P-1268

INFLUENCE OF FIBRE WETTING IN RING FRAME ON FIBRE MIGRATION AND OTHER CHARACTERISTICS OF COTTON HOSIERY YARN AND FABRIC

P-1268

A PROJECT REPORT

Submitted by

M.PRIYANKA
(71201212028)

in partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

in

TEXTILE TECHNOLOGY

KUMARAGURU COLLEGE OF TECHNOLOGY,

COIMBATORE

ANNA UNIVERSITY: CHENNAI 600 025

APRIL 2005

ANNA UNIVERSITY : CHENNAI 600 025

BONAFIDE CERTIFICATE

Certified that this project report **"INFLUENCE OF FIBRE WETTING IN RING FRAME ON FIBRE MIGRATION AND OTHER CHARACTERISTICS OF COTTON HOSIERY YARN AND FABRIC"** is the bonafide work of **M.PRIYANKA** who carried out the project work under my supervision.

SIGNATURE

18/4/05

Dr.V.Natarajan
HEAD OF THE DEPARTMENT
Department of Textile Technology,
Kumaraguru College of Technology
Coimbatore -641 006.

SIGNATURE

18/4/05

Dr.V.Krishnakumar
SUPERVISOR
Asst. Professor
Department of Textile Technology
Kumaraguru College of Technology
Coimbatore - 641 006

INFLUENCE OF FIBRE WETTING IN RING FRAME ON FIBRE MIGRATION AND OTHER CHARACTERISTICS OF COTTON HOSIERY YARN AND FABRIC

This project report has been submitted by

Name	**:**	**M.PRIYANKA**
Register No	**:**	**(71201212028)**

for the viva-voce examination held on 20/4/05

Internal Examiner **External Examiner**

ACKNOWLEDGEMENT

I wish to express my sincere gratitude to the Management of **Kumaraguru College of Technology** for providing me all the facilities to complete the project successfully.

I am immensely grateful to **Dr.K.K.Padmanabhan,** Principal, Kumaraguru College of Technology for the support and the facilities provided to me to complete the project in time.

My sincere thanks to **Dr.V.Natarajan,** Prof & Head, Department of Textile Technology, Kumaraguru College of Technology for his continuing assistance. His valuable advice and suggestions throughout the project has been immensely helpful in the completion of the efforts undertaken.

I express my deepest sense of gratitude to my project guide **Dr.V.Krishnakumar,** Assistant Professor, Department of Textile Technology for his profound ideas, able guidance and continuing motivation. His kindness and invaluable guidance have been integral in the completion of this work. I consider this as an honour to have the opportunity to work under his guidance in this project work.

I am grateful to **M/s. Sangeeth Textiles,** Annur for providing us with the necessary raw materials for this project.

I express my humble gratitude to **Dr.Kathirvel,** Head, Physical testing division and **Mr.Selvaraj,** Technical Officer, SITRA for helping me to carry out the Image Analysis.

I immensely thank **M/s. Lakshmi Machine Works Ltd,** Coimbatore for providing yarn testing facilities.

My thanks are extended to **Mr. Jaffer Sadhik,** and **Mr.M.Arulanandham** technicians of Weaving and Knitting lab, Kumaraguru College of Technology for their assistance in spinning and fabric preparation respectively.

Last but not the least, my heartfelt thanks are extended to my family members and friends who have helped me in the completion of my project work.

ABSTRACT

In ring spinning a strand of fibres is drafted to form a ribbon which comes out of the front roller nip and twisted into yarn with the help of ring and traveller mechanism. The factors influencing the yarn characteristics are the type of fibre, number of fibres in the cross section, draft zone setting, drafting force, roller stand angle and spinning process parameters such as spindle rpm, tpi, etc. The other parameter which is important and influencing the structural properties of yarn is **'Fibre migration'.**

This project work deals with the study of fibre migration parameters of cotton ring yarn using image analysis technique on the regular ring spinning conditions. In addition to that a novel technique of fibre wetting is also carried out using special attachment and fibres are wetted in the front roller zone. For the purpose of study the cotton roving containing 0.5% of black dyed fibres was used in the ring spinning frame to produce 40s combed hosiery yarn under standard spinning conditions. The yarns produced from regular spinning as well as with fibre wetting were taken for investigation using image analyser and fibre migration parameters were studied. The test reveals that the migration factor of yarn produced with wetting process found improved when compared to the same of regular yarn. Also, other physical properties such as yarn hairiness, packing density and yarn diameter were studied using UT4 tester. Similarly the test results shows that wet spun yarn is having reduced hairiness and diameter. The packing density, single yarn strength also found increased for wet yarn. As far as the twist liveliness value is concerned the wet spun yarn shows lesser values when compared to regular yarn. The produced yarn was knitted into weft knit fabric to the study the influence of fibre wetting on spirality. The spirality of weft knit fabric found reduced in the case of wet spun yarn.

செயல் திட்டச் சுருக்கம்

Ring Spinning எனப்படும் நூல் நூற்பு முறையில் கதிர்கள் (Spindles) நூலில் முறுக்கத்தை ஏற்றுகின்றன. பொதுவாக நூல் நூற்புக்கு உட்படுத்தப்படும் இழைகளின் தன்மை, டிராப்டிங் எனப்படும் இழை பகுத்தலுக்கான வடிவமைப்பு மற்றும் உருளைகளின் வேகங்கள் ஆகியவை நூலின் பண்புகளை மாற்றும் தன்மை கொண்டவை. மேலும் இழைகளுக்கு இடையேயான உராய்வுத் தன்மை வேறுபடும் பொழுதும் நூலின் பண்புகள் மாறுபடுகின்றன. இதனைக் கருத்தில் கொண்டு நூல் நூற்பின் பொழுது, இழைகளின் உராய்வுகளை மேன்படுத்துவதற்கு தண்ணீரை பிரயோகித்தால் நூலின் பண்புகள் எவ்வாறு மாறுபடுகின்றன என்பதை கண்டறியும் பொருட்டு இந்த செய்ல்திட்டம் வடிவமைக்கப்பட்டுள்ளது. இதன்படி நூல் நூற்பு இயந்திரத்தில் பியூரெட் (Burette) குழாய் உதவியுடன் நீர் துளிகள் இழை பகுக்கப் பயன்படும் உருளைகளின் மேல் படும்படியாக ஏற்பாடு செய்யப்பட்டு, ஈரத்தன்மையுடன் கூடிய இழைகளை முறுக்கத்திற்கு உள்ளாக்கி நூல் உற்பத்தி செய்யப்பட்டது. இந்த நூலின் பண்புகள் சாதாரண முறையில் உற்பத்தி செய்யப்பட்ட நூலின் பண்புகளோடு ஒப்பிடப்பட்டு விவாதிக்கப்பட்டுள்ளன. மேலும் நீரினால் ஏற்படும் இழைகளின் இடம் பெயர் பண்புகள் (Fibre Migration Characteristics) கண்டறியும் பொருட்டு 0.5% டிரேசர் பைபர் (Tracer Fibre) எனப்படும் கருப்பு சாயம் ஏற்றப்பட்ட பருத்தி இழைகள் உள்ளடங்கிய ரோவிங், நூல் நூற்பதற்கு மூலப் பொருளாக பயன்படுத்தப்பட்டது. 40s CH நூல் இரண்டு முறைகளிலும் உற்பத்தி செய்யப்பட்டு ஆய்விற்கு எடுத்துக் கொள்ளப்பட்டன. Image Analysis எனப்படும் பிம்ப ஆய்வு முறையில் கணிணி உடன் இணைந்த நுண்ணோக்கி உதவியுடன் நூலின் உள்கட்டமைப்பு மற்றும் இழைகள் இடம் பெயர்தல் திறன் ஆகியவை ஆய்வு செய்யப்பட்டன. இந்த ஆய்வில் தண்ணீர் உபயோகத்துடன் உற்பத்தி செய்யபட்ட நூலில் இழைகள் நல்ல முறையில்

இடம்பெயர்வது கண்டறியப்பட்டது. மேலும் இந்த நூலின் பல்வேறு பௌதீகப் பண்புகள் சாதாரண நூலைக் காட்டிலும் 20 சதம் முதல் 40 சதம் மேன்மை அடைந்திருப்பது கண்டறியப்பட்டது. Twist Liveliness எனப்படும் எதிர்முறுக்கப்பண்பு இந்த நூலில் 48 சதம் குறைந்திருப்பது கண்டிறியப்பட்டது. இதன் காரணமாக இந்த நூலில் உற்பத்தி செய்யபட்ட பின்னலாடையில் spirality எனப்படும் சுருள் தன்மை 56 சதம் குறைந்திருக்கிறது.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1. TEXTILE SCENARIO IN INDIA

As per the CII study, Indian textile industry is estimated to grow to $85 billion from the present $13 billion by the year 2010. Besides the ending of the textile quotas have brightened the future of the domestic industry as India turns into a global textile and apparel outsourcing hub.

In the coming 2005-2006 budget, the textile industry hopes that Finance Minister P. Chidamabram has all the goodies including tax sops, hike in subsidies and other benefits that can help the country withstand competition internationally. The size of our textile industry is estimated at Rs.1,24,000 crores constituting one fifty of the industrial production and seven percent of the GDP. The industry has fair global exposure. Textile exports constitute about 35 percent of the total foreign exchange earning of the country and providing employment directly and indirectly to around million people.

Our industry has an impressive profile. We are the largest exporter of cotton yarn in the world, third largest producer of cotton, second largest producer of silk, fifty largest producer of synthetic fibre and have largest loomage and second largest number of spindles in the world. Yet our share is the global textile industry is a dismal 3 percent and the industry is deeply entrapped in problems of stagnation.

A brief overview of the industry reveals that our spindleage increased from 11 million spindles in 1950 to 35 million spindles in 2004. The shuttle looms increased form 2 lacs to 15 lacs during the same period. The shuttle less looms increased from 200 in 1978 to 20,000 in 2004. The Indian textile industry also presents a very complex picture with visages of 18^{th}, 19 and 20^{th} century. The Charkha and the handloom jostle with state of the art automatic plants and compete for the same market.

1.2. THRUST ON YARN AND FABRIC QUALITY

During the last few decades, the use and manufacture of knitted fabrics have increased substantially.

In order to survive in the global market, many technological outsourcing is necessary to upgrade the quality of yarns and fabrics. Specially the key areas in which India has to concentrate in production and quality and cost competitiveness. Production of better quality fabric depends on as efficient weaving or knitting process, as well as the use of quality input material that is the yarn.

1.3. SPIRALITY AND YARN TWIST LIVELINESS

In single jersey weft knitted fabric, "Spirality" is the fault that occurs frequently. In fabrics with no spirality, the wales and courses are perpendicular to each other. Whereas in fabric with spirality, the wales and courses are at an angle less than 90^0C. The angle between the direction of wales and the direction of line drawn at right angle to courses is known as spirality angle. The greater this angle, higher in the spirality.

So the fabric skews towards right or left depending upon physical characteristics. The main reason for spirality is Yarn twist liveliness:

It is well known that the moisture content and ambient conditions in the ring spinning department play a vital role in the twisting behaviour of fibres during spinning. In this context, a novel idea of wetting the fibres during spinning is evolved.

Having this in mind, 40s combed hosiery yarn was produced from two different methods, under similar spinning conditions as mentioned below, two study the effect on physical characteristics of hosiery yarn and fabric.

- Spinning under normal condition
- Spinning by wetting the fibres arriving at front roller nip of the drafting zone with plain water.

In this project the structure of wet spun yarn was also studied. The new parameter, migration factor which represents fibre migration, was found to be higher in wet spun yarns. The packing density of the wet spun yarn was also found to be higher than that of regular spun yarn. Yarn twist liveliness and spirality of weft knitted fabrics were also tested.

2. LITERATURE REVIEW

2.1. INTRODUCTION

The fiber migration is an important aspect which determines the physical properties of yarn spun. Many research workers have studied the fiber migration characteristics in various stages of yarn spinning. This chapter highlights the findings of few important research papers provided by Hearle, J.W.S. (1969), Morton, W.E (1952), Riding, G (1959), Kim, Y.R (1999), Primentas, A and Iype, C. (2001).

This chapter also deals with the literature, on the method of fiber wetting and its influence on yarn characteristics. Some of the papers referred on topics related to twist liveliness, techniques for reducing yarn hairiness and spirality are also reviewed.

2.2. MECHANICS OF SIMPLE YARN STRUCTURE

According to Backer, S (1969), he considered the literature in the order of logical development. Consider a series of fibers infinetely long, uniform in cross section, and uniform in mechanical properties. The fibers are twisted together so as to form a series of uniform helices, with each fibers lying on a helix of radius (and staying at that radius). Each fiber has properties constant along its length; each fiber is similar to its neighbour in geometry and in mechanical properties. It is assumed that there is no interaction between the fibers and it is considered that each fiber element to be so slender that it can withstand only tensile forces along its axis. This is the background of Platt's initial development in yarn mechanics (1950). Gegauff (1907) attempted a similar approach early in the century, but his work was not brought to light until some years later by Hearle (1958).

Platt's approach was as follows. Assume that when a yarn is stretched, each fiber in that yarn has a fixed geometric location identifiable by its inclination angle relative to the yarn axis. A given stretch for the yarn causes fiber strains which differ from position to position. The fiber strain at any location equals the product of the yarn extension and the cosine squared of the helix angle of the fiber. From the stress – strain curve given for the fiber we can determine the tensile force which will develop along its axis as a result of the strain imposed. The contribution of this force to the normal stress acting on the cross section of the yarn at that location is equal to the product of the axial stress in the fiber and the cosine squared to its helix angle. One now considers this stress acting on a small increment of area and integrates the resulting incremental force over the cross section of the yearn for all fibers.

Once this integration process is undertaken, we have an expression for the tensile load or tensile resistance which the yarn puts up to axial stretch at a given level of strain. But the prediction of when the yarn will break depends on the criteria for failure. One may decide that the yarn will break when the fiber in the position of maximum strain reaches its own breaking strain. This fiber lies at the yarn center with a zero helix angle. If the fiber elongation at rupture is known, we can then assume that the yarn breakdown will initiate at this same strain and from the expression developed by Platt for the tensile resistance of the yarn to strain, thus the breaking strength of the yarn can be calculated. An analytical expression for this breaking strength will be a function of the properties of the fiber and the geometry of the yarn, exemplified by its twist and radius.

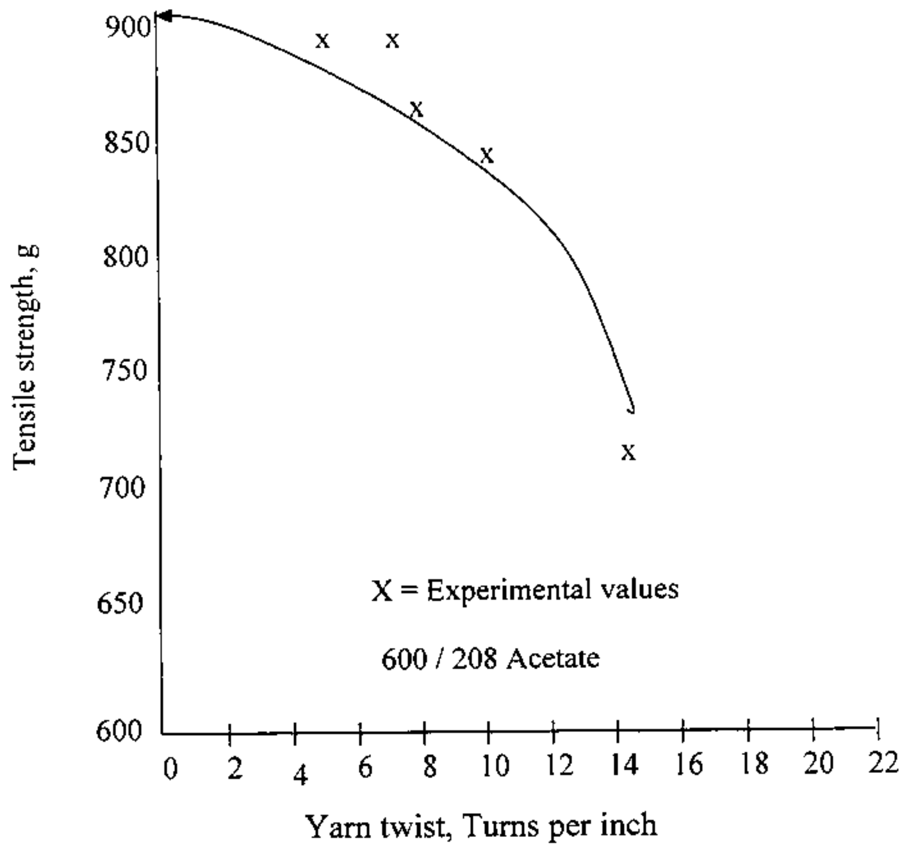


Fig. 2.1. Yarn strength Vs twist

Fig.2.1. shows a plot of yarn strength calculated from Platt's expression and also determined experimentally at various twist levels. For this calculation Platt assumed that the twist angle did not change significantly with yarn extension, nor did the radius of the yarn decrease during the test.

2.3. TEXTILE YARNS

Yarns form an important intermediate stage in many methods of textile production. They may be defined as long, fine structures capable of being assembled or interlaced into such textile products as woven and knitted fabrics, braids, ropes, and cords. Despite the growing use of several forms of nonwoven fabrics directly assembled from fibers, fabrics composed of interlaced yarns will remain of predominant importance for many years. The study of yarns is thus a necessary part of textile technology, and the interrelations between the structure and properties of fibers, yarns, and fabrics are illustrated in the below figure.

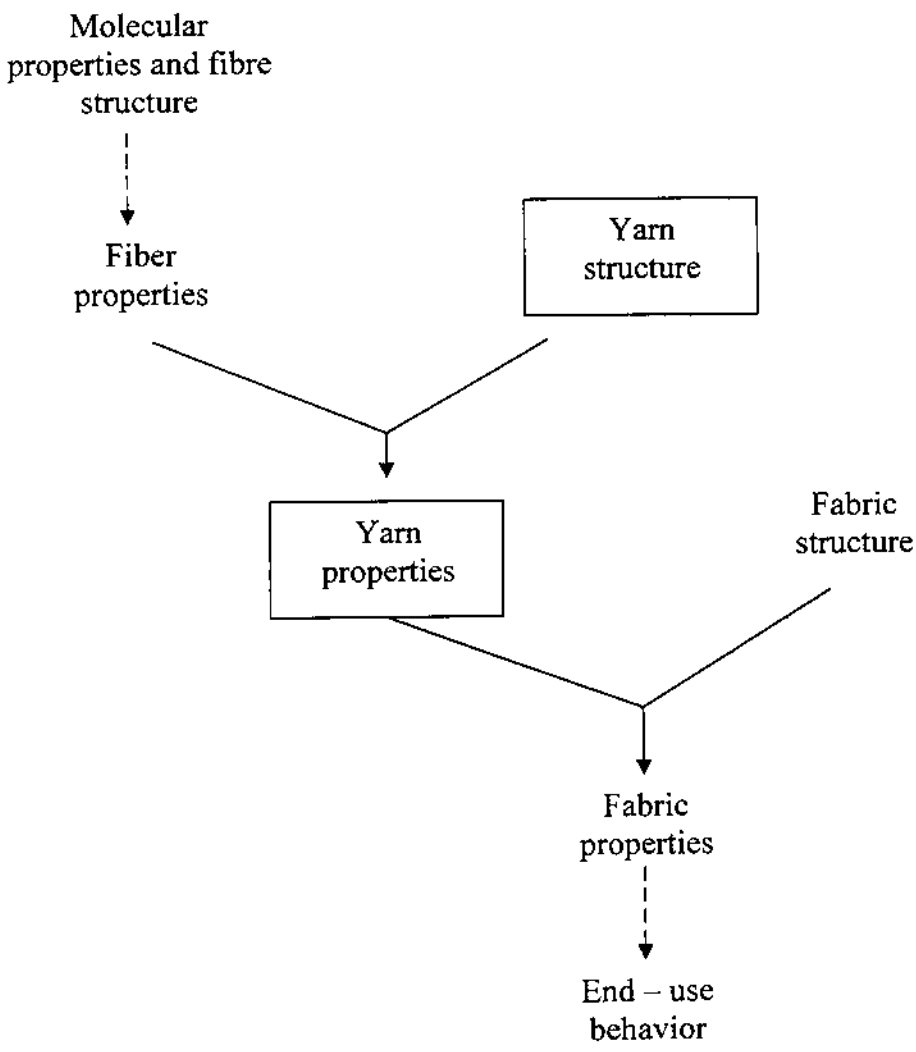


Fig.2.2. Interrelations of fiber, yarn and fabric structure and properties

2.4. THE IDEALISED HELICAL YARN STRUCTURE

As per Hearl, J.W.S (1969), the yarn is assumed to be circular in cross section, and composed of a series of concentric cylinders of differing radii. Each fiber follows a uniform helical path around one of the concentric cylinders, so that its distance from the yarn axis remains constant. A fiber at the center will follow the straight line of the yarn axis; but, going out from the center, the helix angle gradually increases, since the number of turns of twist per unit length remains constant in all the layers. The density of packing of fibers in the yarn remains constant throughout the model; and the structure is assumed to be made up of a very large number of filaments, so that various complicating effects, which are due to the special ways of packing a limited number of fibers together, do not arise.

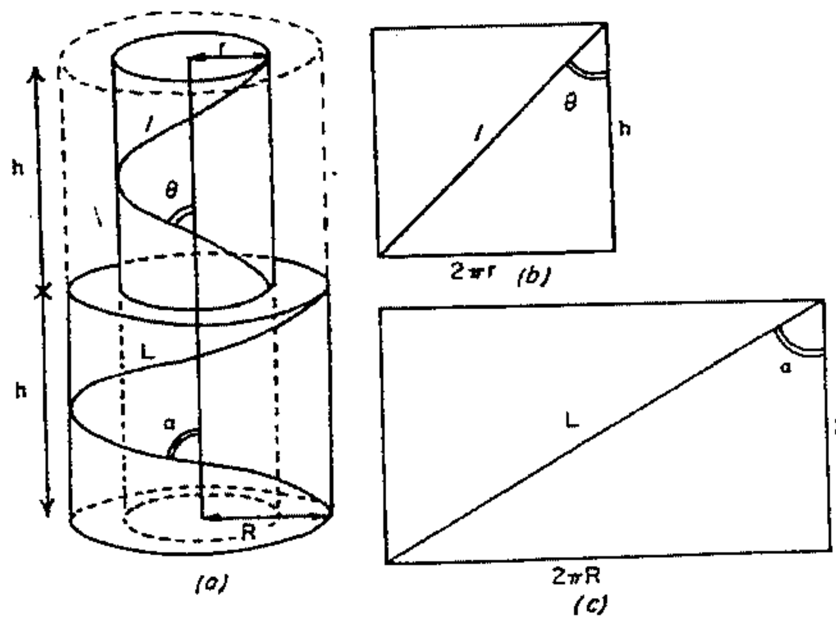


Fig.2.3. Idealized helical yarn geometry (a) Idealized geometry (b) "Opened-out" diagram of cylinder at radius r (c) "opened – out" yarn surface

It is possible to derive a number of useful geometrical relations from a consideration of the idealized structure.

Let :

R = Yarn radius (cm)

r = radius of cylinder containing the helical path of a particular fiber (cm)

T = yarn twist, turns per unit length (cm^{-1})

h = length of one turn of twist (cm)

α = surface angle of twist, namely the angle between the axis of a fiber on the surface and a line parallel to the yarn axis (degrees)

θ = corresponding helical angle at radius r (degrees)

l = Length of fiber in one turn of twist, at radius r (cm)

L = Length of fiber in one turn of twist, at radius R (cm)

Clearly,

$$h = 1 / T$$

By cutting the concentric cylinders of Figure along a line parallel to the yarn axis, and then opening the cylinders out flat, it is possible to obtain figure 2.3b and c. It then follows that:

$$l^2 = h^2 + 4\pi^2 r^2$$

$$L^2 = h^2 + 4\pi^2 r^2$$

$$\tan \theta = 2\pi \, r/h$$

$$\tan \alpha = 2\pi \, R/h$$

It is sometimes useful to establish a cylindrical polar coordinate system for the yarn as shown in figure 2.4. The length along the yarn axis is denoted by z, the angular rotation about the axis by ϕ, and the radial distance from the axis by r. The equations of a fiber following a uniform helix in the idealized yarn are then:

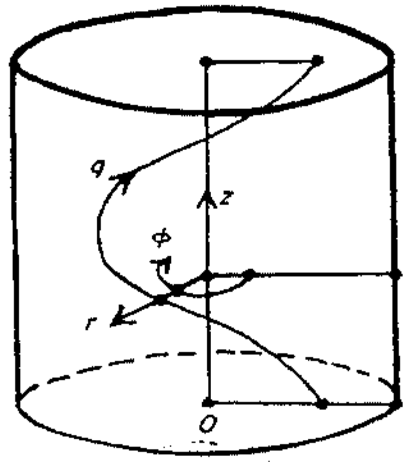


Fig. 2.4. Cylindrical Polar co-ordinates

r = constant

$\phi = 2\pi z / h$

The length q along the fiber is given by:

$q = z \sec \theta$

$= z\,(1+4\pi^2 r^2/h^2)^{1/2}$

$= z\,(1+ (r/R)^2 \tan^2 \alpha)^{1/2}$

Discussion of twist geometry extending into the more complex problems of cord geometry, have been given by Schwarz (1933, 1936, 1950), woods (1933) and Treloar (1956).

2.5. TWIST FACTOR AND TWIST ANGLE

It is interesting to note the twist angles corresponding to different twist factors for typical yarn specific volumes: These are given in Table 2.1

Table 2.1

Twist factor and Twist angle

Specific volume, cm^3/g	**Twist factor, $tex^{1/2}$ turns /cm**						
	Twist angles						
	0^0	20	40	60	80	100	120
0.5	0^0	9^0	18^0	25^0	32^0	38^0	44^0
1.0	0^0	13^0	24^0	34^0	42^0	48^0	53^0
1.5	0^0	15^0	29^0	39^0	48^0	54^0	59^0

2.6. FIBRE MIGRATION

The observation of individual fibres in a mass of fibre becomes possible with the tracer fibre technique. For the microscopic examinations of ring–spun yarn containing tracer fibres, the depth of focusing is used as a reference for the fibre location inside the body of the yarns. Three dimensional configurations of the examined fibres in the yarns are generated by computer graphics. This method assist researcher who are working in the field of yarn and fabric structural mechanics.

2.6.1. Mechanics of Fibre Migration

Basically there are two different types of fibre migration :

- ❖ Tension mechanism proposed by **Morton and Yen (1952).**
- ❖ Geometric mechanism proposed by **Hearl J.W.S et al., (1965).**

❖ **Tension Mechanism**

- ➢ Morton explained the migration on the basis of tension differences which exists among fibre components at the point of yarn formation.
- ➢ They are influenced, by size of spinning triangle.

- When the yarn is given twist, fibres follow helical path with length of fibre path decreases from surface to core.
- Thus angle of helix envelope varies throughout the fibre length showing migration. This is referred as 'short term migration'.

❖ Geometric mechanism

- It is based on ribbon twisting, which gives a wrapped structure.
- Migration period is influenced by roving twist x draft.
- It is referred as 'long term migration'.

2.6.2. Technique adopted for observation of the paths of individual fibers

i. Tracer fibre technique – Morton

In order to study migration behaviour, it is necessary to have a technique for following the path of individual fibers in the yarn. This need has been met by the tracer fiber technique developed by Morton and Yen (1952). A small proportion (less than 1%) of colored fibers is added to the stock from which the yarn is spun. It is essential that the properties of the colored fibers, which are thus incorporated in the yarn, should be identical, or almost identical, with those of the main stock of uncolored (bright) fibers. On immersion in a liquid of the same refractive index as the fibers, the yarn becomes almost transparent (although its outline can be discerned) and the path of the individual colored fibers can be clearly followed in Fig.2.5 a typical example of what can be seen. The use of the tracer fiber technique has been describer by Morton (1956).

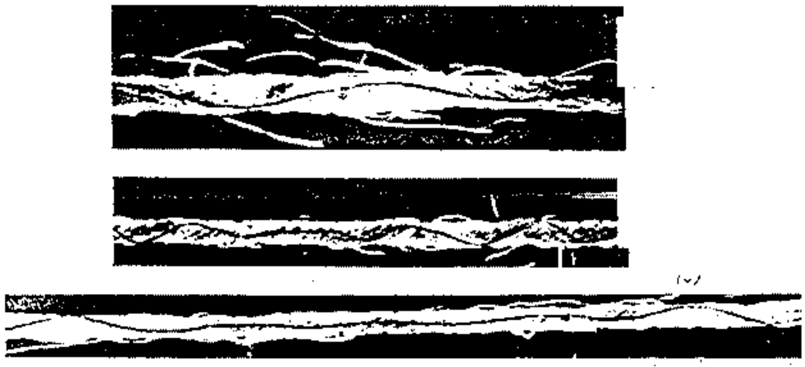


Fig. 2.5. Tracer Fiber Yarn as seen in Polarized Light

ii. Tracer fibre technique – Riding

Riding (1959, 1964) applied the technique to continuous filament yarns containing one colored filament. These yarns were usually made by mounting two spinning jets close together, with one extruding colorless multifilament yarn and the other extruding an otherwise identical colored yarn. One colored filament is the separated and wound up with the uncolored yarn. Alternatively separate monofils can be produced and assembled together. Since the path followed by a fibre is actually in three dimensions, it can only be fully established if observations are made in more than one direction. This can conveniently be done by placing a plane mirror near the yarn in the liquid, with the plane of the mirror at 45° to the direction of observation. The fibres can be viewed from two directions at right angle.

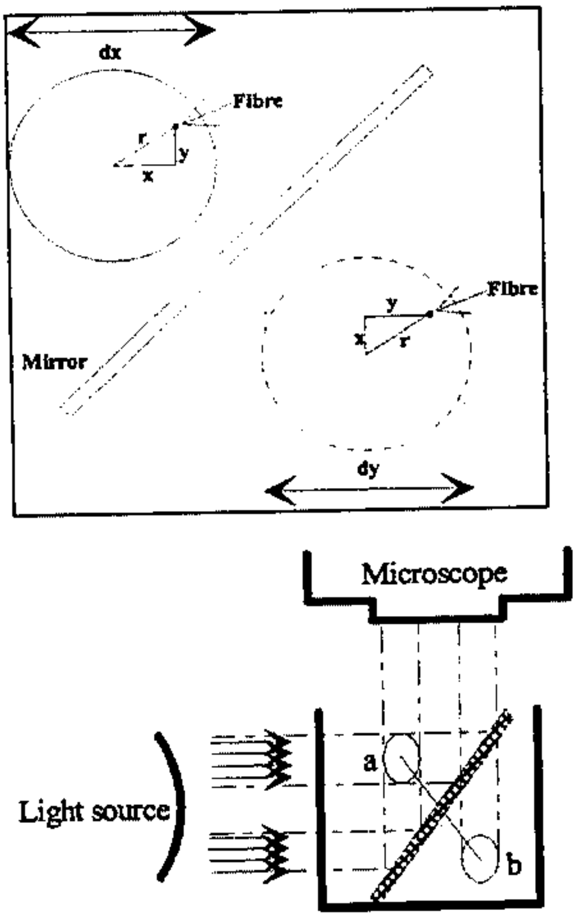


Fig. 2.6. The Tracer filament apparatus made by Riding (1964)

iii. Radio – Active fibre – tracer Technique

To investigate the configuration of fibres by giving radio active treatment to the fibres. Auto–radiographs are prepared for the analysis.

2.7. FIBER WETTING

Wetting binds the fibres arriving at the drafting rollers. It is hence very common to carry out the same in the case of doubling very thick varieties like coirs and ropes. Thus an attempt of wetting of fibres even for the usual counts of yarn spun, would enhance the proper binding of fibres. Wetting of fibres near the spinning triangle causes the selvedge fibres to wind properly into the structure of yarn. There is the least chance of protruding fibres owing to the wetting procedure.

When fibres absorb water, they change in dimensions swelling transversely and axially. This has technical consequences in the dimensional stability of fabrics, the predominant transverse swelling usually resulting in a shrinkage of twisted or interlaced structures. It also means that the course of closely woven fabrics will be completely blocked when the fibres are swollen, and they may then be impermeable to water. Swelling is akin to solution in that there is an interchange of position between fibre molecules and water molecules.

According to K.P.R. Pillai (1961) in his research work suggested that:

1. Wetting increases the breaking strength, strength uniformity and breaking elongation of cotton fibre bundles.
2. More uniform cottons show less increase in uniformity of strength on wetting than less uniform cottons.
3. Stiffness and toughness both show increase on wetting. The magnitude of these effects varies considerably with different cottons.
4. Wetting increases the strength, elongation, stiffness and toughness of yarns, to an extent depending upon the twist and on the cotton fibre properties.
5. The coefficients of variation of single thread strength and elongation are reduced by wetting, as also is the twist multiplier for maximum strength.
6. The fibre properties studied are in general significantly correlated with the corresponding yarn properties, the degree of association varying however, with yarn twist and with the conditions of test (dry or wet).

7. The multiple correlations between the fibre and yarn properties are smaller for the wet test than for the dry, indicating that unmeasured fibre properties assume greater importance of wetting.
8. The effect of wetting on some physical properties of yarns has seen shown to be similar to that of increased spinning twist; consequently when yarns are to be wet processed, lower twist will be necessary to give maximum strength in the wet state.
9. Yarn elongation at break is a affected more by changes in fibre elongation than by changes in twist; therefore the choice of a cotton with greater fibre elongation should enable a more extensible yarn to be spun without increase of twist and subsequent loss of production. Further, it is possible to get equal yarn elongation for two widely differing yarn counts by selecting the proper combination of spinning twist multipliers and fibre elongations.
10. The co-efficient of variation of elongation at break of yarns appears to be an important quality factor for evaluating processing efficiency because of its high correlation with yarn toughness; in other words yarns which are more uniform in elongation possess greater ability to withstand strains in processing.

2.8. YARN HAIRINESS

Hairiness in spun yarn is caused by the fibres protruding out of the yarn. Hairiness imparts a fuzzy appearance to the yarn and reduces the lustre of the yarn. Excessive hairiness in yarn impairs proper sizing, causes more end breaks during weaving due to the hairs in adjoining threads sticking together and mars fabric quality by creating weft bars in fabrics. The various fibre and processing parameters that affect yarn hairiness and methods to control hairiness are briefly dealt.

2.8.1. Facts about yarn hairiness

Hairiness occurs because some fibre ends protrude from the yarn body, some looped fibres arch out from the yarn core and some wild fibres in the yarn.

- Pillay proved that there is a high correlation between the number of protruding ends and the number of fibres in the yarn cross-section.
- Torsion rigidity of the fibres is the most important single property affecting yarn hairiness. Other factors are flexural rigidity, fibre length and fibre fineness
- Mixing different length cottons-No substantial gain in hairiness. Although the hairiness of a yarn could be reduced to some extent by the addition of a longer and finer cotton to the blend. The extent of reduction is not proportional to the percentage of the longer and finer component. This is probably due to the preferential migration of the coarser and shorter component, which has longer protruding ends, from the yarn body. The addition of wastes to the mixing increases the yarn hairiness; the effect of adding comber waste is greater than that of adding soft waste.
- Blending-not a solution to hairiness. The blended yarns are rather more hairy than expected from the hairiness of the components; a result similar to that found in cotton blends. This may be due to the preferential migration of the shorter cotton fibers; a count of the number of protruding ends of both types of fiber shows that there is more cotton fiber ends than expected, although the difference is not very great.

- The proportion of fiber ends that protrude from the yarn surface, counted microscopically has been found to be about 31% of the actual number of ends present in the yarn.
- If the length of the protruding fibre ends as well as that of the loops is considered, the mean value of the hairiness increases as the cross-sectional area increases and decreases with the length of the loops. The hairiness is affected by the yarn twist, since an increase in twist tends to shorten the fibre ends.
- Fibre length influences hairiness in the sense that a greater length corresponds to less hairiness.
- Cotton yarns are known to be less hairy than yarns spun from man-made fibres. The possible reason for this is the profile of the two fibres. Because of taper, only one end, the heavier root part of the cotton fibre, tends to come out as a protruding end in a cotton yarn. With man-made fibres, both ends have an equal probability of showing up as protruding ends.
- The yarn hairiness definitely depends on the fibres on the outer layer of the yarn that do not directly adhere to the core. Some of them have an end in the core of the yarn gripped by other fibres, whereas others, because of the mechanical properties of the fibre(rigidity, shape, etc.) emerge to the surface. During the twisting of the yarn, other fibres are further displaced from their central position to the yarn surface.
- Greater the fibre parallelization by the drawframe, lower the yarn hairiness.
- Drafting waves increase hairiness. Irregularity arising from drafting waves increases with increasing draft. Yarn hairiness also may be

accepted to increase with yarn irregularity, because fibers protruding from the yarn surface are more numerous at the thickest and least twisted parts of the yarn

- Parallel fibers-less hairiness. The improvement of yarn quality on combing is mainly ascribed to the reduction in the number of short fiber improvement in length characteristics, and fiber parallelization. There is a marked difference in hairiness of the carded yarn and the combed yarns, even with a comber loss of only 5%, but the effect on hairiness of increasing the percentage of comber waste is less marked. Combing even at low percentage waste causes a marked drop in hairiness relative to that of the carded yarn. In the case of combed cotton yarns the average value of hairiness decreases with increase in count, whereas in the case of polyester/ viscose blend yarns the hairiness increases with increase in count. In the case of polyester/ cotton blend yarns trend is not clear.
- Yarn spun in a dry atmosphere is more hairy.
- Yarn hairiness is caused by protruding ends, by the presence of a majority of fibre tails.
- This suggests that these tails will become heads on unwinding and that friction to which the yarn is subjected will tend to increase their length. It is therefore logical that a yarn should be more hairy after winding.

2.8.2. Methods of measurement of yarn hairiness

As per SITRA focus (1987) eventhough several methods were suggested in literature to measure hairiness, 3 methods are very common in research laboratories. They are i. Microscopic technique, ii. Loss of weight in singeing and iii. Measurement using photo – electric principle.

i. Microscopic Technique

Here, the yarn under study is passed under a projection microscope and examined on a screen under a magnification of 50X. The portion of yarn appearing between two lines on the screen (corresponding to 3 mm length of yarn) is examined for the number of protruding fibres and looped fibres. In order to measure the length of the fibre involved in loops and ends, the ends and loops appearing between the two lines on the screen are traced on a tracing paper fixed on the screen. From the tracings, the actual lengths of ends and loops are calibrated by means of calibrated map measuring device.

ii. Singeing method

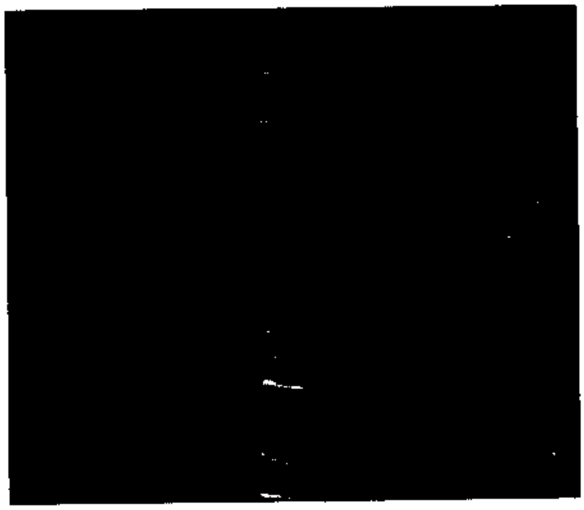
The yarns under study are wound on cones, conditioned and accurately weighted. They are then singed using yarn singeing machine under optimum condition of speed and temperature. The singed yarns are then conditioned and weighted. From these weights, the loss in weight on singeing for 1 gram of yarn is calculated. Higher weigh loss indicates the presence of higher number of hairs.

iii. Photo-Electric principle

Shirley yarn hairiness meter works using this principle. Here, optical technique is employed to detect the fibres projecting from the body of the yarn. The yarn to be tested is passed over a guide, which accurately locates the axis of the yarn relative to a beam of light and a photo cell. As the yarn is drawn over the guide, the projecting fibres momentarily interrupt the light beam. The resulting signal from the photo cell is amplified, and if it then exceeds a certain threshold level, it is counted by a counter. A simple integrator provides an output related by an exponential law to the counting rate.

2.8.3. Hairiness Testing of Yarns

Hairiness of yarns has been discussed for many years, but it always remained a fuzzy subject. With the advent of compact yarns and their low hairiness compared to conventional yarns, the issue of measuring hairiness and the proper interpretation of the values has become important again. Generally speaking, long hairs are undesirable, while short hairs are desirable (fig. 2.7).



a. Ring Yarn **b. Compact Yarn**

Fig. 2.7 Visual impression of undesirable and desirable hairiness at the edge of a cop

There are two major manufacturers of hairiness testing equipment on the market, and both have their advantages and disadvantages. Some detail is given below.

i. Uster

USTER is the leading manufacturer of textile testing equipment. The USTER hairiness H is defined as follows

H =total length (measured in centimeters) of all the hairs within one centimeter of yarn.

(The hairiness value given by the tester at the end of the test is the average of all these values measured, that is, if 400 m have been measured, it is the average of 40,000 individual values). The hairiness H is an average value, giving no indication of the distribution of the length of the hairs. Table 2.2 provides Uster hairiness test results.

Table 2.2

Uster hairiness

	0.1cm	0.2cm	0.3cm	0.4cm	0.5cm	0.6cm	0.7cm	0.8cm	0.9cm	1.0cm	total
yarn 1	100	50	30	10	5	6	0	2	1	0	398
yarn 2	50	10	11	5	10	0	5	10	0	11	398

Both yarns would have the same hairiness index H, even though yarn is more desirable, as it has more short hairs and less long hairs, compared to yarn 2. This example shows that the hairiness H suppresses information, as all averages do. Two yarns with a similar value H might have vastly different distributions of the length of the individual hairs.

The equipment allows to evaluate the variation of the value H along the length of the yarn. The "sh value "is given, but the correlation to the CV of hairiness is somehow not obvious. A spectrogram may be obtained.

ii. Zweigle

Zweigle is a somewhat less well known manufacturer of yarn testing equipment. Unlike USTER, the Zweigle does not give averages. The number of hairs of different lengths are counted separately, and these values are displayed on the equipment. In addition, the S3 value is given,which is defined as follows:

S3 =Sum (number of hairs 3 mm and longer)

In the above example,the yarns would have different S3 values:

S3yarn 1 =2 .

S3yarn 2 =4 .

A clear indication that yarn 2 is "more hairy "than yarn 1. The CV value of hairiness is given a histogram (graphical representation of the distribution of the hairiness) is given.

The USTER H value only gives an average, which is of limited use when analyzing the hairiness of the yarn. The Zweigle testing equipment gives the complete distribution of the different lengths of the hairs. The S3 value distinguishes between long and short hairiness, which is more informative than the H value.

2.9. TWIST

In a spinning process, a strand of fibre in a more or less parallel form is drafted and twisted on its own axis to form a yarn.

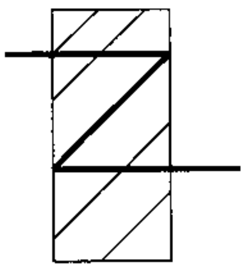
2.9.1. Definition

According to Skinkle, "Twist is defined as the number of spiral turns given to a yarn in order to hold the constituent fibres or threads together".

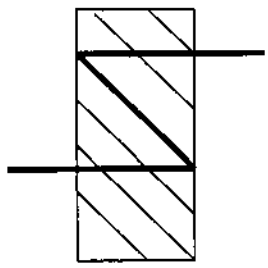
In the Indian standard, twist is defined as the spiral disposition of the components of yarn and is generally expressed as the number of turns per unit length of the yarn. For example turns per inch (TPI) or turns per meter (TPM).

2.9.2. Direction of twist

The direction of twist is expressed as either "S" twist or "Z" twist.



"Z" Twist



"S" Twist

Fig. 2.8. Diagrammatic representation of S twist and Z twist

2.9.3. Amount of twist

Twist in the yarn depends upon

- Count of the yarn to be spun
- Quality and type of raw material used
- End use of the yarn

Turns per inch = T.M* $\sqrt{(\text{COUNT})}$

2.10. TWIST LIVELINESS

2.10.1. Definition

Twist liveliness is defined as the "Tendency of the yarn to twist or untwist spontaneously". The direction and the degree of twist in the yarn determine the twist liveliness of the yarn. Higher the value of twist multiplier (TM), this effect is more pronounced.

2.10.2. Factors Affecting Twist Liveliness

The twist liveliness of a yarn depends upon the following factors

- ❖ Amount of twist (TPI)
- ❖ Direction of twist
- ❖ Material used
- ❖ Properties of the raw materials such as micronaire

2.10.3. Determination of Yarn Snarl Helix Angle

In theoretical analysis, snarl helix angle was shown to be an important factor in the twist liveliness of a yarn.

The snarl helix angle can be calculated by measuring the half – turn length and the yarn diameter. The half – turn length can be measured by

$$\mathbf{Tan\ \theta = \pi\ D/h}$$

Where D is the filament diameter r and h is the length of 1 turn and θ is the snarl helix angle.

2.11. SPIRALITY

Spirality is the twist that takes place in fabric during the washing / tumble drying process and is evident at the side seams of a garment that has been washed and dried in relaxed state. The garment becomes unacceptably distorted in severe cases.

The causes of spirality is a combination of a number of factors, the two most significant of these is the twist liveliness of the yarn and the stitch length of the fabric.

Fabric spirality is a complex phenomenon arising from many factors influencing the nature and degree of loop distortion in single jersey knitted fabrics. Residual torque is believed to be the most important and fundamental factor affecting the degree of fabric spirality. Platt et al., (1958) have demonstrated that total torsional stresses in a twisted yarn arise mainly from the effect of fibre bending and twisting.

2.11.1. Direction of spirality

It is known that the direction of the spirality in fabrics knitted from singles short staple yarns is normally determined by the direction of the yarn twist (De Araujo and Smith 1989).

Z – twist yarns make the wales go to the right, giving a Z – skew, and S –twist yarns make the wales go to the left, giving a S – skew to the fabric. Further more with multi feed machines, the fabrics is created in a helix, which gives rises to course inclination and consequently wale spirality. The wales will be inclined to the right, giving a Z – skew in machines that rotate counter – clockwise and to the left giving S – skew in machines that rotate clockwise.

In order to minimize spirality – twist, yarns should be knitted on machines that rotate clockwise and s–twist yarns should be knitted on machines that counter clockwise.

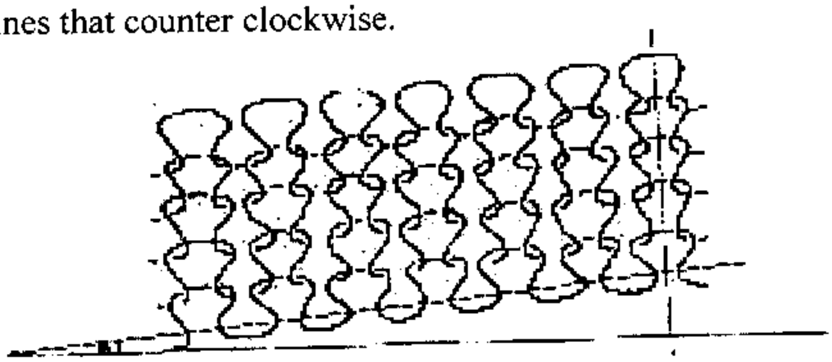


Fig.2.9. Spirality of weft knitted fabrics

2.11.2. Factors causing spirality

Three main factors which produce the loop distortion – spirality in the plain knitted fabrics are :

- **Fibre parameters**

According to the type of fibres used the degree of spirality in knitted fabrics varies. Fibre factors include the modulus and moment of inertia of fibre. The different types of modulus is tensile, bending and shear. The moment of inertia of fibres depends on fibre cross section shape and dimension.

- **Yarn parameter**

Yarn factors include structure and residual strain, the most prominent factor causing spirality in a single jersey fabric is the relaxation of torsional stress in the yarn. The yarn twist factor has a large influence on fabric spirality. The next important factor is the direction of twist in the yarn. The direction of loop spirality in a knitted fabric is controlled to a large extent by the twist direction of the yarn. Thus the direction and the degree of twist in the yarn used determine the direction and the magnitude of the spirality.

- **Knitting factors**

With multi feeder circular knitting machines, the knitted fabric are produced spinally thus giving rise to the course inclination. The magnitude of fabric spirality arising from the use of multi feeders depends on

1. No of feeders
2. No of needles on the knitting machine
3. The direction of spirality depends on the rotating direction of knitting machine

2.11.3. Measures to minimise spirality

Spirality can be eliminated or the problems arising due to spirality in the knitted fabrics from twisted single yarns can be alleviated by two methods namely.

a. Reducing the residual torque in the yarn
b. Balancing the yarn torque by various means.

i. Measure to reduce residual torque

It is known that, more the amount of permanent setting introduced within a fibre, the less is the degree of spirality due to yarn residual torque. Setting under stress introduces new intermolecular bonds within fibre structure after breaking the previous ones. The process makes fibre more stable in their deformity state. Therefore this results in less residual torque and consequently smaller fabric spirality.

ii. Balancing Yarn Torque

This can be done by various means. Some of the technique adopted is:

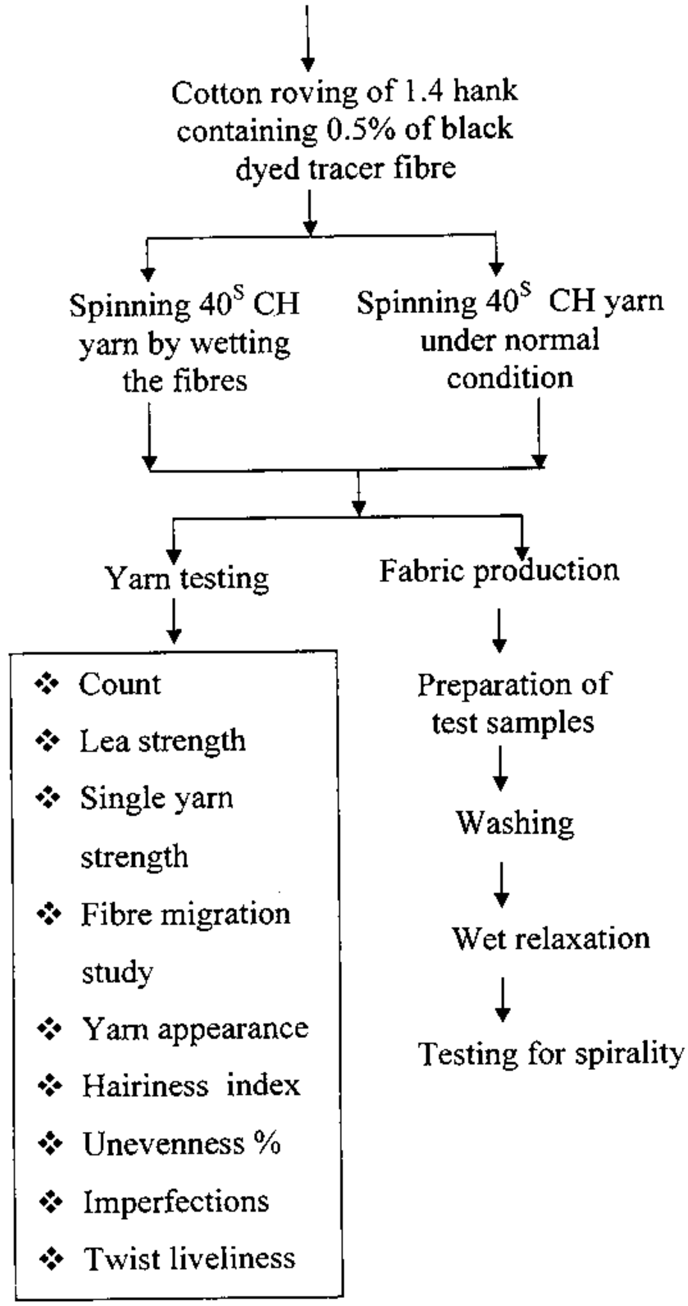
a. Plying two identical single yarns with a twist in the opposite direction to that in the single yarn.
b. Feeding two single yarns with twist of the same magnitude but in the opposite direction on to the same feeder, or simply.
c. Knitting with plaited yarns of the same number of twisted but in the opposite direction.

3. OBJECTIVES

1. To spin 40s combed hosiery yarn in ring frame under two different spinning conditions
    - Spinning under normal condition
    - Spinning by wetting the fibres in the top front roller zone with plain water.
2. To investigate the fibre migration characteristics of regular and wet spun yarn using image analysis technique.
3. To study the effect of fibre wetting on twist liveliness and spirality of weft knit fabric.

4. MATERIALS AND METHODOLOGY

4.1. EXPERIMENTAL PLAN



4.2. RAW MATERIAL SPECIFICATIONS

Raw material	:	100% cotton
Variety	:	Shankar 6
Station	:	Gujarat
2.5% span length	:	31 mm
Micronaire	:	3.2 μ gm / inch
Uniformity ratio	:	48
Trash %	:	4.6
Roving hank	:	1.4 (with 0.5% of black dyed fibre)
Yarn Count	:	40^S combed hosiery

4.3. STEPS INVOLVED IN THE PRODUCTION OF YARN SAMPLES, FABRIC SAMPLES AND TESTING

4.3.1. Production of Yarn Samples

Spinning under normal condition

- Roving of 1.4 hank was used for producing 40^S combed hosiery yarn in the ring frame
- 24 cops under normal conditions were produced from 8 spindles

Spinning in wet condition using plain water as frictioniser

- Burettes using burette holders were placed exactly above the top front roller in the drafting zone to facilitate spinning under wet condition (Refer Fig. 8.1 and 8.2 in Appendix).
- Burettes were primarily filled with plain water
- The water drops at a rate of 1 ml /min were allowed to fall on the top front roller.
- Front top roller was always maintained in wet condition in order to ensure uniform wetting of fibres arriving at the front roller nip.
- 24 cops using the same 8 spindles were produced under the above mentioned condition.

4.3.2. Methodology for fibre migration study

4.3.2.1. Sample preparation

Two types of ring spun cotton yarns of 40 Ne (15 tex) namely regular and wet spun yarn were produced from a mixing with a nominal twist of 27 (tpi).

4.3.2.2. Test methods

Tracer fibre technique–Instrumentation adopted for measuring migration

The tracer fibre technique was adopted for the study. The yarn samples containing 0.5% of black dyed tracer fibre were mounted on glass plate and both sides of the yarn were stuck by adhesive tape to keep the yarn straight. Then the yarn was wetted by immersing in a liquid medium (methyl salicylate) having substantially the same refractive index as that of fibres concerned. Olympus Bx 50 microscope of 40x magnification was used and yarns were observed under transmitted light.

A monochrome video CCD (Charge Coupled Device) camera was attached with the microscope. The CCD solid image sensor, used in this experiment, provides light resolution image with 768 x 494 pixels.

This CCD camera was linked with a personal computer (PC) with Pentium processor with Windows 95. A Video Graphic Adopter (VGA) with 256 colour display device with 800 x 600 pixels were fixed on the computer. For analysis of the images grabbed by the camera image pro-plus 4.0 software was used (Refer Fig.8.3 in Appendix). The number of pixels per 1 mm was 450. Image analysis was performed using the following sequence.

Process → Image acquire → Segmentation → Image matching → Measurement

Fig. 4.1. The picture shows the image of the yarn captured by the image analyser

With regard to the external structure, yarn can be viewed into two basic elements the yarn core and the tracer fibre. Core is defined as a part of the yarn that forms a compact agglomeration of fibres. It has a cylindrical form and a variable diameter. On its surface the fibres were laid along the curves characterizing the twist. The rest of the yarn, consisting of single outlying fibres or their agglomeration, competitive hairiness. Thus the position of the black dyed tracer fibre from the stands of fibre can be viewed determined by the method described below:

4.3.2.3. Characterisation of migration

The chief features of the migration behaviour are usually characterized by the following parameters.

i. Mean fibre position

This represents the overall tendency of a fibre to be near the surface near centre of a yarn.

It can be obtained from the formula :

$$\overline{Y} = \frac{1}{Z}\int_0^z y\,dz = \frac{\Sigma y}{n}$$

where

$$Y = \left[\frac{r}{R}\right]^2$$

where r = helix radius, R = yarn radius, Z = length along the yarn, and n = number of observations.

ii. Amplitude of migration

The magnitude of the deviations from the mean position and is represented by the Root Mean Square Deviation (RMS):

$$D = \left[\frac{1}{z}\int_0^z (Y-\overline{Y})^2\,dz\right]^{1/2} = \left[\frac{\Sigma(y-\overline{y})^2}{n}\right]^{1/2}$$

For an incomplete migration in which $(r/R)^2$ varies linearly with Z, it is shown (Hearle 1965) that the amplitude of migration is given by $A = D\sqrt{3}$ and the mean radial traverse is $P = 2A = 2D\sqrt{3}$

iii. Rate of migration (Migration intensity)

This is rate of change of radial position. For this the mean migration intensity is used

$$I = \left[\frac{1}{z}\int_0^z \left(\frac{dy}{dz}\right)^2 dz\right]^{1/2} = \left[\Sigma\left(\frac{dy}{dz}\right)^2 / n...\right]^{1/2}$$

iv. Equivalent migration frequency

This given by

$$\text{Frequency} = \frac{1}{4\sqrt{3D}}$$

where D is the amplitude of migration

v. Migration factor

Kim, Huh and Ryu (1999) have suggested another measure known as migration factor for characterizing fibre migration in yarns.

Migration factors = r.m.s deviation x migration intensity.

4.3.2.4. Measurement

Measurements a, b, c and d were made at successive peak and trough of a tracer fibre image have been made, and diameter of yarn which is (c-a) (figure 4.2).

The number of observation (n) was determined from the equation

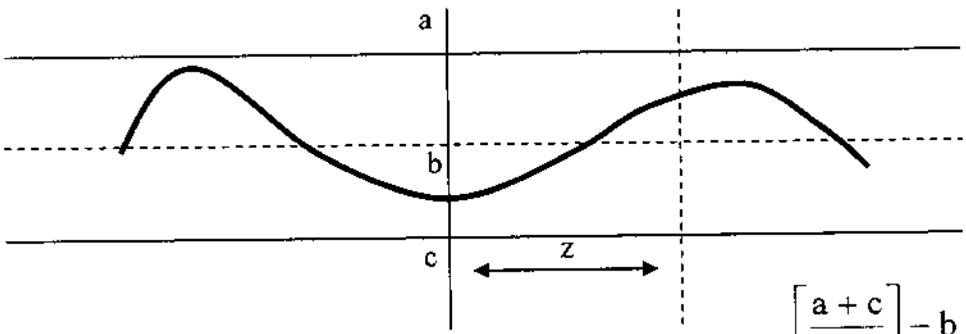
$$n = \frac{t^2{}_{95\%} . V^2}{E}$$

where $t_{95\%}$ = 1.96

V = coefficient of variation in percentage of observed samples

and E = the error of estimation (taken as 8)

Number of test, according to this, is 200 samples, and mean value was considered.



$$\frac{r}{R} = \frac{\left[\frac{a+c}{2}\right] - b}{\left[\frac{a-c}{2}\right]}$$

Fig.4.2. Plot of r/R Vs Length of yarn

4.3.3. Twist Liveliness Meter

Twist liveliness was measured by means of an designed by Krishnakumar (2005). Initially the distance between the two clamps was 1000 mm i.e., yarn sample length of 1 m was used. When the motor rotates ine, the threaded shaft rotates at a speed of 120 rpm. Hence each of the clamps will move at 120 mm per minute towards the center. A dead weight of 0.2 gms was hanged at the middle of the yarn suspended between the two clamps before testing starts. When the clamps move towards each other, the yarn sample assumes a shape of "V" in the vertical direction. Once the yarn starts forming the first loop, the motor is stopped immediately. The twist liveliness value can be found out from the following formula:

Twist liveliness = 1000 – (2 * COUNTER READING)

Where, counter reading = distance moved by either clamps

After the test was over the motor was driven in the reverse direction to bring the clamps to the original position. Once the clamps reach their initial position, the limit switch provided will automatically switch off the motor.

4.3.4. Fabric Production

- Cops are converted to cones using semi automatic cone winding machine.
- Single Jersey fabric samples from wet and regular yarn samples were prepared on a circular weft knitting machine.
- 4 meters of fabric samples were produced from each category.

4.3.5. Fabric Testing

- Test specimens were made from regular and wet samples.
- The fabric was washed in domestic washing machine.
- Drying of samples
- Testing fabric samples for spirality.

4.3.6. Measurement of Spirality

4.3.6.1. Spirality

In a hosiery fabric knitting in plain stitch, the length wise rows of stitches called needle lines or wales, should always be at right angles to the cross wise courses of stitches. In most of the cases the wales are not perpendicular to the courses but skew towards right or left depending on its characteristics, this is called spirality. The angle of skewness is called angle of spirality.

4.3.6.2. Test Methods for Measuring Spirality

The three well known standard test methods available for determining the spirality of knitted fabrics are:

- IWS Test Method No.276
- British Standard 2819
- ASTM 3882.88
- AATCC Test Method 179-2001

For the project the adopted test procedure was based on AATCC Test Method 179 - 2001.

AATCC Test Method 179 - 2001

i. Washing

The cut test specimens were prepared for washing by stitching the samples using an over lock stitch for three sides leaving one side open which is known as pillow case method. A 25x25cm square was marked on the stitched samples. Now the test specimens were washed in a domestic washing machine for 45 minutes using water at 30^0 Celsius and finally dried.

ii. Measurement

After washing and drying or in other words after wet relaxation it was found that the wales were not perpendicular to the courses which was evident by the lines of the square drawn earlier now appearing skewed. This angle of skewness to the direction of courses was measured and known as the angle of spirality.

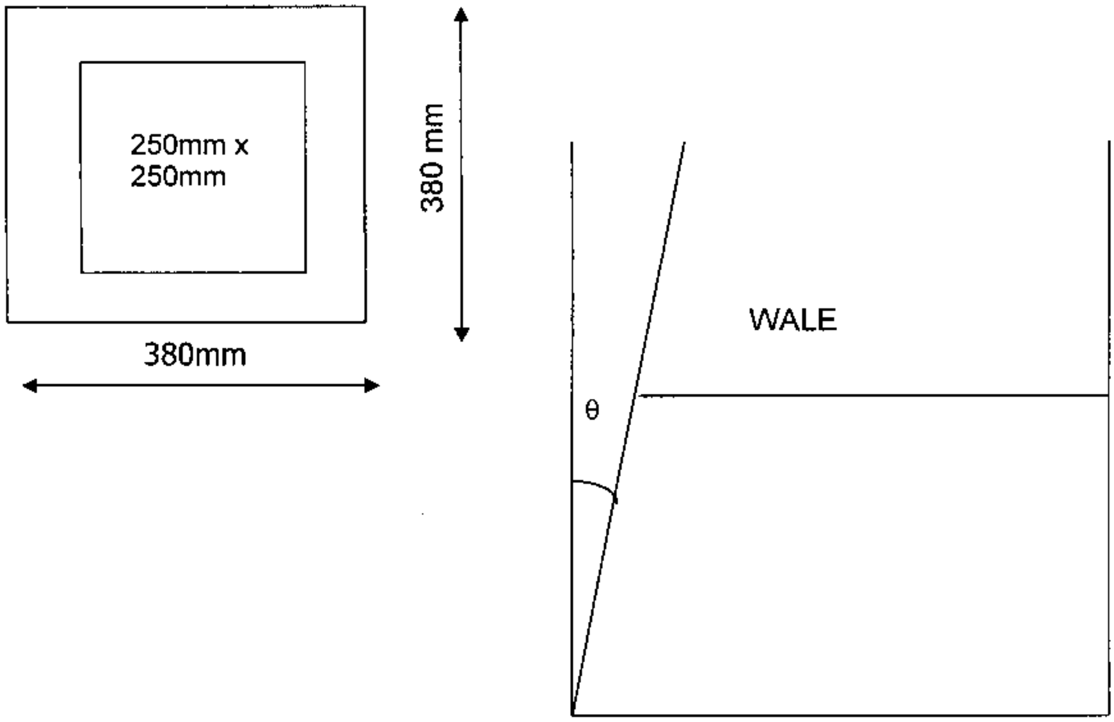


Fig. 4.3. Fabric Marking

4.4. MACHINERY DETAILS

Machinery's used for the project:

- ❖ Ring frame
- ❖ Cone winding machine
- ❖ Single jersey knitting machine
- ❖ Washing machine

Machine Specifications

1. Ring Frame

Make	:	Mafatlal Engineering Industries Limited, India
Model	:	Super spinning Mark – II
Year	:	1981
Drafting System	:	3/3 suessen (spring loading) 40
No.of spindles	:	160
Spindle speed	:	9000 RPM
Lift	:	8 inches
Ring Diameter	:	41 mm
Gauge	:	70 mm
Drive to spindles	:	4 spindle synthetic tape drive
Creel	:	Umbrella creel
Ring type	:	Single flange
Traveller Number	:	6 / 0
Spindle wharve diameter	:	24.3 mm

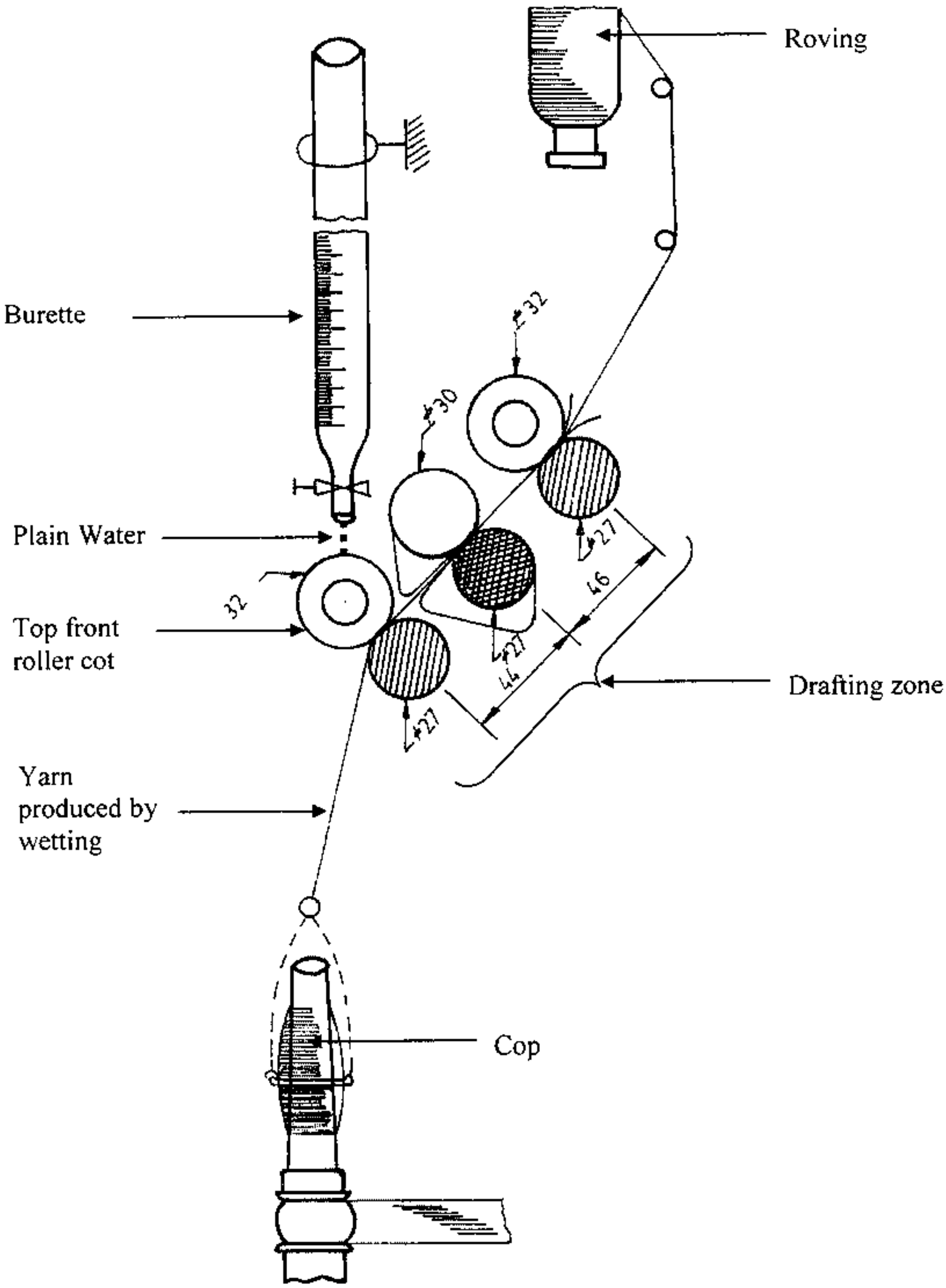


Fig. 4.4. Schematic diagram of Wetting of Fibres during Spinning of yarn

2. Cone Winding

Make	:	Jayanth
Type	:	Non Automatic
Capacity	:	24 Drums
Speed	:	500 m/min
Slub catcher setting	:	13 / 1000”
Tension weight	:	2 gms

3. Single Jersey Knitting Machine

Machine Name	:	Two Track circular knitting machine
Make	:	Knitmac
Year	:	1999
Total needles	:	996
Needle Type	:	102 52.G03
	:	102 52.G04
Total sinkers	:	996
Sinker type	:	38.23
Gauge	:	20
Cylinder dia	:	16”
Speed	:	24 rpm
Number of feeders	:	22

4. Washing Machine (Tumbling Process)

Make	:	IFB
Capacity	:	4 kg of Dry Cloth
Spin speed	:	70 RPM
Temperatures selection	:	Room temperature (30^0C)
Water consumption rate	:	76 litres / cycle
Cycle Name	:	45 minutes

4.5. TESTING

1. Count	:	Electronic Wrap Reel
2. Lea Strength	:	Lea strength tester
3. Single yarn strength	:	Uster tensorapid 3
4. Twist	:	Electronic Twist Tester
5. Unevenness and Imperfections	:	UT 4
6. Hairiness	:	Zweigle Hairiness tester
7. Packing density	:	UT 4
8. Twist liveliness	:	Twist liveliness meter
9. Spirality	:	AATCC test method 179 – 2001

5. RESULTS AND DISCUSSIONS

The 40s combed hosiery yarn samples spun under regular and wet conditions were tested for various physical properties and compared. The effect of fibre wetting on these fibre properties are discussed in this chapter.

5.1. COUNT AND COUNT CV%

The count and count CV% was measured using computerized wrapping system with electronic wrap reel. The values for the same could be seen for both wet and regular spun yarn in table 5.1.

Table 5.1

Count and count CV%

(Count : 100% cotton 40^S Ne)

Content	Count	Count CV%
Regular	39.87	0.51
Wet	39.60	0.71

The test result reveals that the deviation from the actual count is nominal for both regular and wet spun yarn.

As far as the CV% is concerned, the wet spun yarn has more CV% compared to the regular ring spun yarn. However it is evident from the values that the difference in values between the sample are not significantly high. The trend could be noted in the figure 5.1.

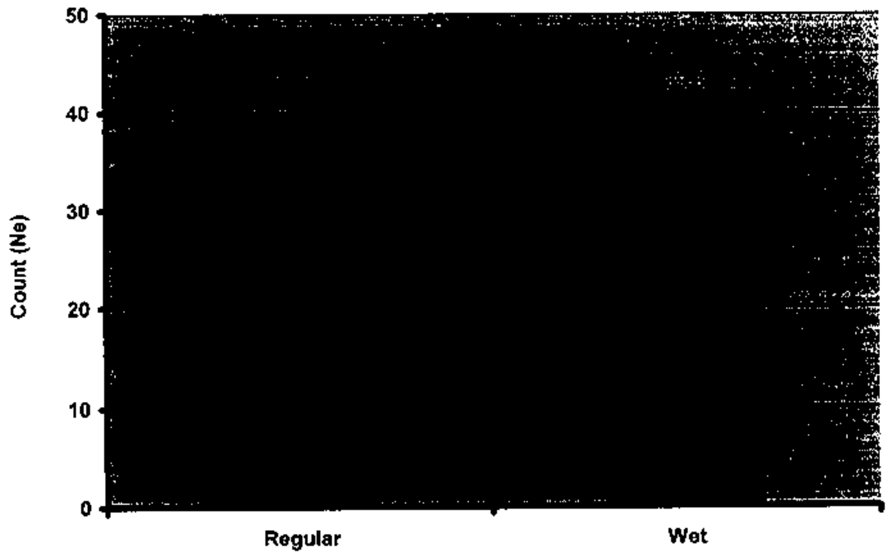


Fig. 5.1.
EFFECT OF FIBRE WETTING ON COUNT

5.2. LEA STRENGTH

The lea strength was measured using lea strength tester. The deviation in the strength values for regular and wet spun yarn could be noted from the table 5.2.

Table 5.2

Lea Strength

(Count : 100% cotton 40^S Ne)

Content	Regular	Wet
Strength (lbs)	47.16	61.59

It is evident from the test results that the lea strength for yarn produced by wetting the fibres with plain water depicts a tremendous increase of 23% over yarn produced under regular spinning condition.

The positive feature of yarn sample produced by wetting may be due to good fibre binding characteristics of all the fibres after immediate exit from the front roller. The trend for the strength variation for wet and dry spun yarn can be referred from the figure 5.2.

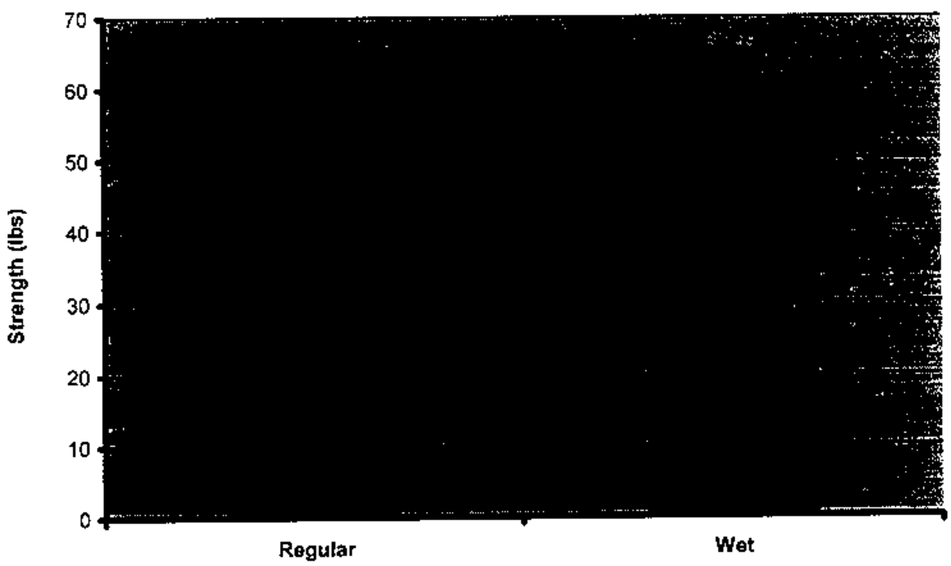


Fig. 5.2.
EFFECT OF FIBRE WETTING ON LEA STRENGTH

5.3. COUNT STRENGTH PRODUCT

Already the count and lea strength were discussed individually. Here the product CSP value is discussed. The values are given in table 5.3.

Table 5.3

Count Strength Product

(Count : 100% cotton 40^S Ne)

Content	Regular	Wet
CSP	1880.3	2438.5

As discussed earlier due to the increased lea strength value, the CSP of wet spun yarn found to be increased by 30% compared to regular yarn. Fibre wetting resulted in proper twisting and binding of fibres and improved the yarn structure. The individual data can be referred from the table 8.2a and b in appendix. The trend for the same could be noted in the figure 5.3.

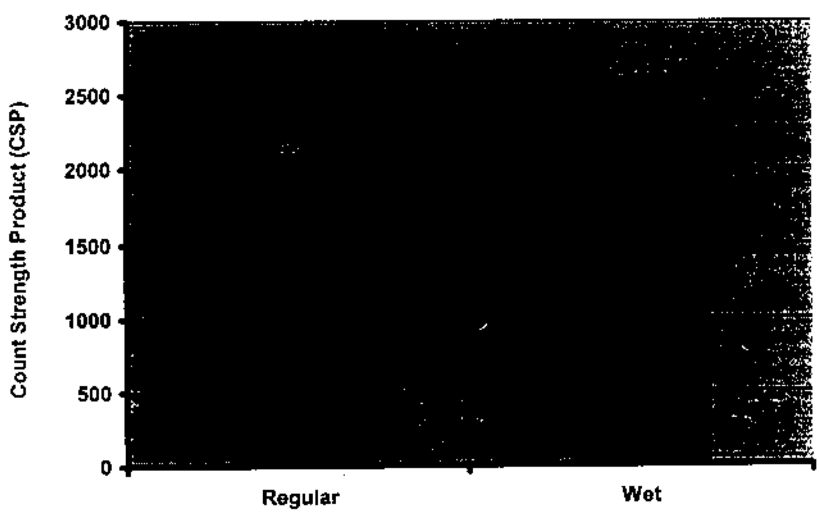


Fig. 5.3
EFFECT OF FIBRE WETTING ON CSP

5.4. SINGLE YARN STRENGTH

The single yarn strength was measured in Uster tensorapid 3 and the mean value is provided in table 5.4.

Table 5.4
Breaking load and single yarn strength
(Count: 100% cotton 40^S Ne)

Content	Regular	Wet
Breaking load (gf)	204.1	236.9
Single yarn strength (gf/tex)	13.82	16.04

The results revealed that the single yarn strength of wet spun yarn found to be increased by 16% when compared to regular yarn strength. Also the breaking load for wet yarn is 16% high compared to regular spun yarn.

The reasons attributed for this increase in single yarn strength are compact packing and twisting of fibres inside the yarn. The individual data can be referred from the table 8.3a and b in appendix. The trend in the variation of single yarn strength for both the yarn can be visualized in figure 5.4.

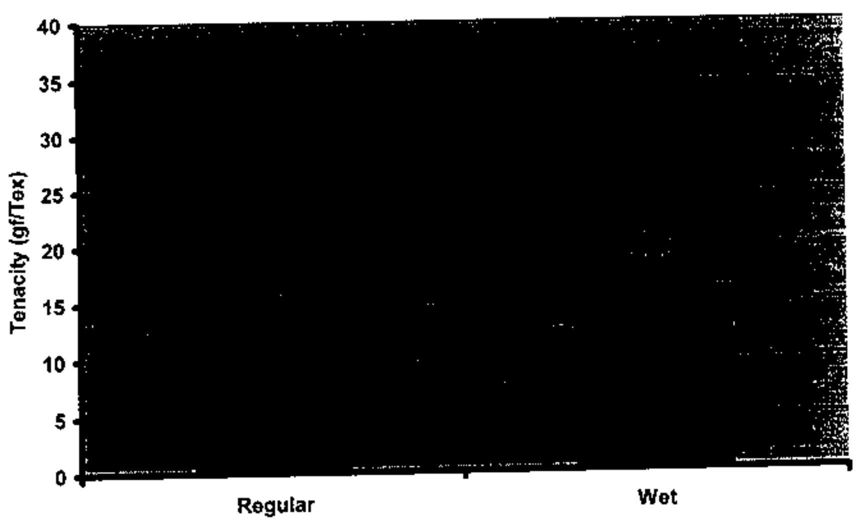


Fig. 5.4
EFFECT OF FIBRE WETTING ON SINGLE YARN STRENGTH

5.5. YARN DIAMETER AND PACKING DENSITY

The yarn diameter of the sample was measured using image analyser and the packing density using Uster 4–SX-OM tester. The values are provided in table 5.5.

Table 5.5
Yarn Diameter and Packing Density

Content	Regular	Wet
Yarn Diameter (mm)	0.14	0.13
Packing density (g/cm^3)	0.39	0.60

From the data given in the table it can be seen that there is an overall reduction of yarn diameter to the tune of 7% for the wet ring spun yarn when compared to the regular spun yarn. Similarly there is an increase in the overall packing density by 54% of wet spun to regular spun yarn.

This may be due to the compaction of fibres due to wetting process with plain water. The trend for the packing density could be noted from figure 5.5.

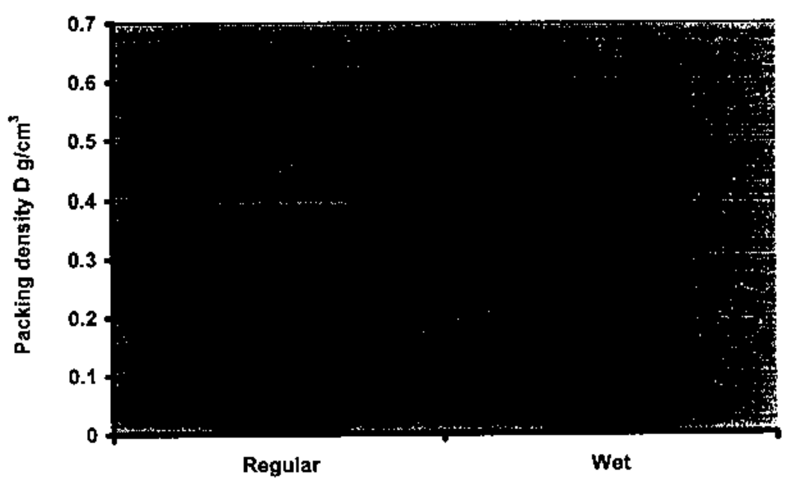


Fig. 5.5
EFFECT OF FIBRE WETTING ON YARN PACKING DENSITY

5.6. FIBRE MIGRATION CHARACTERISTICS

The migration analysis was carried out in image analyser with optically dissolving solution namely Methyl Salicylate. The Image captured by the Image analyser for both wet and regular spun yarn could be seen in Fig. 8.4a and b. The migration characteristics are listed in the table 5.6.

Table 5.6

Fibre Migration Characteristics

(Count : 100% cotton 40^S Ne)

Content	Regular	Wet
Mean fibre position	0.52	0.54
RMS deviation (D)	0.26	0.30
Migration intensity (I) cm^{-1}	7.75	9.74
Equivalent migration frequency (cm^{-1})	4.27	4.70
Migration factor (cm^{-1})	2.03	2.9

The test reveals that the migration characteristics show an increase for wet spun yarn against regular spun yarn. The Mean fibre position ($\overline{Y}$) was found to be increased for wet spun yarn to the tune of 4% when compared to regular spun yarn. For ideal migration, the value of MFP (Mean Fibre Position) should be 0.5, higher the value the migration is said to be good. The RMS deviation (D), Migration Intensity (I) and equivalent migration frequency have also been found increased for wet spun yarn to the tune of 15%, 26% and 10% as against regular spun yarn. The migration factor shows a higher value for wet spun yarn which is 31% more than the regular spun yarn and this explains the reason for the increase in tenacity of the wet spun yarn.

As far as "T" test is concerned the values of the yarn diameter, MFP, RMS deviation, migration intensity, equivalent migration frequency, migration factor measured from wet spun yarn were not significantly differed from those values of the regular spun yarn due to less number of samples studied in the image analysis technique. Only 160 readings were taken in this project. Instead if the readings are more than 200 definitely the results would be highly significant (refer table 8.1 in appendix). The trend for the migration characteristics could be seen in figure.5.6.

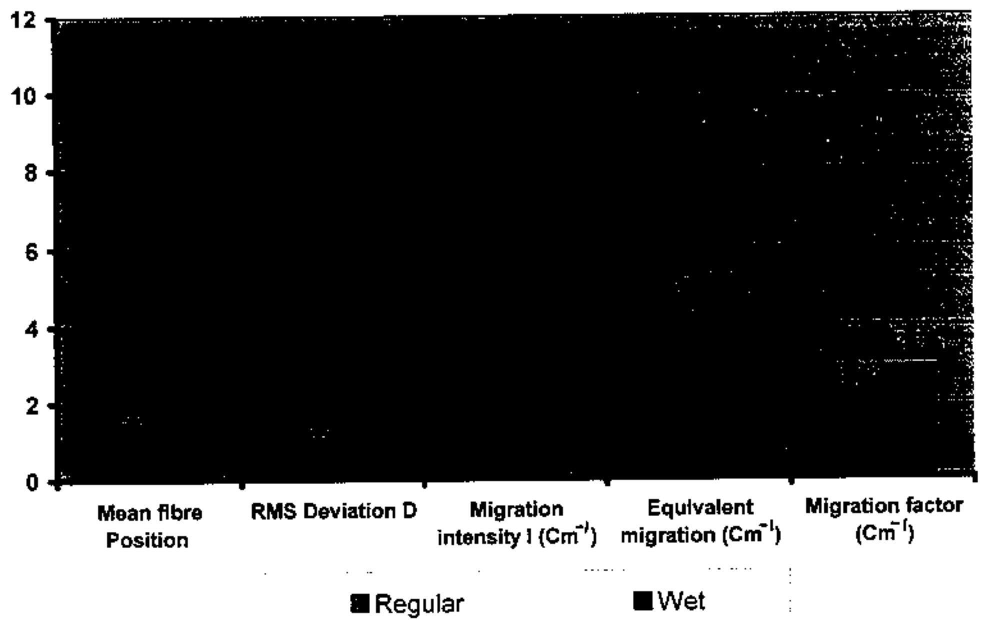


Fig. 5.6
EFFECT OF FIBRE WETTING ON MIGRATION CHARACTERSITICS

5.7. HAIRINESS

The parameter hairiness (H) index was measured in Uster 4 SX-OM-Tester while S3 was measured by Zweigle hairiness tester. Hairiness index is the total length of all the hairs within 1 cm of yarn while S3 is the sum of the number of hairs 3 mm and longer. The values for H index were measured over a length of 100 m while S3 measured for a length of 50 m which are provided in the table 5.7.

Table 5.7
Hairiness
(Count:100% cotton 40^S Ne)

Hairiness value	Regular	Wet
H index	5.97	2.68
S3	1934	192

It is apparent that the H index values were found to be reduced for wet spun yarn in comparison to regular yarn by 55%. As for as the S3 value is concerned the wet spun yarn has 90% less when compared with the regular yarn.

Because of wetting the cohesive force within the fibres are able to draw all the fibres to the core and also the fibers could not escape outside due to retention of water molecules. This factor minimised the protruding hairs in the yarn spun under wet condition. The individual data for hairiness tested by zweigle hairiness tester can be referred from the table 8.5 in appendix. The reduction in hairiness for wet yarn compared to regular yarn can be viewed in the figure 8.4a and b in appendix. The trend for the variation in the H index value for both the yarns can be seen in figure 5.7.

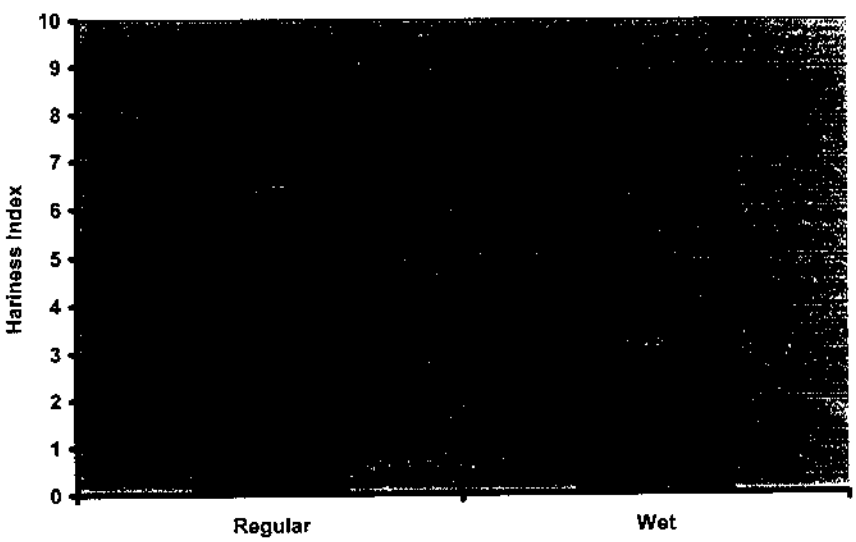


Fig. 5.7
EFFECT OF FIBRE WETTING ON HAIRINESS

5.8. UNEVENNESS AND IMPERFECTIONS

The unevenness percentage and other imperfections were measured by Uster 4 –SX-OM-tester. The values are quoted in the table 5.8.

Table 5.8

Unevenness percentage (U%) and imperfections

(Count : 100% cotton 40^S Ne)

Content	Regular	Wet
U%	18.67	18.45
Thin – 50% / km	915	945.0
Thick + 50% / km	2200	2005
Neps + 200% / km	1795	2020

The results reveal that there is a marginal decrease in the U% level for wet spun yarn which is not significant.

As far as imperfections are concerned there is a considerable increase (11%) in the nep level. Due to the moisture on the surface of the rollers, some of the loose fibres adhere on to the roller surface and pass subsequently into the yarn, forming neps and thick places. This can be overcome by taking suitable measures that avoid lapping such as anti – stick coating. The trend for the U% could be seen in figure 5.8.

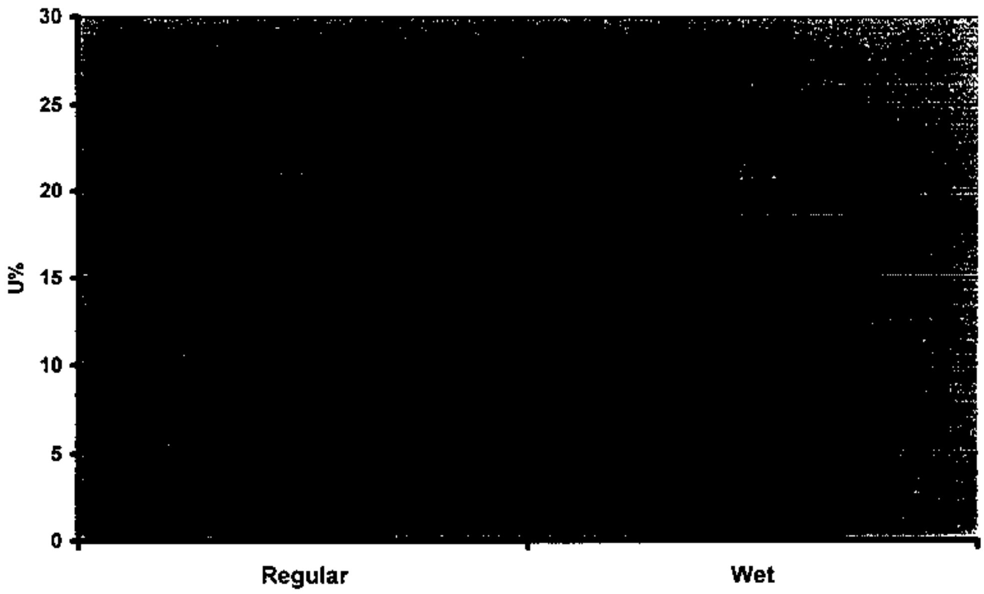


Fig. 5.8
EFFECT OF FIBRE WETTING ON U%

5.9. TWIST PER INCH

The TPI is measured using electronic twist tester and the variation in the mean values for both wet and regular spun yarn could be noted in the table 5.9.

Table 5.9

Twist Per Inch (TM =4)
(Count : 100% cotton 40^S Ne)

Content	Regular	Wet
TPI	27.6	27.1

From the table it can be observed that there is not much variation in the TPI level of regular and wet spun yarn. The graphical trend in the values for both the yarns are depicted in the figure 5.9.

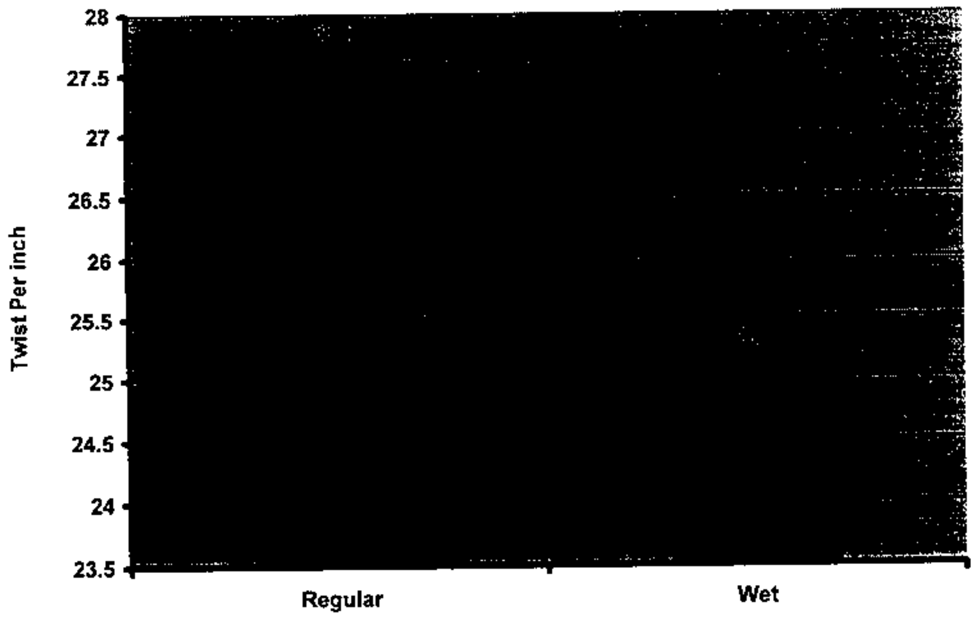


Fig. 5.9
EFFECT OF FIBRE WETTING ON TPI

5.10. TWIST LIVELINESS

The tendency of the yarn to untwist to reach the minimum state of energy level is so called twist liveliness. Apart from the amount of twist and type of fibres used, the fibre wetting also had a greater influence on the twist liveliness value. The table 5.10 provides the values of twist liveliness (cm) measured using Twist Liveliness Meter Developed by Krishnakumar (2005) as shown in the figure 8.5 in appendix.

Table 5.10

Yarn twist liveliness

(Count : 100% cotton 40^S Ne)

Content	Regular	Wet
Twist liveliness (cm)	19.76	10.2

From the results it is evident that wetting has successfully reduced the twist liveliness values. Fibre wetting improved the twisting characteristics of all fibres and hence the residual torque in the yarn got reduced to the greater extents. Because of less residual torque the wet spun yarn are less twist lively. The wetting of top roller cots has been instrumental in properly binding the oncoming mass of fibres in the drafting zone. Further this condition facilitates even the edge fibres of the spinning triangle to move into the structure of the yarn which not observed phenomenally in spinning under normal condition due to the reason of **'fibre migration'**. Thus all these advantages accrue to reduce the twist liveliness of the yarn and subsequently the spirality. This wet spun yarn could be treated as compact yarn due to less hairiness, good strength and less twist liveliness.

Yarn twist liveliness is one of the major contributors of spirality. This project mainly aims at lowering the yarn twist liveliness values by wetting and hence reducing spirality of weft knitted fabrics.

The percent reduction in yarn twist liveliness of wet spun yarn on comparison with regular spun yarn is 48% respectively. The individual datas can be referred from the table 8.6 in appendix. The trend of the twist liveliness value for both wet and regular spun yarn can be seen in the figure 5.10.

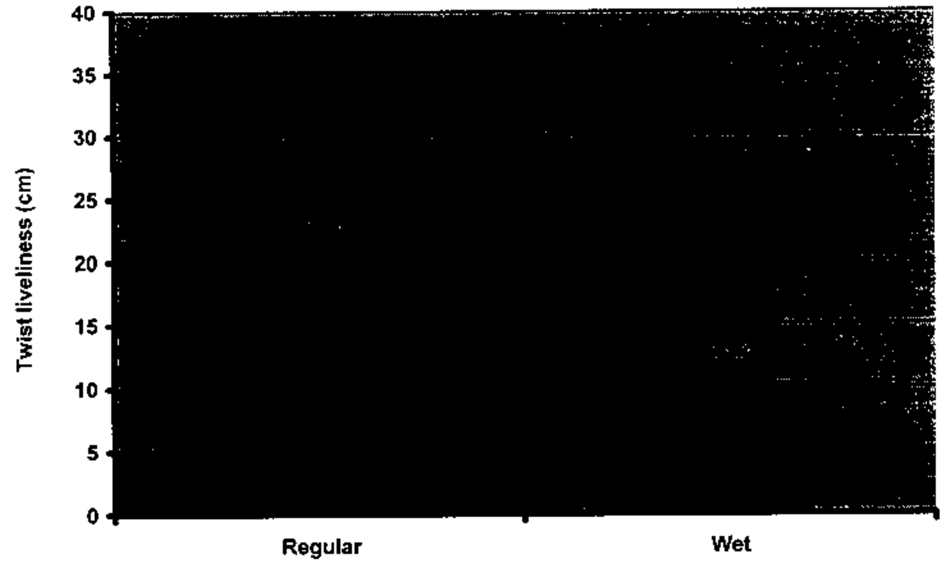


Fig. 5.10
EFFECT OF FIBRE WETTING ON TWIST LIVELINESS

5.11. SPIRALITY

The yarn samples were converted into the weft knit fabrics. The fabric samples were properly wet relaxed and the spirality was measured as per AATCC test method 179-2001. The table 5.11 shows the spirality angle measured from fabric samples produced from wet and regular spun yarn.

Table 5.11

Spirality of weft knit fabric

(Count : 100% cotton 40^S Ne)

Content	Regular	Wet
Spirality (degrees)	9.1	4

It is obvious from the table 5.11 that the spirality angle in the weft knit fabric produced out of yarns spun by wetting was substantially lower. The percentage decrease in the spirality angle for the fabric made by wet spun yarn in comparison with the regular spun yarn is 56%. This is due to the reduction of yarn twist liveliness in the wet spun yarn which contributed maximum in reducing the tendency of the fabric to twist over its axis and hence resulted in less spirality. The individual data can be noted from the table 8.7 in appendix. The trend for the variation of the spirality in comparison with twist liveliness value can seen in the figure 5.11 for both the category.

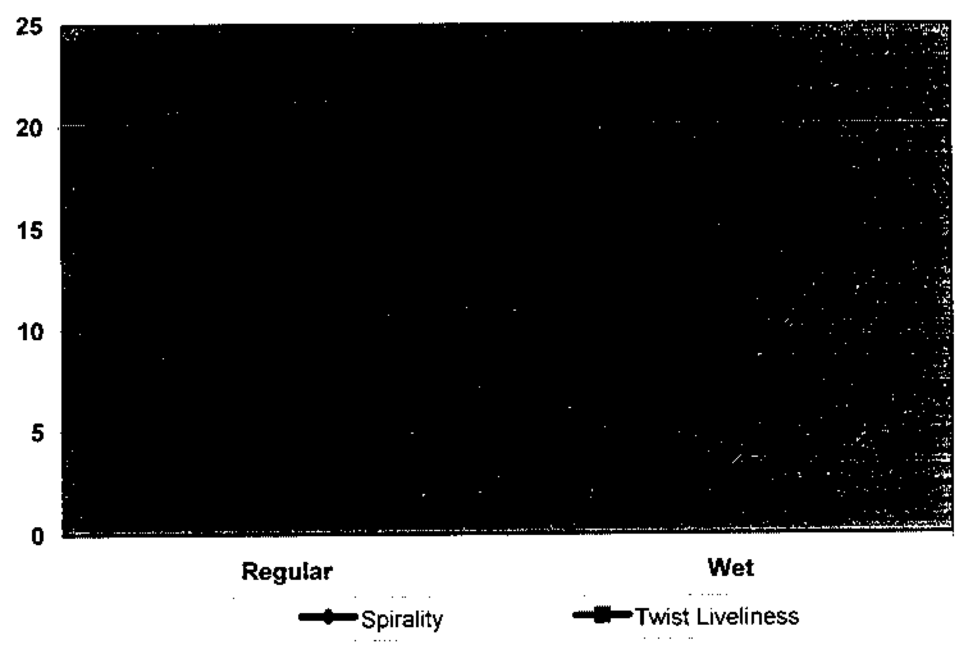


Fig. 5.11
TWIST LIVELINESS AND SPIRALITY COMPARISON

6. CONCLUSIONS

The following conclusions were obtained from the project

When compared to regular spinning, the effect of fiber wetting resulted in the reduction of:

a. Yarn Diameter from 0.14 mm to 0.13 mm (7%)
b. Hairiness index from 5.97 to 2.68 (55%)
c. U% from 18.67 to 18.45 (1.2%)
d. Twist liveliness from 19.76 cm to 10.20 cm (48%)
e. Spirality angle from 9.1^0 to 4^0 (56%)

At the same time the following factors showed considerable increase, in the following parameters.

a. Yarn packing density from 0.39 g/cm^3 to 0.60 g/cm^3 (54%)
b. Fibre migration characteristics
   - Mean fibre position from 0.52 to 0.54 (4%)
   - RMS deviation (D) from 0.26 to 0.30 (15%)
   - Migration Intensity (I) cm^{-1} from 7.75 to 9.74 (26%)
   - Equivalent migration frequency (cm^{-1}) from 4.27 to 4.70 (10%)
   - Migration ratio (cm^{-1}) from 2.03 to 2.9 (43%)
c. Single yarn strength (gf /tex) from 13.82 to 16.04 (16%)
d. CSP from 1880.3 to2438.5 (30%)
e. Neps / km from 1795 to 2020. (13%)

It is finally concluded that the fibre wetting in ring frame improved almost all the physical properties of cotton yarn and also reduced the spirality of weft knit fabric by 56% as mentioned above.

7. FUTURE SCOPE OF THE PROJECT

- There is further scope to reduce the imperfections and reduce thick and thin places by minimizing the incidence of roller lapping and fibre carrying characteristics. This could be achieved by
    i. Using roving stop motion mechanism
    ii. Incorporating knee brake for spindles
    iii. Applying anti stick coating for the rollers
- The burette and burette stands could be replaced by a long tube with facilities to wet the top roller cots by means of relay nozzles. The water inlet could be accompanied by cool moisturized air that would enhance the overall wetting and twist setting process. Further such an arrangement could be improvised to precisely control the rate of flow of wetting solutions both in terms of quantity and timing.
- The project can be extended to study the migration characteristics for different draft zone setting, draft setting, spacer setting, drafting force, top arm pressure setting, roller stand inclination, spindle speed.
- At the same time the project can be extended further to study moisture regain, moisture content, heat of sorption, rate of absorption of moisture, retention of liquid moisture, swelling properties and other physical properties.

8. APPENDICES

Table 8.1

Migration Analysis Summary of Regular and Wet Ring Spun Yarn

(Count : 100% cotton 40^S Ne)

Parameters	Yarn dia mm		Mean fibre position (Y)		RMS Deviation (D)		Migration intensity (I) cm^{-1}	
No	Regular	Wet	Regular	Wet	Regular	Wet	Regular	Wet
1	0.13245	0.13619	0.47980	0.63556	0.29703	0.4228	9.61949	12.22399
2	0.14385	0.10608	0.45759	0.53177	0.27978	0.22442	7.77269	9.60744
3	0.14613	0.12988	0.46402	0.37593	0.29319	0.28764	8.27563	7.51611
4	0.14944	0.13449	0.30844	0.76173	0.20811	0.22466	3.63875	8.58113
5	0.12966	0.13656	0.79320	0.40931	0.18814	0.28846	6.45902	10.10385
Overall mean	**0.13761**	**0.12864**	**0.51789**	**0.54286**	**0.26223**	**0.29836**	**7.75326**	**9.73596**
S.D. of Mean	**0.01023**	**0.01289**	**0.16439**	**0.15994**	**0.04765**	**0.08074**	**2.19021**	**1.76916**
C.V % of Mean	**7.43677**	**10.0194 4**	**31.7417 1**	**29.4621 0**	**18.1699 1**	**27.06099**	**28.2488 5**	**18.17138**
$T_{95\%}$ / $F_{95\%}$	**T= 2.262**		**T=2.262**		**F = 1.22000**		**T = 2.262**	
T_{act}/F_{act}	**1.289**		**0.269**		**1.12**		**1.626**	
S.D of individual								
C.V. of Individual								
$T_{95\%}$ of Individual	**T = 1.96**		**T=1.96**					
T_{act} of Invidious								
Equil. Mig. Freq. cm^{-1}							**4.26758**	**4.71001**
Mig.Factor cm^{-1}							**2.03314**	**2.8561**

Table 8.2a

Yarn parameters test result

For Regular Spun Yarn
(Count : 100% cotton 40^S Ne)

Sl.No	Count (Ne)	Strength (lbs)	CSP	TPI
1	39.45	51.42	2029.1	28.3
2	39.45	45.55	1797	27.7
3	41.11	48.49	1993	27.8
4	39.45	46.31	1827	26.7
5	40.29	45.72	1842.1	28.3
6	39.73	49.51	1967	27.5
7	39.19	50.62	1983.8	27.8
8	40.85	48.65	1987.4	26.9
9	39.45	45.32	1787.9	27.5
10	40.85	46.54	1901.2	27.8
11	39.19	45.72	1791.8	27.6
12	38.43	45.55	1750.5	27.4
13	40.05	46.45	1860.3	27.2
14	40.85	45.32	1851.3	26.9
15	39.73	46.21	1835.9	28.2
Mean	**39.87**	**47.16**	**1880.3**	**27.6**

Table 8.2b

Yarn parameters test result

For Wet Spun Yarn (wetting of fibres with plain water)
(Count : 100% cotton 40^S Ne)

Sl.No	Count (Ne)	Strength (lbs)	CSP	TPI
1	39.45	59.14	2333.1	27
2	38.56	60.98	2351.4	27.1
3	38.17	62.81	2397.5	26.8
4	40.85	59.95	2449.0	27.2
5	39.45	60.01	2367.4	27.3
6	38.56	62.50	2410.0	26.4
7	40.83	61.05	2492.7	27.1
8	38.56	60.78	2343.7	27.2
9	39.54	62.62	2476.0	27.1
10	39.54	62.56	2473.6	27.6
11	40.85	61.93	2529.8	27.3
12	39.56	62.87	2487.1	27.2
13	40.85	62.53	2554.4	26.9
14	39.65	61.38	2433.7	27.2
15	39.45	62.81	2477.9	27
Mean	**39.60**	**61.59**	**2438.5**	**27.1**

Table 8.3a

Single yarn strength result for regular spun yarn

(Count : 100% cotton 40^S Ne)

Velocity V = 5000 mm / min

Length LH = 500 mm

S. No	Time to break	Breaking force	Elongation	RKM
	(Sec)	(gf)	(%)	(gf / Tex)
1	0.3	201.9	4.30	13.67
2	0.3	206.4	4.75	13.98
Mean	**0.3**	**204.1**	**4.52**	**13.82**
CV %	-	11.88	11.41	11.88

Table 8.3b

Wet single yarn strength result for wet spun yarn (Uster tensorapid 3)

(Count : 100% cotton 40^S Ne)

S. No	Time to break	Breaking force	Elongation	RKM
	(Sec)	(gf)	(%)	(gf / Tex)
1	0.3	234.7	4.19	15.89
2	0.2	239.1	3.59	16.19
Mean	**0.3**	**236.9**	**3.89**	**16.04**
CV %	-	11.82	13.45	11.82

Table 8.4 a

Yarn characteristics test result of regular spun yarn (Uster tester 4)

Normal count : **Ne 40^S (100% cotton)**

Normal twist : **25.3 twist / inch**

S. No	**Parameters**	**Mean**
1	U %	18.67
2	Thin – 50 % / km	915.0
3	Thick + 50 % / km	2200
4	Neps + 200 % / km	1795
5	H index	5.97
6	D (g / cm^3)	0.39

Table 8.4b

Yarn characteristics test result of wet spun yarn (Uster tester 4)

Normal count : Ne 40^S (100% cotton)

Normal twist : 25.3 twist / inch

S. No	Parameters	Mean
1	U %	18.45
2	Thin – 50 % / km	945.0
3	Thick + 50 % / km	2005
4	Neps + 200 % / km	2020
5	H index	2.68
6	D (g / cm^3)	0.60

Table 8.5

Zweigle Hairiness test result for regular and wet spun yarn

(Count : 100% cotton 40^{S} Ne)

Yarn	1 mm	2 mm	3 mm	4 mm	6 mm	8 mm	10 mm	12 mm	15 mm	18 mm	21 mm	25 mm	S3
Regular	11902	899	924	757	191	59	2.5	0	0	0	0	0	**1934**
CV%	4	1.34	6.04	21.19	50.35	64.72	141.42	0	0	0	0	0	**18.31**
Wet	3283	352	133	50	8.00	1.00	0	0	0	0	0	0	**192**
CV %	28.88	50.35	66.99	79.20	88.39	141.42	0	0	0	0	0	0	**71.45**

Table 8.6

Twist liveliness (cm)

(Count : 100% cotton 40^S Ne)

S. No	Regular	Wet
1.	18.7	9.2
2.	17.8	10.4
3.	18.2	9.3
4.	19.0	9.6
5.	20.2	10.5
6.	19.7	9.8
7.	19.3	11.3
8.	20.6	9.8
9.	21.3	11.6
10.	20.2	10.4
11.	21.6	9.4
12.	18.6	10.6
13.	18.7	9.9
14.	20.8	10
15.	21.6	11.1
16.	18.0	11.2
17.	21.0	10.4
18.	21.3	9.7
19.	17.6	10.2
20.	21.0	9.6
Average	**19.76**	**10.2**

Table 8.7

Spirality

(Count : 100% cotton 40^S Ne)

S. No	Angle of Spirality (In degrees)	
	Regular	Wet
1.	8.4	3.2
2.	9.6	3.8
3.	8.7	4.1
4.	9	4.3
5.	9.4	4.1
6.	9.9	3.8
7.	8.3	3.5
8.	8.8	3.6
9.	9.2	3.9
10.	9.7	4.3
Average	**9.1**	**4**

Fig. 8.1
MACHINE PREPARATION FOR SPINNING UNDER CONDITION WITH WATER

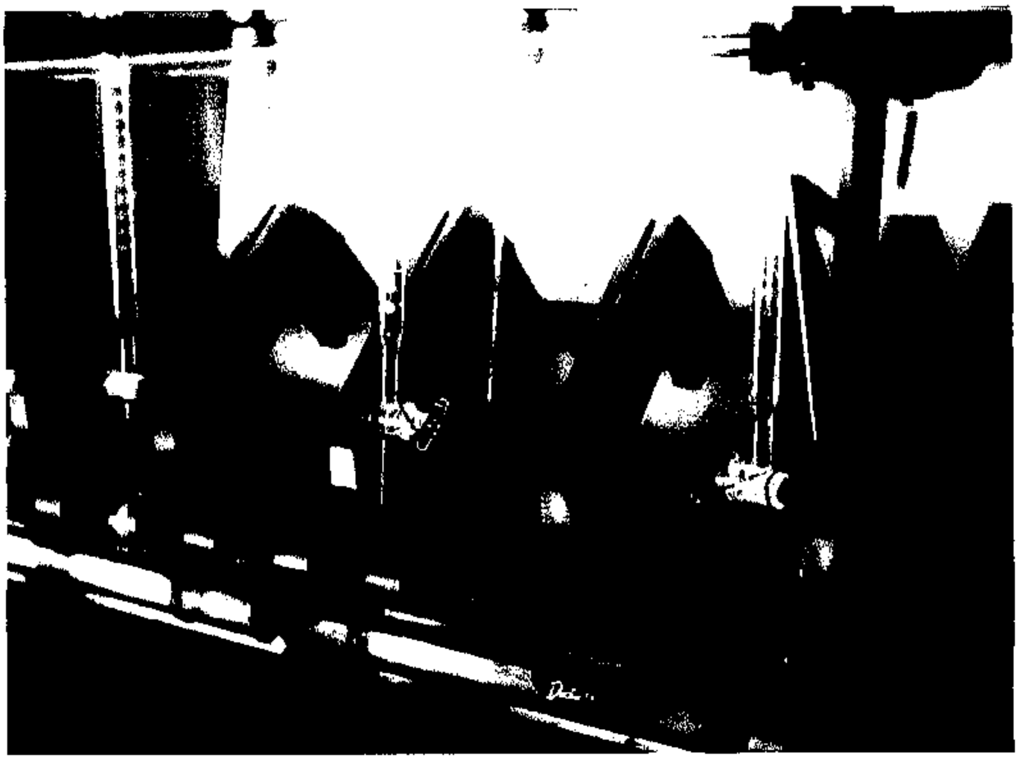


Fig. 8.2
BURETTE POSITION ON TOP FRONT ROLLER

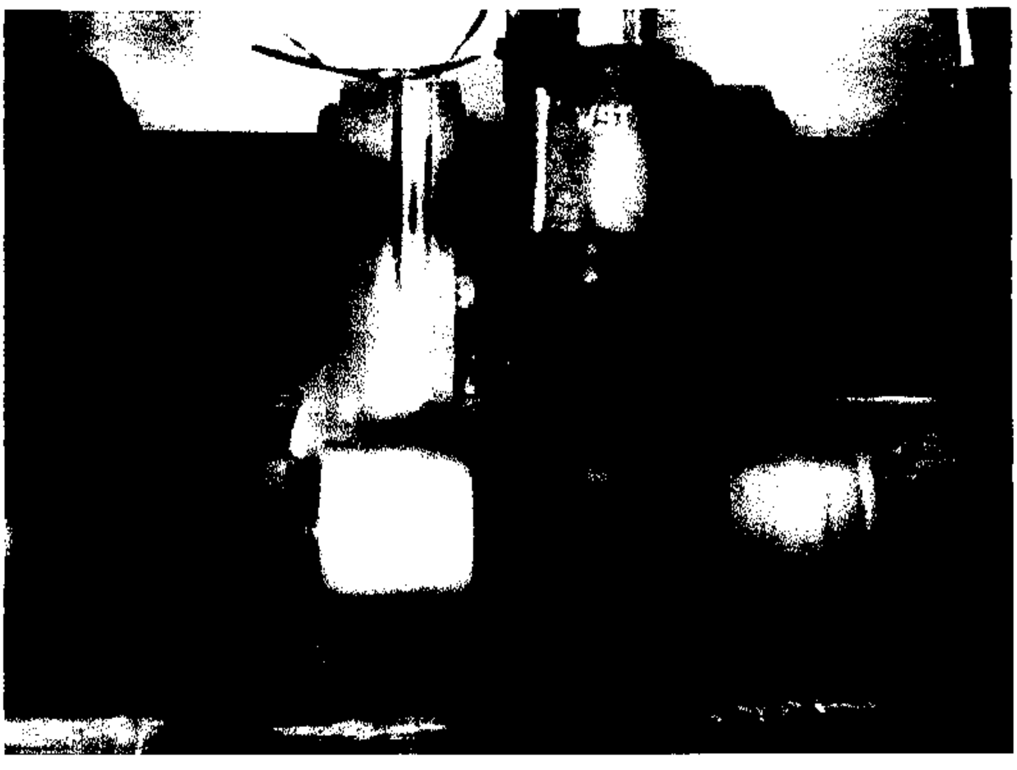


Fig. 8.3

SCHEMATIC SET UP OF THE IMAGE-ANALYSIS SYSTEM

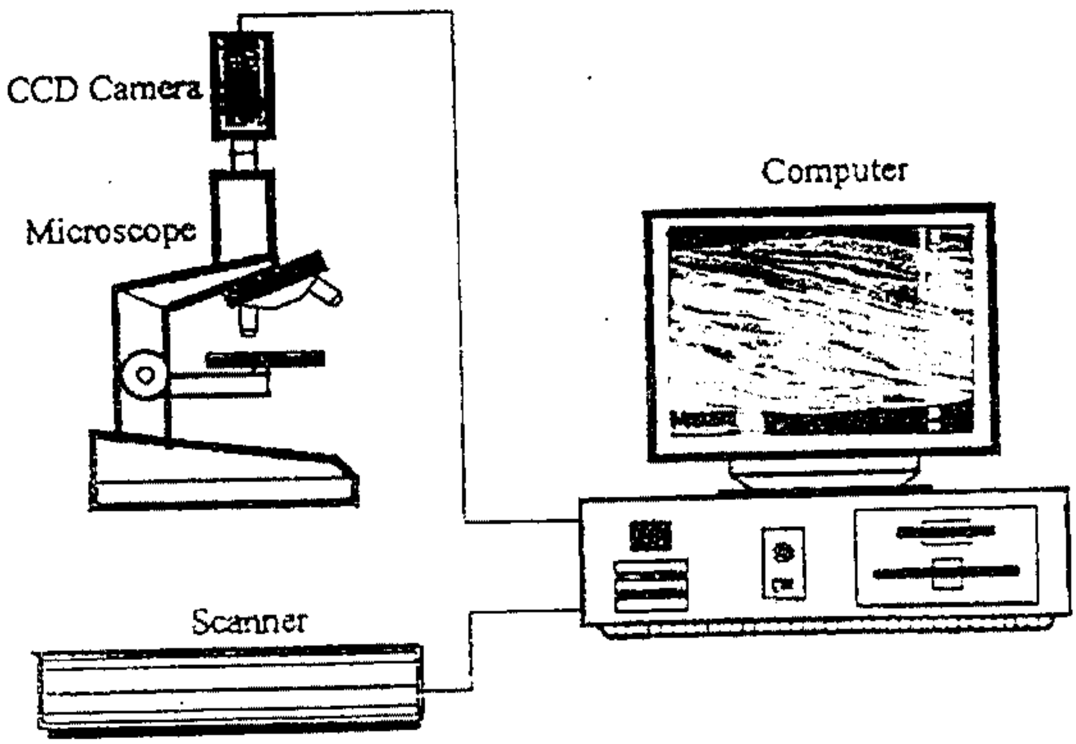
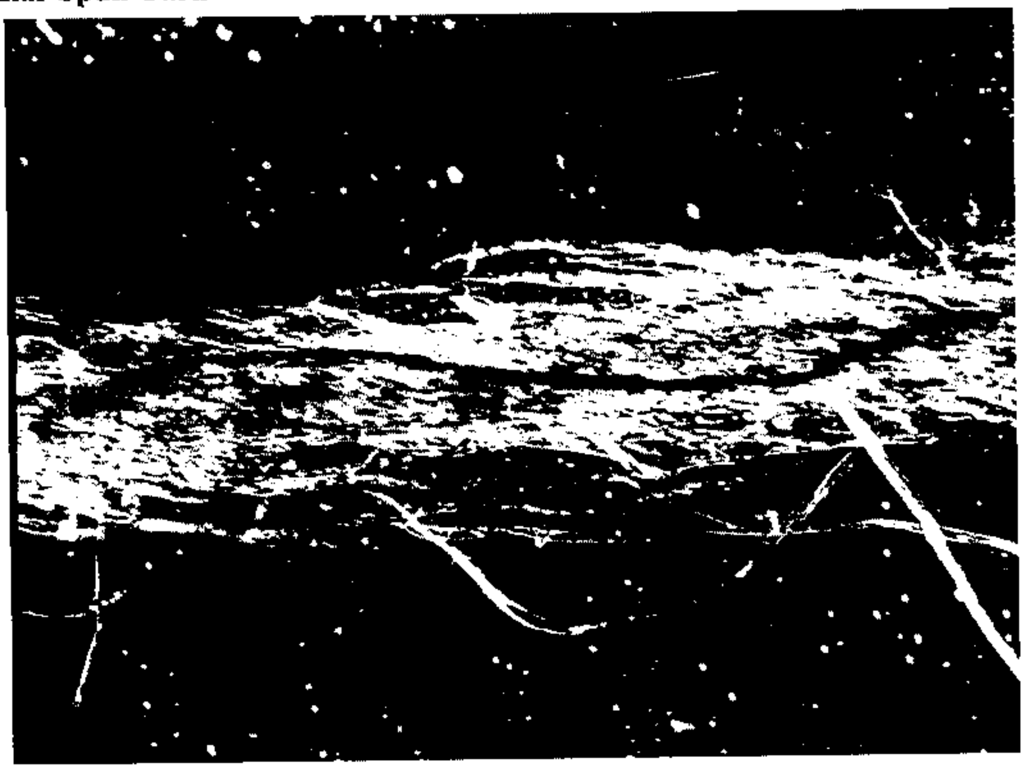


Fig. 8.4

IMAGE CAPTURED BY IMAGE ANALYSER

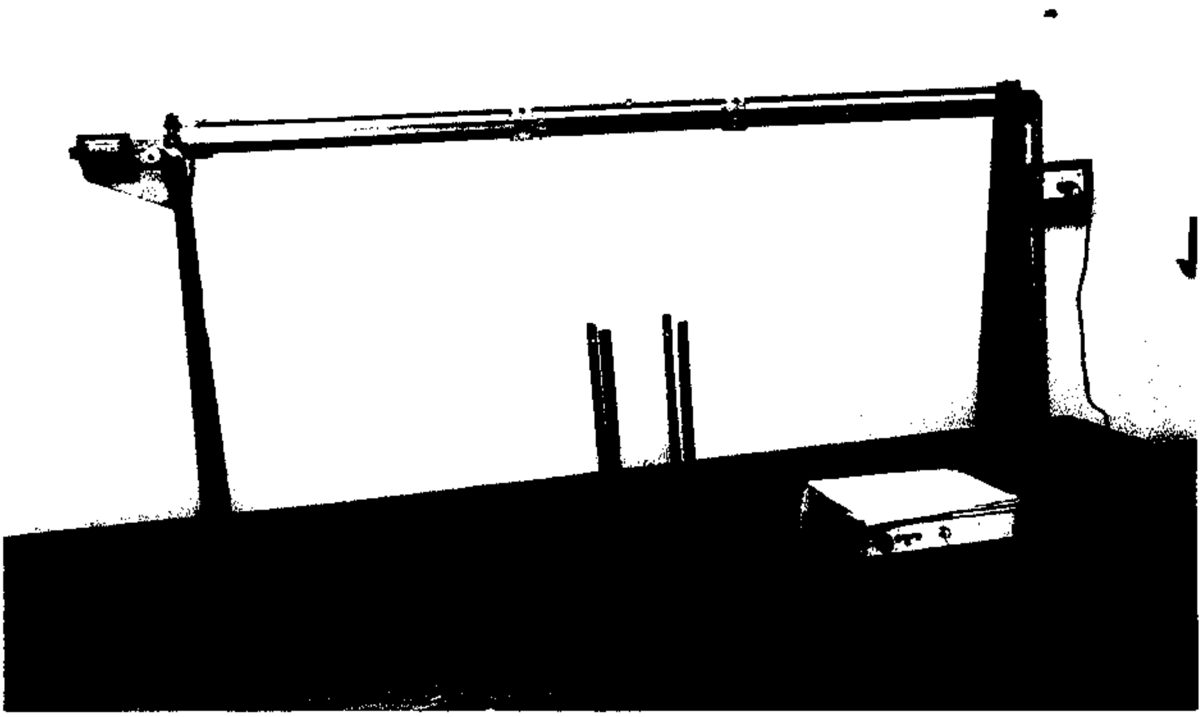
a. Regular Spun Yarn



b. Wet Spun Yarn

Fig. 8.5

TWIST LIVELINESS METER



9. REFERENCE

1. De Araujo, M.D and Smith, G.W. (1989) 'Spirality of Knitted fabric part 2; the effect of yarn spinning technology on spirality', Textile research journal, 59, Pp. 350-356.

2. Hearl, J.W.S, Backer, S and Grosberg, P (1969) 'Structural mechanics of fibers, yarns and fabrics", Textile research journal, Vol. I, Pp. 9,10, 65-68.

3. Kim Y.R., Huh.Y and Ryu W.Y. (1999) 'Comparison of fibre migration behaviour according to ring, rotor and friction spinning methods', Proc. 5th Asian Textile Conference, Vol.1, Pp. 197-200.

4. Krishnakumar, V. (2005) 'A novel technique for reduction of spirality of weft knitted fabrics', Ph.D thesis, Pp. 131 – 137.

5. Morton, W.E and K.C.Yen. (1952) 'The arrangement of Fibres in Fibro Yarns' Journal of Textile Institute, Vol 43, Pp T60.

6. Morton, W.E. (1956) 'The arrangement of Fibres in Single yarns' Textile Research Journal, Vol 26, Pp 325.

7. Pillai, K.P.R. (1961) 'Investigation of the relation between the tensile properties of cotton fibre bundles and yarns in dry and wet states', Journal of the South India Textile Research Association, Vol.6, Pp.14.

8. Primentas, A and Iype, C. (2001) 'The configuration of Textile Fibers in Staple Yarns', Journal of Textile and Apparel, Technology and Management, Vol. I, Pp.1-3.

9. Riding, G. (1959), Journal of Textile Institute, 50, T425.

10. Sitra Focus (1987), 'Hairiness in Spun yarn – reasons and remedies', Journal of The South India Textile Research Association, Vol. 4, Pp.1,2.