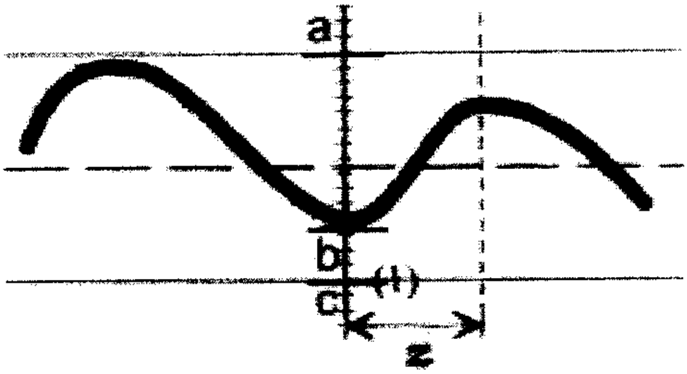


Fig.4.1. Characterisation of Migration Parameters

4.3.4 Statistical Analysis:

Test of significance (t-test and f-test) has been carried out for the interpretation of results.

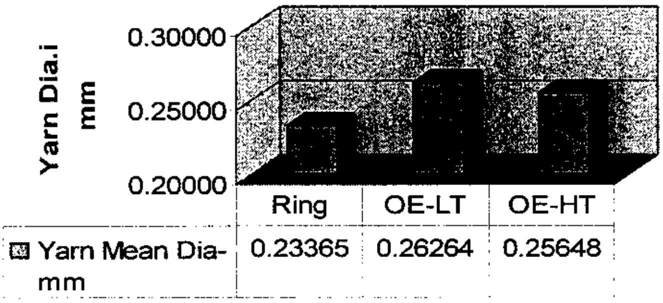
CHAPTER 5

RESULTS AND DISCUSSIONS

The Table 5.2 gives the migration characterization data summary obtained from measurements taken each on 10 tracer fibres of Ring and OE-LT & OE-HT yarns of Ne 20 and the individual tracer fibre details are given in Table 5.1

5.1. Effect of Spinning System on Yarn Diameter:

The diameter of OE-LT is 12.4% greater than Ring yarn and the diameter of OE-HT is 9% greater than the Ring yarn. These results for micro denier fibre yarns are in line with the earlier findings for Ring and Rotor yarn made of normal denier fibre.



OE-LT>R-12.4%, OE-HT>R-9%

Fig.5.1. Histogram-Effect of Yarn Diameter:

Table 5.1 Migration Characterization Individual Tracer Fibre Data of Ring and Rotor Yarn-Ne 20

Parameters	**Yarn Dia.-mm**			**Mean Fibre Position**			**RMS Deviation (D)**			**Migration Intensity(I) cm^{-1}**		
Fibre No	**Ring**	**OE-LT**	**OE-HT**	**Ring**	**OE-LT**	**OE-HT**	**Ring**	**OE-LT**	**OE-HT**	**Ring**	**OE-LT**	**OE-HT**
1	0.22971	0.30148	0.24795	0.67220	0.46504	0.32336	0.23863	0.33005	0.33110	4.23267	12.80960	13.72101
2	0.22938	0.23638	0.26830	0.47898	0.42822	0.29976	0.33474	0.30603	0.36665	11.71552	10.91546	17.11314
3	0.22637	0.22964	0.23772	0.45166	0.45884	0.26700	0.32047	0.42291	0.31500	9.34961	10.69286	13.09650
4	0.21396	0.25175	0.24963	0.28786	0.34016	0.28820	0.33165	0.34071	0.29152	7.09924	12.74330	8.94564
5	0.22235	0.24427	0.26399	0.70414	0.43297	0.30129	0.23478	0.34984	0.33949	4.66897	7.96119	9.25302
6	0.25471	0.25896	0.25118	0.62791	0.31845	0.39149	0.60637	0.33583	0.33375	13.31561	8.87167	21.42582
7	0.22439	0.27362	0.27376	0.54213	0.32386	0.27884	0.30801	0.26038	0.32762	5.92866	6.70001	10.40322
8	0.25901	0.23334	0.25350	0.29259	0.34743	0.28005	0.31657	0.32240	0.30879	5.32374	15.85997	10.27251
9	0.23221	0.28922	0.26325	0.32866	0.26447	0.28282	0.25745	0.24247	0.29516	4.82241	7.20453	7.88633
10	0.24442	0.30769	0.25557	0.41853	0.33251	0.30543	0.33870	0.31969	0.31113	9.20718	8.76253	10.45309
Overall Mean	**0.23365**	**0.262636**	**0.25648**	**0.48047**	**0.37119**	**0.30182**	**0.34360**	**0.32641**	**0.32273**	**8.14621**	**10.61680**	**12.89405**
S.D of Mean	**0.01450**	**0.02881**	**0.01080**	**0.15364**	**0.06912**	**0.03541**	**0.10536**	**0.04937**	**0.02247**	**3.18170**	**2.90798**	**4.21924**
c.v % of Mean	**6.21**	**10.97**	**4.21**	**31.98**	**18.62**	**11.73**	**30.66**	**15.13**	**6.96**	**39.06**	**27.39**	**32.72**
S.D of Individual	**0.01716**	**0.02483**	**0.03854**	**0.35234**	**0.33359**	**0.32896**						
C.V. % Individual	**7.34444**	**9.45519**	**15.02624**	**73.33266**	**89.86876**	**108.9925**						

Table 5.2 Migration Characterization Summary of Ring and Rotor Yarn-Ne 20

Parameters	Yarn Dia.-mm			Mean Fibre Position			RMS Deviation (D)			Migration Intensity(I) cm^{-1}		
Count - Ne 20^s	Ring	OE-LT	OE-HT	Ring	OE-LT	OE-HT	Ring	OE-LT	OE-HT	Ring	OE-LT	OE-HT
Overall Mean	0.233652	0.26264	0.25648	0.48047	0.37119	0.30182	0.34360	0.32641	0.32273	8.14621	10.61680	12.89405
S.D of Mean	0.014503	0.02881	0.01080	0.15364	0.06912	0.03541	0.10536	0.04937	0.02247	3.18170	2.90798	4.21924
c.v % of Mean	6.21	10.97	4.21	31.98	18.62	11.73	30.66	15.13	6.96	39.06	27.39	32.72
$T_{95\%}/F_{95\%}$	T=2.262			T=2.262			F=1.22			T=2.262		
T_{Act}/F_{Act}	Ring↔OE-LT= 2.842 Ring↔OE-HT= 3.993			Ring↔OE-LT= 2.051 Ring↔OE-HT= 3.583			Ring↔OE-LT=0.811 Ring↔OE-HT=0.990			Ring↔OE-LT=1.813 Ring↔OE-HT=2.841		
S.D of Individual	0.01716	0.02483	0.03854	0.35234	0.33359	0.32896						
C.V. % Individual	7.34444	9.45519	15.02624	73.33266	89.86876	108.9925						
$T_{95\%}$ of Individual	T=1.96			T=1.96								
T_{Act} of Individual	Ring↔OE-LT=15.187 Ring↔OE-HT=8.556			Ring-↔OE-LT=3.561 Ring↔OE-HT=5.860								
Equivalent Migration Frequency- cm^{-1}										3.422	4.695	5.767
Migration Factor- cm^{-1}										2.799	3.465	4.161

Note:-$T_{95\%}$ /$F_{95\%}$ - A statistical term indicating the Limiting Significance Value for 't' and 'F' derived from Statistical Tables

T_{Act} / F_{Act} - Calculated value for the actual values of Mean & S D found from the study.

When the Calculated Values exceeds the Limiting Values the difference between the two is Significant at 95 % Confidence Level

5.2. Effect of Spinning System on Mean Fibre Position of Micro Fibre Yarn:

The mean fibre position represents the over all tendency of fibres to be located near the surface or near the centre of the yarn. Histogram-Fig 5.2 shows that the Ring spun yarn, OE-LT & OE-HT has a mean of 0.480, 0.371 and 0.302 respectively. This indicates that the fibres in the rotor yarn are mostly located near the yarn axis and those in the ring spun yarn the fibres spread in the middle of the yarn cross section.

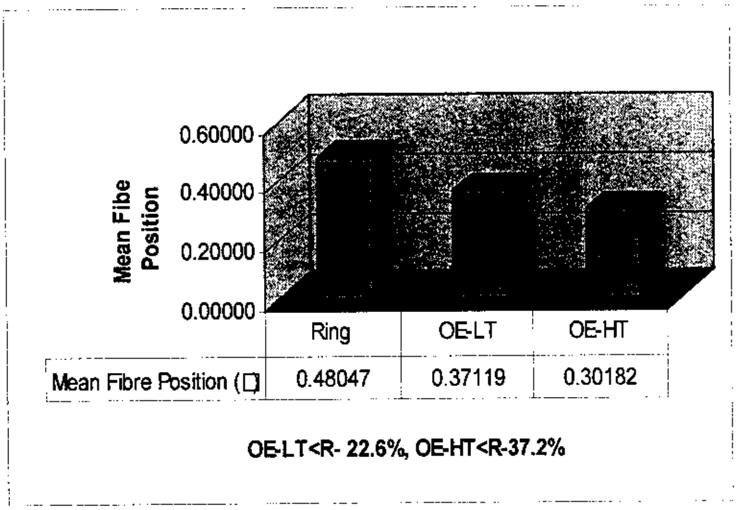


Fig. 5.2. Histogram- Effect of Mean Fibre Position

There is reduction in Mean Fibre Position of OE-LT & OE-HT yarn compared to Ring yarn to 22.6% and 37.2% respectively. These results match with the findings made by You Huh et al (2002) for normal denier fibre yarns. Hence it could be inferred that fibre fineness is having less influence than the system of spinning on the mean fibre position,

5.3. Effect of Spinning System on RMS Deviation of Micro Fibre Yarn:

For the ring spun yarn the fibres migrate with the amplitude of 0.343 whereas the OE-LT and OE-HT migrate with the amplitude of 0.326 & 0.322 respectively as revealed through histogram- Fig. 5.3. There is reduction in RMS deviation of OE-LT & OE-HT yarn compared to Ring yarn to the tune of 5% and 6% respectively, which found to be statistically insignificant. These findings are inline with the spinning system comparison study of You Huh and co on Ne 10 cotton made from 4.2 micronaire fibre (1.49 denier)

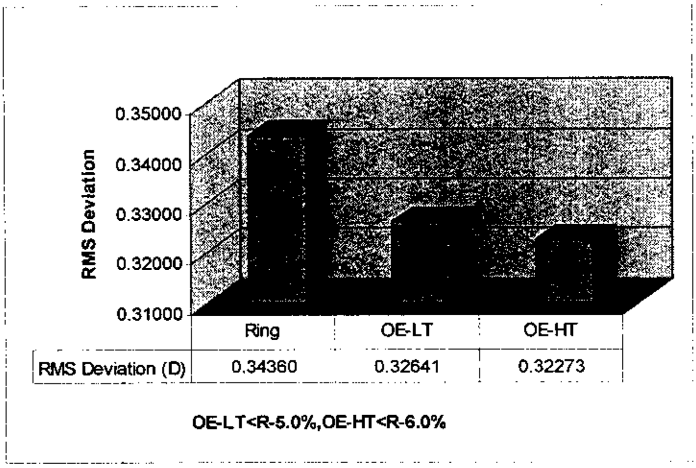


Fig.5.3. Histogram- Effect of RMS Deviation

5.4. Effect of Spinning System on Migration Intensity of Micro Fibre Yarn:

It represents the rate of fibre position change along the yarn axis. The OE-HT yarn has the highest value of 12.89 followed by OE-LT (10.61) and Ring yarn (8.14). OE-LT & OE-HT is 30.3% & 58.2% higher than the ring yarn respectively as given in Fig. 5.4.

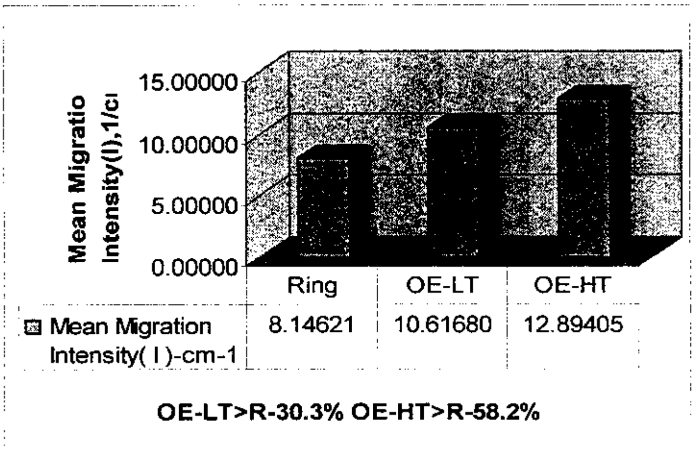


Fig.5.4. Histogram- Effect of Mean Migration Intensity

This is contradictory to the findings by You Huh and Hearle, where Migration Intensity of Ne 5-10 ring yarn have been more compared with rotor yarn made of normal denier fibres, where the stress strain characters are different from the fine denier fibres. Previous studies also indicate that the higher twist yarns always have higher rate of change of positions and so the intensity. Since this study deals with the fine fibre (Micro Modal) Ne 20 yarn, the increase in intensity may be also due to the variation in stress strain values, as modal is a low elongation high tenacity fibre and also it has low flexural rigidity value compared to normal denier viscose. At the same time, increase in intensity matches with the work done Pillay & co on equivalent Ne 20 cotton, where the intensity of Rotor yarn was found to be greater than Ring yarn made from normal denier fibre (1.5 denier).

5.5. Effect of Spinning System on Equivalent Migration Intensity of Micro Fibre Yarn:

This is derived using Migration Intensity and RMS Deviation. Since RMS deviation has less effect and because of higher Intensity values, Equivalent migration frequency increases for OE-LT & OE-HT yarn by 37.2% & 68.5% than the Ring yarn respectively.

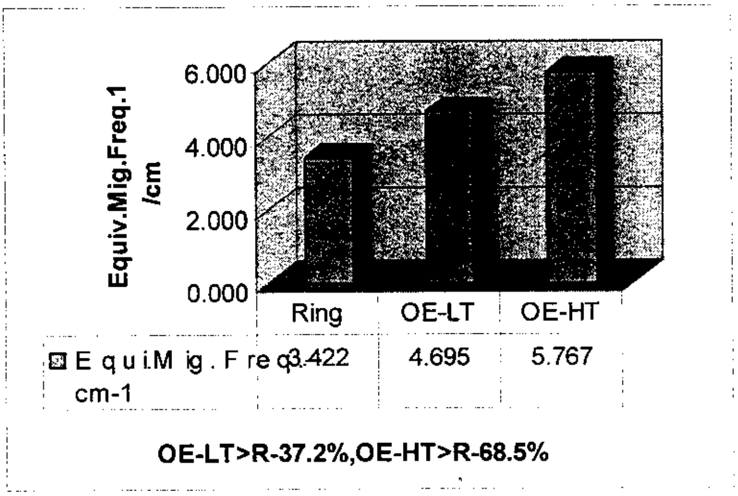
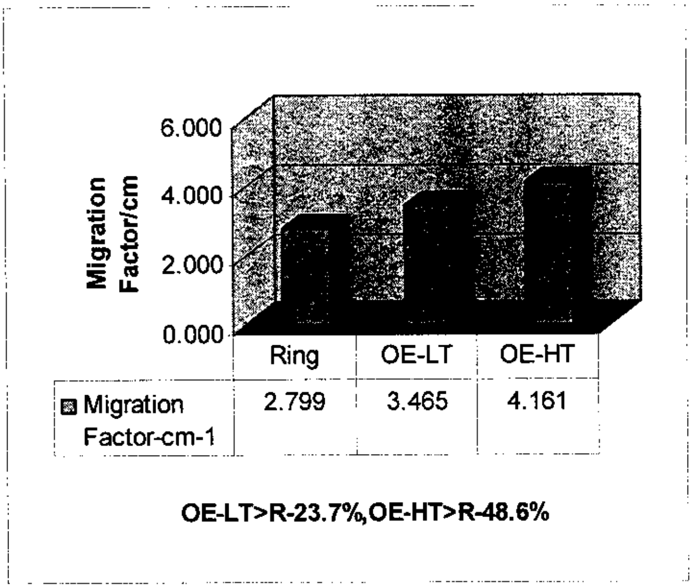


Fig.5.5. Histogram- Effect of Equivalent Migration Intensity

5.6. Effect of Spinning System on Migration Factor of Micro Fibre Yarn:

It is the product of RMS deviation and Migration Intensity (I).Since Intensity increase Migration Factor increases. OE-LT & OE-HT is 23.7% & 48.6% higher than the ring yarn respectively.



OE-LT>R-23.7%,OE-HT>R-48.6%

Fig.5.6. Histogram-Effect of Migration Factor

Fibre migration seems to be closely related to the fibre accumulation mechanism and spinning tension. In ring spinning, a ribbon like fibre assembly, delivered by a roller pair, is twisted into yarn. As the nip of the front roller restrains the fibre movement, there is a wide range of fibre tension variation generated across the fibre bundle which causes the fibres to migrate. In open-end rotor spinning, fibre accumulates in the rotor groove and is twisted into the yarn under very low tension within the strand. The yarn core almost has the same structure of ring yarn, but the yarn sheath consists of fibres experiencing different twist and almost no migration. Therefore fibres in rotor yarns take part in migration to a lesser extent than in the ring spun yarn.

From the present study and other previous works it has been inferred that Mean fibre position is mostly affected by the spinning system used , RMS deviation is mostly affected by the process variables in the spinning system used and Migration intensity is affected by the fineness of the fibre being used apart form twist intensity. The CCD photograph given below show the tracer fibre of Ring and Rotor yarns which indicates the differences in migration behaviour of tracer fibres

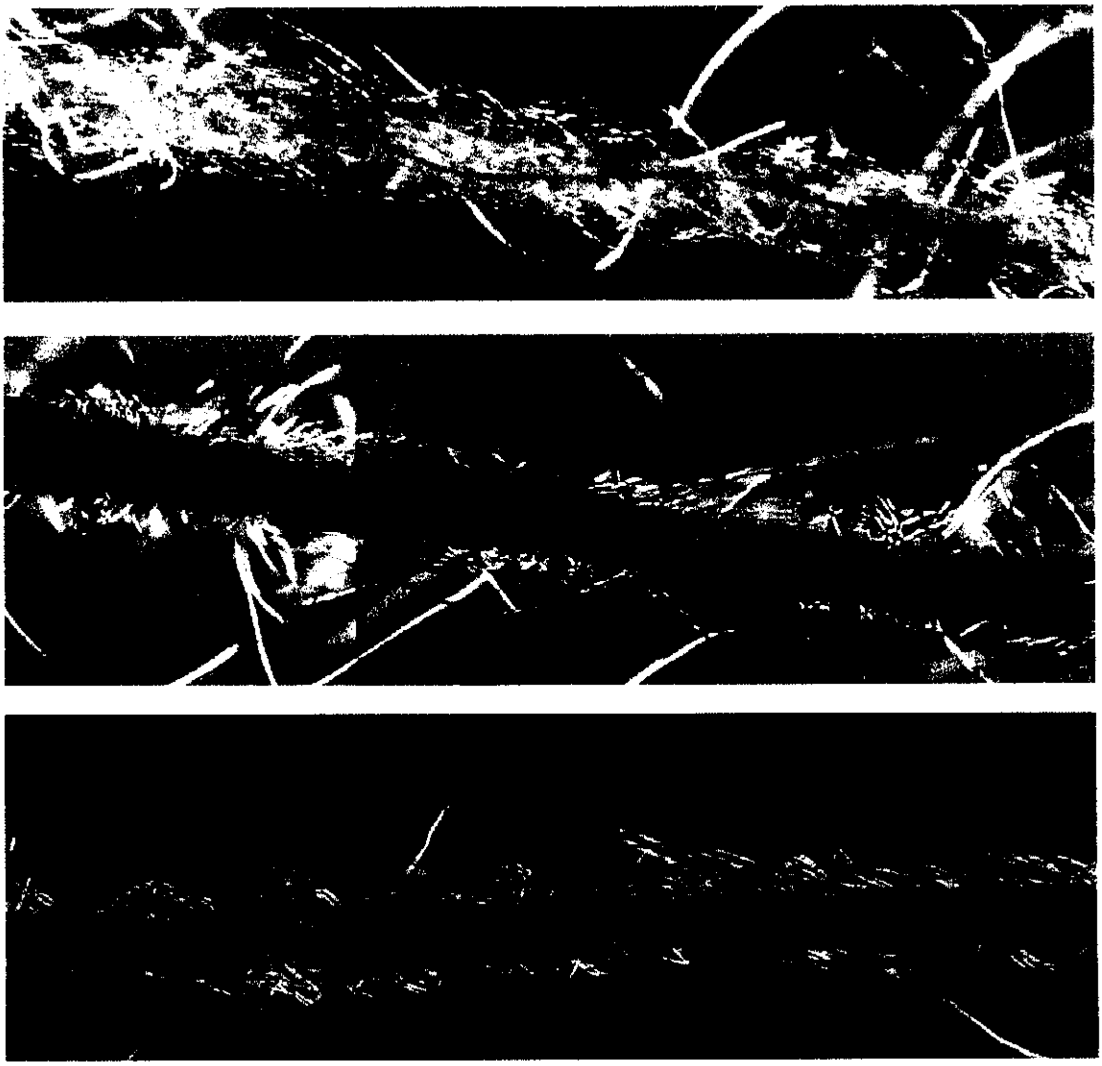


Fig.5.7. Microscopic view-Ring spun & OE-LT, OE-HT yarn's with Tracer Fibre

CHAPTER 6

CONCLUSION

The following conclusions are drawn from the migration study of Micro-fibre Ring and Rotor yarns:

- There is reduction in Mean Fibre Position of OE-LT & OE-HT yarn compared to Ring yarn to the tune of 22.6% and 37.2% respectively.
- There is reduction in RMS deviation to the tune of 5% and 6% respectively for OE-LT & OE-HT yarn compared to Ring yarn, which is statistically insignificant.
- There is an increase in Migration Intensity to the tune of 30.3% & 58.2% respectively for OE-LT & OE-HT compared to the ring yarn, and so the Equivalent Migration Intensity and Migration Factor. This may due to the variation in stress strain values of fine denier fibre and also the flexural rigidity is less for the fine denier fibres compared to the coarser fibres.
- From the present study and other previous works it could be inferred that Mean fibre position is mostly affected by the spinning system used, RMS deviation is mostly affected by the process variables in the spinning system used and Migration intensity is affected by the fineness of the fibre being used apart form twist intensity.

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