INFLUENCE OF FIBRE WETTING IN RING FRAME ON SPIRALITY OF COTTON & BLENDED WEFT KNIT FABRICS

A PROJECT REPORT

Submitted by

GAYATHRI.P

NARMATHA DEVI.S

SHARMADA.S

In partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

in

TEXTLIE TECHNOLOGY

KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE

ANNA UNIVERSITY:: CHENNAI 600 025

ABSTRACT

Many research workers have studied the frictional properties of fibres in the spinning stage and found that due to friction of fibres in the spinning with the machine components as well as cohesive force within the fibres influence the yarn characteristics such as strength, hairiness, evenness, diameter and twist liveliness.

The yarn with higher twist liveliness value always increases the spirality of weft knitted fabric which affects the dimensional stability. In this context, an attempt is made to add frictionizer during spinning process to study its effect. As a frictionizer , plain water is made to wet the fibres in the front roller zone with a special attachment without affecting the apron zone. For this purpose four different raw materials in the form of roving such as P/C(65/35), P/V(60/40), 100% polyester and 100% cotton were used to produce 38s hosiery yarn ina ring frame with the addition of frictionizer and compared with regular spun yarn produced without frictionizer. To study the effect of frictionizer the produced yarn samples were tested for U%, single yarn strength, hairiness and packing density.

The twist liveliness value of each yarn samples was tested using in-house developed twist liveliness meter. The yarn samples were then converted into weft knit fabric using single jersey knitting machine. One of the important factor causing dimensional instability i.e. spirality was tested after wet relaxing all the fabric samples and compared with regular spun yarn fabric samples. The results revealed that the fibre wetting has positive influence on physical properties of yarn spun from cotton . Also the twist liveliness value of cotton yarn has decreased due to fibre wetting. The corresponding spirality value of the single jersey fabric produced from cotton wet spun yarn has also decreased.

In case of yarn produced from 100% polyester roving, hairiness found to be increased on fibre wetting. The other properties such as single yarn strength, elongation% and evenness found to be deteriorated. The packing density for 100% polyester yarn showed only marginal increase. Twist liveliness and spirality has also increased.

In case of yarn produced from P/C and P/V blends hairiness has reduced. The other properties such as single yarn strength, elongation% and evenness found to be deteriorated. The packing density for 100% polyester yarn showed only marginal increase. Twist liveliness and spirality has also increased.

Thus from this project, we infer that fibre wetting in ring frame has positive influence on the physical properties of yarn produced from cotton where as it does not show much improvement in the physical properties of yarn produced from blends namely P/C, P/V and 100% polyester.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 GENERAL

During the last few decades, the use and manufacture of knitted fabrics have increased substantially. This expansion has resulted in the creation of new markets as well as the competition of knitted structures with woven and other textile structures. Although it is a welcome trend, it is unfortunate that the amount of single jersey knitted fabrics which has been rejected due to spirality is quiet high. Exports of knitted fabrics have been good in that they account for 30% of total export.

Spirality has been a fascinating subject, and it is interesting to note that this problem in weft knitted fabrics was tackled by a number of research workers. Since in knitting the yarn plays an important role most emphasis should be placed on it. Recently, the production of compact yarn has become very popular and this yarn is characterized by somewhat higher strength and lower hairiness. Ring spinning is capable of spinning any fibre in a wide spectrum of count.

In this perspective, a great deal of efforts are being directed towards introducing new modifications based on ring spinning system in order to introduce some special characteristics in the spun yarn. More recently, WRONZ, the wool mark company and CSIRO Textile and Fibre Technology have developed solo spinning system. Solo spun technology is a simple, inexpensive clip-on attachment to standard long staple worsted spinning frames to produce a single yarn that can be successfully woven as either warp or weft. Unlike sirospun, solospun is spun from a single roving strand. The other development is

Rocospun developed by Lakshmi Machinery Works Ltd., Coimbatore very recently

1.2 THE COMPACTING SYSTEMS IN RING SPINNING

Compact and solo spinning systems are essentially modifications to the conventional ring spinning process with the aim of altering the geometry of the spinning triangle so as to improve the structure of the ring spun yarn by more effective binding in of surface fibres into the body of the yarn. This reduces yarn hairiness and in the case of solo spinning, makes single worsted/semi-worsted yarns suitable for use as warps in weaving and therefore dispensing with ply twisting.

As the name implies, with compact spinning (also called condensed spinning) the fibres leaving the front drafting roller nip are tightly compacted, making any sign of a spinning triangle at the twist insertion point virtually imperceptible.

In solo spinning, the drafted ribbon, instead of being compacted, is divided into sub-ribbons or strands that form the spinning triangle. At the apex of the triangle the strands are twisted together, similar to plying of several yarns. This confers better integration of the edge fibres as fibres are trapped within and between strand. Table 1.1 lists the basic features of the four techniques currently used to compact the spinning triangle. All utilize air suction and are essentially either a modification or an attachment to the front of a conventional type drafting system.

Besides the distortion caused by stretching, there is the other distortion caused by spirality which results in spreading difficulties. This defect arises from twist stress in the constituent yarns of plain fabric, causing all loops to distort and throwing the fabric wales and courses into an angular relationship other than 90°.

Table 1.1

THE COMPACTING SYSTEMS IN RING SPINNING

Manufacturer	Trade Names	Basic Features
Rieter Machine Works Ltd	Com 4 spin or Comfor spin	4-over-3 double apron drafting system with perforated bottom front roller and two top rollers; drafted ribbon compacted by air suction through bottom front roller
Spindel Fabrik Suessen	EliTe	3-over-3 double drafting system with additional roller and special lattice apron (moving around slotted, air suction tube tubular profile) for compaction of drafted ribbon
Zinser Textilmaschinen GmbH	Air-com-Tex 700	4-over-4 double apron drafting system with perforated apron circulating around top front roller drafted ribbons in front, zone compacted by suction through perforated apron
Maschinen-und Anlagenbau Leisnig GmbH MAL,(D)	P4	4-over-4 double apron drafting system with perforated apron circulating around bottom front rollers drafted ribbons in front, zone compacted by suction through perforated apron

In a gist, chapter 2 deals with detailed literature review. Chapter 3 explains about the materials and methods. In chapter 4 a detailed discussion about the results has been made. This project deals with the technique of wetting the fibres during spinning process itself to produce special yarn. This effect was studied for P/C, P/V, 100% polyester and 100% cotton.

2. LITERATURE REVIEW

2.1 INTRODUCTION

The moisture content and moisture regain properties of various fibres influences the physical properties of the yarns produced. Various research workers made intensive study on moisture properties of fibres and their influence on various physical properties. This chapter deals with research papers with respect to wetting of fibres, various techniques involved in reduction of yarn hairiness.

2.2MOISTURE REGAIN & MOISTURE CONTENT

The property of absorbing moisture is a valuable feature of clothing materials. The absorbtion changes the properties of fibres. It causes swelling which alters the dimensions and thereby alters the size, shape, stiffness& permeability of yarns and fabrics. The amount of water in a specimen may be expressed in terms of either the regain or the moisture content.

$$\text{Moisture Regain (R)} = \frac{\text{Mass of absorbed water in specimen}}{\text{Mass of dry specimen}} \times 100\%$$

$$\text{Moisture Content (M)} = \frac{\text{Mass of absorbed water in specimen}}{\text{Mass of undried specimen}} \times 100\%$$

2.3 MOISTURE ABSORBTION BEHAVIOUR OF TEXTILE FIBRES

When a textile is placed in a given atmosphere, it takes up or loses water at gradual decreasing rate until it reaches equilibrium, when no further changes takes place. This dynamic equilibrium , occurs when the number of water molecules evaporating from the specimen in a given time becomes equal to number condensing and being absorbed.

Moisture absorption of fibres

Material	Absorption regain %
Cotton	7-8
Viscose	12-14
Polyester	0.4

Table 2.1

2.4 WETTING PROCESS

Water is chiefly used for the process of wetting the fibres in ring spinning. Since the synthetic fibres are hydrophilic in nature, water does not get absorbed . Instead it is adsorbed on the fiber surface.

Dynamic wetting of fibres was observed by Q.F.WEI & R.RMARTHER(2003) in an environmental scanning electron microscope (ESEM) has revealed the following:

Stage 1:During the process of wetting as the relative humidity reaches 100%, the condensation of water droplets is initiated by small water droplets forming on the fibre surface. The water droplets are only a few microns at this stage.

Stage 2: As the condensation continues more water droplets form on the fibre surface.

Stage 3: At a proper angle the spherical cap shapes of the water droplets on the fibre surface can be seen.

Stage 4: As more water condenses the droplet sizes increase and closely deposited water droplets coalesce. These water droplets however remain in spherical cap shape on the fibre surface.

As water is not absorbed by the synthetic fibres, difficulty occurs during the yarn formation and hence it does not show improvement in the strength values

2.4.1Contact angle:

The contact angle θ is a quantitative measure of the wetting of a solid by a liquid. It is defined as angle between the tangent to the liquid- vapours interface and the tangent to the solid-liquid interface. Lower value of θ indicate good wetting.

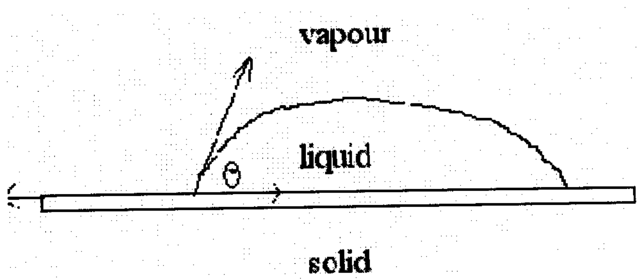


Figure 2.1 Contact angle

The following equation shows the balance between the gravity of a water droplet and the surface tension:

$$2Rg\rho_w \text{(gravity) vs. } 2\gamma_w/R \text{ (surface tension)}$$

where R is the radius of a droplet,

ρ_w is the density of water 1000 kg/m3

g is 9.81m/s2

γ_w is the surface tension of water 0.073 N/m

Cotton is a highly hydrophobic fibre. Since water gets absorbed it helps in easy twist propagation during the yarn formation in ring spinning. This in turn improves the strength of cotton yarn.

2.5 YARN HAIRINESS

LINGLI CHANG & ZHENG- XUE (2003) deals with yarn hairiness which is an important factor which influences the energy consumption in rotating a ring-spun yarn package. Yarn with fibre mends and loops protruding out from the main body are classed as hairy yarns. Due to the process of wetting, the hairiness is immensely_reduced in both synthetic & cotton fibres.

When a yarn package is rotating at a high speed the hair fibres may stay perpendicular to the package surface due to the centrifugal force acting on them.

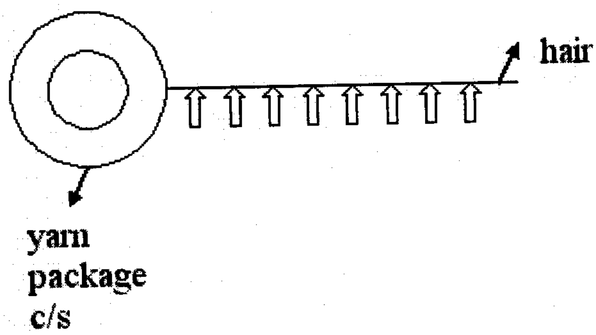


Figure 2.2(a) Model of a yarn package-perpendicular

If the hair is not perpendicular to the surface of the yarn package the projected length of the hair will be L sin φ.This situation would arise from the action of the air drag and flexibility of the hair fibres, which would decrease the L value. Consequently, we expect the measured power of the hairs to be less than their calculated power value.

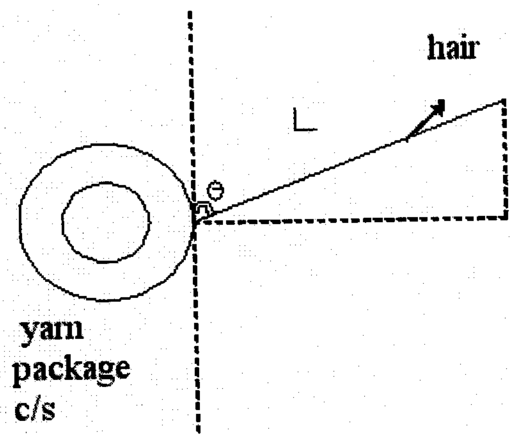


Figure 2.2(b) Model of yarn package-inclined

For a yarn with a single horizontal hair of length L travelling vertically at a speed V (in steady air),the drag F acting on the hair owing to air resistance can be calculated using the following formula

$$F = 1/2 C_D \rho A V^2$$

where ρ is air density ,

A is the projected frontal area

V is the hair velocity

C_D is the drag co-efficient

2.5.1 Measurement of yarn hairiness

Dr.H.R.SHEIKH(2001) measures the hairiness of yarn by photoelectric sensors. The sensors not only details and counts the number of fibres protruding from the yarn body in excess of 2 mm but also estimates the total length of all such fibre present in the total length of yarn tested. The hairiness measured is given in the form of a number which is derived automatically by the sensors so ratio of the total length of the producing fibres and the total length of the yarn tests that OS-sensor is included in the optic-electronic sensor supplied with the fourth generation of Uster® Tester - 4 5 X and measures hairiness of yarn

2.5.2 Consequences of Hairiness

1. In the manufacture of leisure user especially for textiles worn in contact with skin yarn hairiness is an excellent characteristics as it influences touch, feel and wear quality of fabrics. However, hairy yarns also give rise to adverse consequences in the textiles produced from such yarns.
2. If the hairiness is more than 5, the fabrics will exhibit pilling tendency.
3. Excessive hairiness of yarn contributes to appearance of barre' in fabrics woven or knitted from such yarns up to about 10%.

2.5.3 Causes for hairiness:

(I) Most common cause of yarn hairiness is marginal fibers of the drafted roving ribbon escaping twist as it emerges from the front drafting roller nip. Some of these fibers are lost as fly while others have only one end incorporated in the yarn body. The other end protrudes out and yarn produces hairy. Failure of the marginal fibers to get twisted fully into the yarn is mainly due to short spinning triangle or application of high draft or both low spinning tension resulting from the use of two light travelers also
contributes to yarn hairiness.

(ii) If the relative humidity is not at optimum level, fibre exhibits a tendency to stick on the surface of drafting rollers which produces hairiness in the yarn.

(iii) Non-uniform rotation of the travellers because of worn-out rings, vibration of spindles because of worn-out or slipping tapes becoming leaded with waste.

(iv) Trapping of the yarn between the traveler and top of the ring flange.

(v) Traveler scraps the yarn when traveler number is not correct with respect to the count of yarn being spun.

(vi) Yarn balloon lash on the separator plates.

2.6 SPIRALITY

2.6.1FACTORS AFFECTING SPIRALITY

Spirality is a defect which is noticeable in weft knitted fabrics, in particular in single jersey fabric. The magnitude of spirality affects the garment manufacture. This covering the research on spirality, includes investigation of the factors such as fibre, yarn structures and geometrical properties of fabrics which affect spirality as given below:

1. Effect of fabric tightness factor.
2. Effect of relaxation treatments.
3. Effects of relaxation and washing treatments on spirality.
4. Effect of chemical treatment on spirality.
5. Effect of mechanical treatments for reducing spiralitry.

Yarn structure of different types of yarns can contibute to spirality as they are also found to differ due to the level of twist imparted to them. In addition ,yarn setting treatments such as steaming starching and swelling affect spirality due to the influnce of the on residual torque.there is the tendency of yarn to rotate the yarn in the inside the fabric gives rise to spirality.Detailed review of spirality has been provided by Dr.V.KRISHNAKUMAR (2004) in his Ph.D ., thesis.

Several standards are available for measuring the spirality angle eg. The BSI, 1WS and ASTM. With the aid of protractor ,the spirality in a weft knitted fabric can be determined easily. Anand et al have suggested the pillow case method for studying spirality.

2.7 CAUSES OF SPIRALITY

Knitted fabrics mainly suffer from various defects and the most common is the spirality. Spirality is being caused by the use of yarn that is twist lively , the direction and the degree of spirality being determined by the direction and the degree of twist liviliness.

Spirality is a regular deformation of the structure caused by each loop twisting over to approximately the same angle. The angle between the wales and courses is less than 90o and when the angle is less than 83o the distorted appearance of the structure is very obvious and the merchandise is likely to bring customer complaints.

Spirality is due to "twist liveness" the release in torsional potential energy in the yarn. The result of the section of yarn of each loop trying to move into a state of lower strain under the constraint of forces from neighbouring loops is for the loop to twist over. This phenomenon may be seen when the fabric is produced from singles yarns which have not been properly set or from unset two fold yarns which do not have balancing ratio of singles twist to folding twist.

2.7.1 EFFECT OF YARN TWIST

The effect of twist on stability the knitted fabrics and the tendency for unbalanced twist is to cause "spirality" has been investigated. Essentially ,the degree of spirality can be related to the twist liveliness in the yarn, rather than the absolute twist, and to the tightness or stiffness of the fabric 0structure.

2.7.2 EFFECT OF YARN SETTING

DAWIS W, EDWARD C.H(1934) also studied the effects of yarn setting treatments on spirality,they have found that cotton yarns steamed and cooled , boiled and cooled and mercerized had led to lower spirality. Another finding is that the alteration of spirality for equal changes of stitch length varies from one machine to another.Spirality of a fabric increases with the fineness of machine gauge, but the rate of increase appears to vary with the type of machine used.They did not think about measuring residual torque of the yarn.

2.8 SPIRALITY IN SELF TWIST YARN

CARNABY (1974) had discussed the spirality in single jersey fabrics knitted from self-twist yarns .He produced a range of knitted fabrics on a 10.8 cm dia , 148 needles Komet half hose machined from an R55/2-tex-ST yarn , the knitting tension was varied from 0-600 mN at the feed point and the stitch cam setting was varied to produce frabics with different cover . In general, the loop distortion was found to be due to twist distribution in the yarn before its entry to the feed-in guide and loop distortion was found to be higher at lower cover factors. This was found to be similar to the problem of spirality. CARNABY (1974) concludes that reduction in spirality can be obtained by increasing tightness factor , reducing the yarn twist or steaming the yarn package before knitting. Twist redistribution in the yarn reduces with reduction in yarn twist.

Spirality is a regular deformation of the structure caused by each loop twisting over to approximately the same angle. The angle between the wales and courses is less than 90° and when the angle is less than 83° the distorted appearance of the structure is very obvious and the merchandise is likely to bring customer complaints.

Spirality is due to "twist liveness" the release in torsional potential energy in the yarn. The result of the section of yarn of each loop trying to move into a state of lower strain under the constraint of forces from neighbouring loops is for the loop to twist over. This phenomenon may be seen when the fabric is produced from singles yarns which have not been properly set or from unset two fold yarns which do not have balancing ratio of singles twist to folding twist.

2.9 EFFECT OF THE BLEND COMPOSITION ON THE SPIRALITY

LORD MOHAMED &AJGAONKAR(1974) have studied the performance of weft knitted fabrics made out of open-end, twistles and ring yarns. In addition to many physical properties which were studied, values of spirality produced from open end cotton yarns, polyester/cotton blended, yarns produced by ring spinning and open end spinning technologies were provided. That the spirality increases with increase in twist factor and that it reduces with steaming and wetting of cotton yarns has been demonstrated. Wetting of yarn had led to a significant reduction in spirality.

A very interesting observation made by the authors is the effect of blend composition of polyester and cotton yarns on spirality of fabrics. It was demonstrations that polyester , due to higher torque, had led to higher spirality regardless of various relaxation treatments. With regard to weft knitted fabrics produced from twistless yarns, it was found that for both dry and fully relaxed samples, spirality was very low and with the insertion of twist, values of spirality increased.

Thus it has been found that spirality in weft knitted fabrics is caused by twist , and any relaxation treatment may cause a reduction. That twist plays a dominant role in reducing the spirality whatever relaxation treatments are given to the fabrics has been emphasized and reinforced.

2.10 EFFECT OF TYPE OF YARN

A study conducted by LO, HOW and MIAO (1996) shows that the knitted fabrics produced from OE yarns shows lower spirality (3.75^o) compared to the fabric produced from ring spun yarns (9.25^o). Postle R.(1964) have demonstrated that yarn torque arises due to fabric tension in addition to fibre blending and fibre torsion.Total yarn torque comprises three components namely fibre bending, fibre torsion and fibre tension. Platt et al(1951) have ignored the component due to fibre tension in their analysis of yarn torque. Postle et al(1964) who have extended the work of Platt et al (1959) have obtained the following relationship

$$L_T=L_{FE}+L_{FT}+L_{FB}$$

Where L_{FT} = Fibre torsion

L_{FE} = Fibre extension

L_{FB} = Fibre bending

L_T = Total yarn torque

In all the processes the yarn is subjected to considerable amount of stresses which are likely to affect yarn torque. Stress relaxation in fibres drastically reduces on exposure to moisture and temperature; they may affect yarn torque considerably. Accordingly to NUTTING(1960) the relaxation process changes the intermolecular structure inside the fibre and helps to relieve the torque stored inside the yarn. Torsional instability of yarns affects spirality in knitted fabrics. The work carried out by POSTLE(1964),DHINGRA and POSTLE(1974) is very relavant for understanding torsional properties of yarns.

2.11 SPIRALITY OF WEFT KNITTED FABRICS

Nature, origin & characteristics of spirality effect has been examined by A PRIMENTAS(2003) In a relaxed state of a single jersey tubular fabrics knitted from single yarns, the wales instead of being at right angles to the courses, show pronounced inclination towards the left or right following a spiral path around the axis of the fabric. This distortion is known as spirality effect and its magnitude is measured by the spirality angle. This is unpredictable when the fabric is still on the knitting machine because of the imposition of strain on it due to the take-down tension.

The main reason for spirality is the unbalanced as well as the residual torque in the yarn shown by its twist liveliness. Hence the greater the twist liveliness the greater is the spirality. The degree of freedom of yarn movement in the fabric structure contributes significantly to the rise of spirality. The more slack the fabric structure , the greater is the spirality.

As the measurement of the angle of spirality is concerned, either a protractor or a specially designed transparent board can be used. The percentage spirality is considered as the sum of the net spirality caused by the yarn torque and the additional spirality caused by all other factors. It can be calculated following the two different geometrical approaches. As the level of acceptable spirality angle is concerned, the maximum value is five degrees or seven degrees and the percentage spirality is 8.

The fabrics produced from the unconditioned and conditioned yarn samples showed differences in the values of spirality angle. The less twist lively the yarn, the smaller is the spirality distortion in single jersey garments knitted with a normal tightness factor.

The reason for the appearance of spirality on the knitted fabrics is the yarn twist liveliness. Twist liveliness is a yarn characteristic that describes the active torsional energy present in the yarn .Its magnitude depends on the torque inserted in the yarn by means of twist. Because spirality appears commonly in fabrics produced from singles yarns, it was decided to produce a range of singles yarn samples having different twist factors in order to investigate the effect of the yarn twist and twist liveliness on spirality.

The fabrics produced from the unconditioned and conditioned yarn samples showed differences in the values of spirality angle. The less twist lively the yarn, the smaller is the spirality distortion in single jersey garments knitted with a normal tightness factor.

2.12 EFFECT OF YARN STEAM SETTING AND FABRIC WASHING ON SPIRALITY

A.PRIMENTAS(2003) has mentioned that there are several techniques dealing with yarn and fabric processing have been adopted to overcome spirality. The most suitable method for producing spirality-free single jersey fabrics is by knitting two-folded yarns where the opposing torsional forces in the singles yarns and the resulted folded yarn are counterbalanced. Although the use of folded yarns, instead of singles yarns, improves the fabric characteristics, due to the problems regarding the appropriate relation between their twist levels, fabrics may exhibit spirality that would be in the direction of the residual twist.

When two singles yarns of equal twist level, equivalent twist liveliness and opposite twist directions are fed to a feeder of a knitting machine, their tendency to distort the knitted loops towards the one or other direction(S or Z) is neutralized and a straight fabric appears.

The production of yarns of similar twist liveliness is rather difficult and any exhibited spirality of the resultant fabric assumes the twist direction of the yarn with the yarn with the twist liveliness. This method similar to plating is an effective technique for keeping the spirality to a minimum level. Further more knitting alternate ends of S & Z twisted yarns with equivalent twist liveliness will produce an overall spirality- free fabric.

The first attempt for chemical correction of spirality was made on fabrics produced from crossbred worsted yarns. Research involving mercerization treatment of cotton yarns showed 45% reduction in twist liveliness and 10-13% reduction in the spirality of dry relaxed fabrics on the other hand tremendous reduction of 20-30% in spirality was observed when mercerization took place in the fabric stage. Although mercerization is an efficient wet-relaxation process giving the best results compared to others, it is not a complete solution for the spirality of single knitted fabrics.

Twist setting or relaxation improves the mechanical stability of yarns as it relieves the stress set up in the textile fibres by twisting and ensures the stand still of the twist liviliness of even highly twisted yarns while retaining their twist level.

2.13 Effect of steam setting on yarn properties

Actual linear Density, tex	Twist factor turns. cm^{-1}. $tex^{1/2}$	Steam setting	Tenacity $cN.tex^{-1}$	Hariness hairs. m^{-1}	Regularity Cv%	Snarliness Cm
29.5	32.4	N	12.55	61.80	14.22	43.5
30.1	32.4	Y	12.40	63.01	12.40	7.0
29.2	34.9	N	15.11	57.00	13.63	55.2
30.2	34.9	Y	12.66	52.42	13.33	9.3
29.8	38.6	N	16.43	49.29	14.31	61.7
30.0	38.6	Y	14.13	47.62	13.69	12.2

Table 2.2

N-Unset yarn

Y-Set yarn

The spirality reduction was very significant for the fabrics produced from the set yarns prior to washing and less significant after washing. It must be pointed out that a great reduction can only be achieved by the optimum yarn steaming conditions.

2.14 EFFECT OF PARTIAL DETWISTING OF STEAM –SET YARNS ON SPIRALITY

Sample no	Yarn condition	Nominal linear density (Tex)	Twist factor turns. $cm^{-1.} tex^{1/2}$	Actual twist $turns.m^{-1.}$	Fabric spirality(deg)	
					BW	AW
1	Normal	39	32.3	531.7	28.5	28.5
2	Steam set	39	32.3	520.9	11.0	13.0
3	Normal	39	39.5	642.1	35.5	30.0
4	Steam set	39	39.5	630.1	16.5	17.0
5	processed	39	39.5	531.6	2.5	4.0
6	Normal	29	32.4	601.6	31.0	26.0
7	Steam set	29	32.4	590.9	13.5	13.5
8	Normal	29	38.6	719.4	38.5	23.5
9	Steam set	29	38.6	719.2	19.0	11.0
10	processed	29	38.6	576.0	-2.0	3.0

Table2.3

A.PRIMENTAS & C.IYPE(2003) Many methods have been developed to overcome the spirality of weft knitted fabrics. The most commonly applied but expensive one, method is the use of two-folded yarns. The widely used yarn steam set process merely reduces the spirality rather than preventing its appearance. Moreover the washing of the fabrics produced from steam set yarn increases the small spirality angle appeared before washing.

A possible method for the reduction of the spirality effect should include a real reduction of the twist liveliness or torque existing in the short staple ring spun yarns.

2.15 YARN TWIST

Twist: A term that applies to the number of turns and the direction that yarns are turned during the manufacturing process. The yarn twist brings the fibers close together and makes them compact. It helps the fibers stick to one another, increasing yarn strength. The direction and amount of yarn twist helps determine appearance, performance and durability of both the yarns and the subsequent fabric or textile product. Yarns may be twisted to the right (S twist) or to the left (Z twist). Twist is generally expressed as turns per meter (tpm).

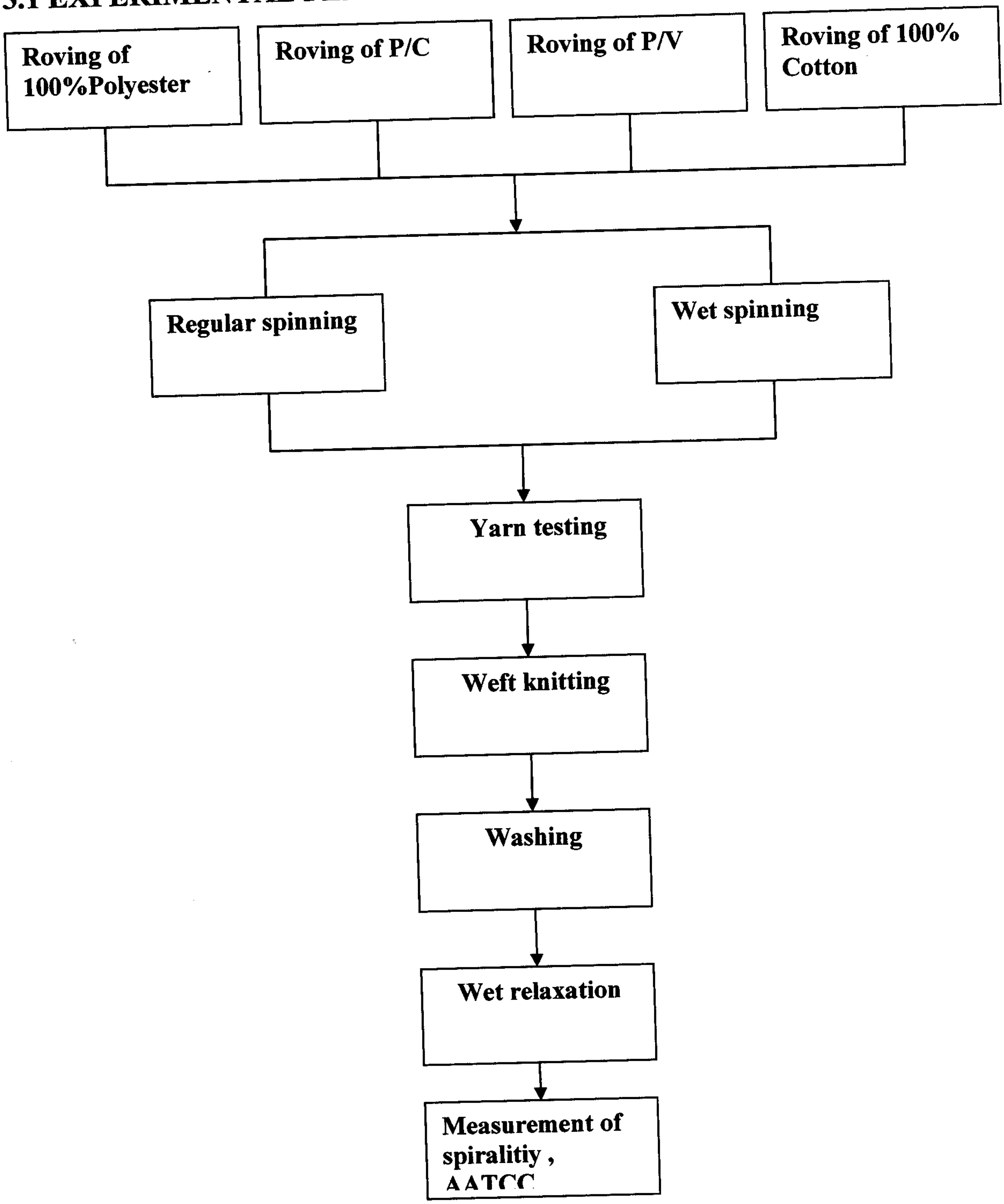
2.15.1 Assessing yarn twist- liveliness

E.B.BELOV (2002) had an objective assessment of yarn twist- liveliness requires more attention if the information gained is to be of value in processing.a method for assessing twist- liveliness is the snarl method. This is an indirect method based on measurements of geometrical characteristic of the snarl formed in a yarn when the end of the yarn are brought together. There are semidirect method of assessing twist- liveliness .Some of these are based on torsional pendulum technique and relate properties to the torsional oscillation of a weight suspended by the yarn.

The most accurate method is the direct approach based on the measurement of the residual torque in the yarn. In direct methods for measuring yarn torque a torsional balance technique is applied.

3. MATERIALS AND METHODS

3.1 EXPERIMENTAL PLAN



3.2 RAW MATERIAL

38s H yarns were produced from 100%cotton, 100% polyester and blends such as P/C[65/35], P/V[60/40]. The yarns used in this study were of two types, one produced from regular spinning method and the other produced by fibre wetting method.

FIBRE SPECIFICATIONS

Fibre used	Denier/mic	Staple length(mm)
Cotton	3.8	29
Polyester	1.2	44
Viscose	1	44

Table 3.1

FABRIC SPECIFICATIONS

Knitting – process parameters	
Wales/ inch	30
Course/inch	36
Stitch length(cm)	0.2
Tightness Factor($tex^{0.5}cm^{-1}$)	14.1

Table 3.2

3.3 YARN PRODUCTION

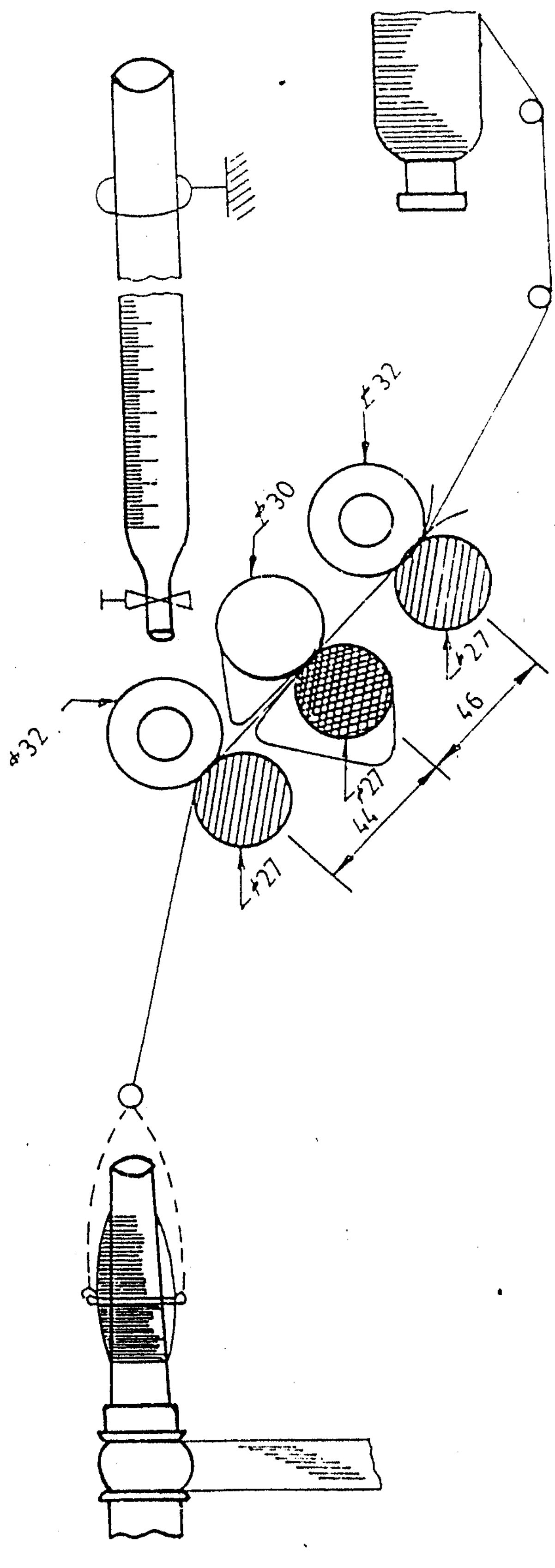
The roving of various fibres namely P/C (hank-2), P/V (hank-2), Polyester (hank-1.8),Cotton(hank-2) was processed in the ring frame machine.

3.3.1 Machine details

Make	: Mafatlal engg. Industries
Model	: Super spinning mark 2
Year	:1981
Draft system	: 3over 3 sussen spring loaded
No.of spindles	:160
Spindle speed	:12000-15000 rpm
Lift	:7"
Ring dia	:41mm
Gauge	:70mm
Drive to spindles	: 4 spindle synthetic tape drive

3.4 METHOD OF FIBRE WETTING

The method involved the use of burettes in ring frame. The burette was filled with water and fixed on the top of the top roller. The water particles are allowed to trickle on the top roller which wetted the drafted fibre material. The tap is opened and the jet of the solution of the frictioniser(water) is directed to the spinning zone where a parallel strand of the fibres, comes out for twisting. The spinning takes place and only the front bottom and top rollers become wet. The winding and twisting arrangements have been retained.



The method of producing yarn by fibre wetting is given in figure 3.1.

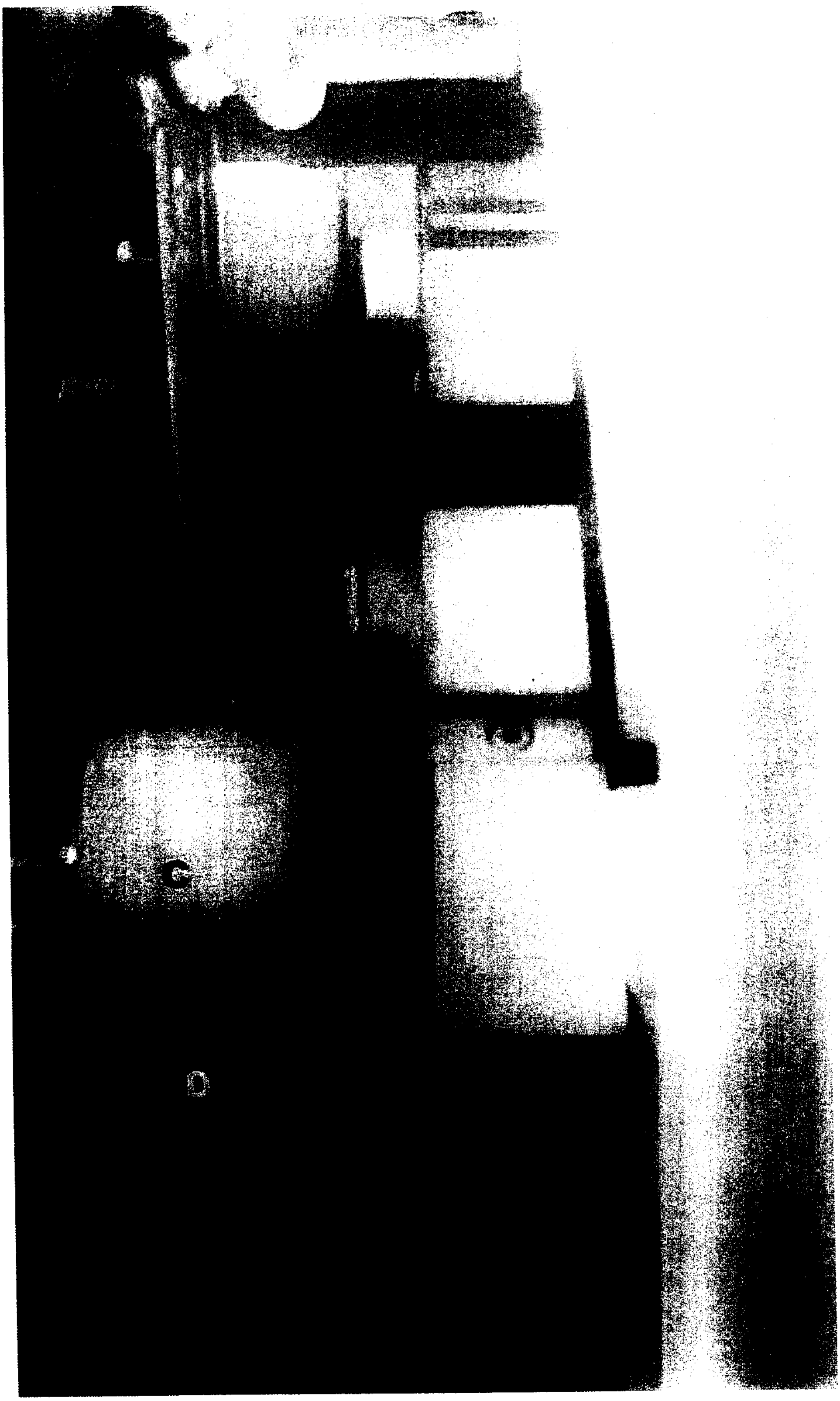


Fig : 3.2 Experimental model of wet Spinning

A-Burette B-Liquid Drop C-Top Roller D-Yarn

Figure 3.4 Experimental model of Fibre Wetting.

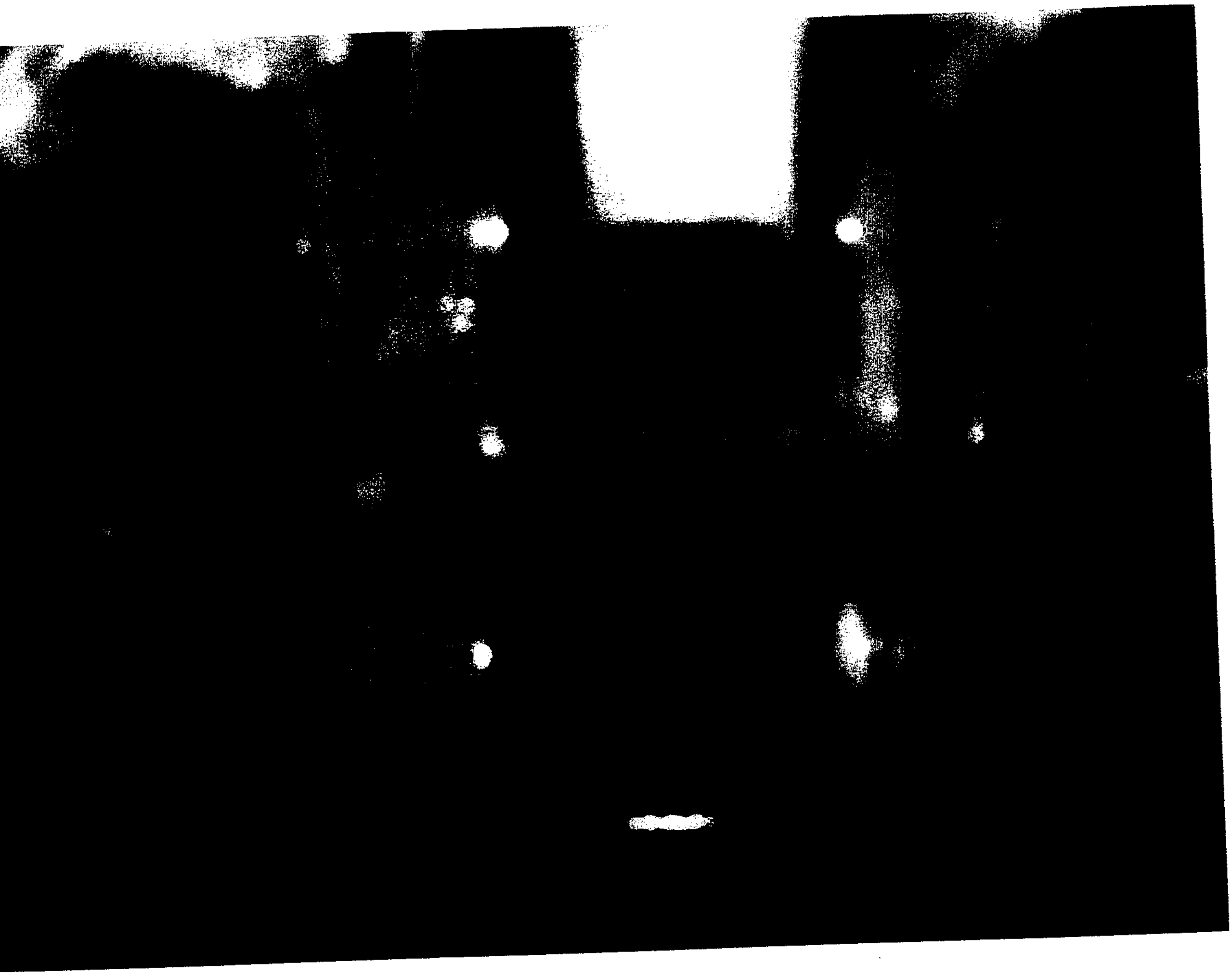


Figure 3.3 Experimental model of Fibre Wetting.

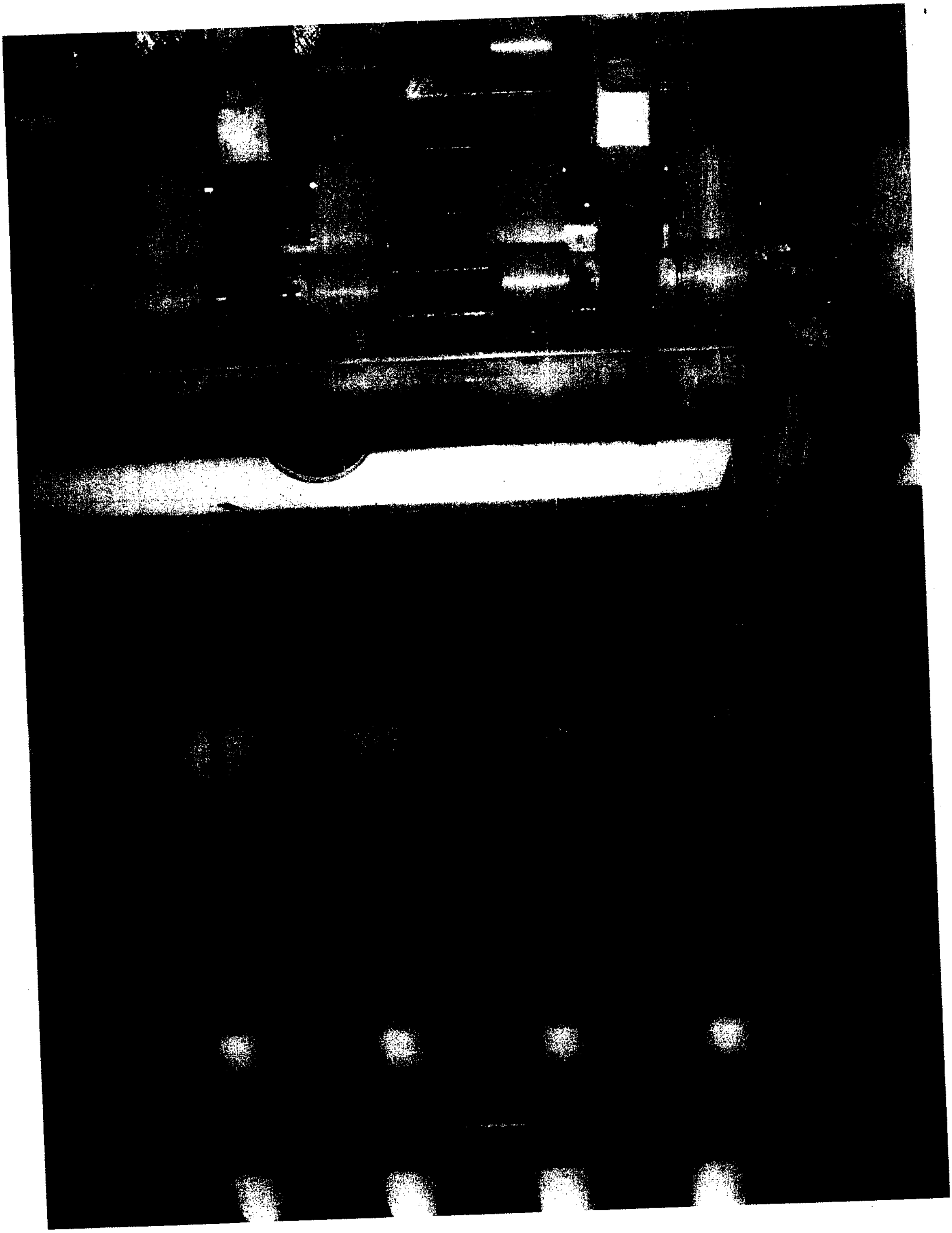


Figure 3.6 Experimental model of Regular Spinning

3.5 YARN TESTING

S.no	QUALITY PARAMETERS	INSTRUMENT USED
1.	COUNT	CSP SYSTEMS
2.	COUNT CV%	CSP SYSTEMS
3.	SINGLE YARN STRENGTH	USTER TENSORAPID
4.	SINGLE YARN STRENGTH CV%	USTER TENSORAPID
5.	ELONGATION	USTER TESTER 4
6.	ELONGATION CV%	USTER TESTER 4
7.	U% & IMPERFECTION	USTER TESTER 4
8.	PACKING DENSITY	USTER TESTER 4
9.	YARN DIAMETER	USTER TESTER 4
10.	YARN HAIRINESS	ZWEIGLE
11.	YARN APPEARANCE	APPEARANCE BOARD
12.	YARN TWIST LIVELINESS	TWIST LIVELINESS METER

3.6 Calculation of water uptake:

$$\text{Quantity of yarn delivered in mpm} = \frac{\text{spindle speed(rpm)}}{\text{tpi x 39.37}} \quad \ldots\ldots\ldots 1$$

$$= \frac{11000}{22}$$

$$= \frac{500}{39.37}$$

$$= 12.7 \text{ mpm}$$

$$\text{Weight of yarn delivered /min in grams} = \frac{0.59 \text{ x mpm}}{\text{Hank}} \quad \ldots\ldots\ldots 2$$

$$= \frac{0.59 \text{ x } 12.7}{38}$$

$$= 0.2 \text{grams}$$

Weight of yarn delivered /3 secs = 0.01 grams

Observation showed that,

Quantity of water delivered in 60 secs = 1 ml

Therefore,

Quantity of water delivered in 3 secs = 0.05 ml

Material (g) : water (ml) ratio = 0.01 : 0.05

= 1 : 5

3.7 METHOD FOR MEASURING YARN TWIST LIVELINESS

3.7.1 INTRODUCTION

In ring 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. A twisted yarn has a tendency to untwist, and attain the minimum state of energy. Higher the value of twist multiplier (T.M), this effect is more pronounced. This factor influences dimensional stability of a fabric, particularly a knitted fabric, as the yarn is not subjected any tension during knitting. The main problem in the knit fabric due to yarn twist liveliness is spirality. This tendency is called twist liveliness and is defined as the " Tendency of a yarn to twist or untwist spontaneously".

3.7.2 TWIST LIVELINESS TESTING METHODS

The measurement of yarn twist liveliness is made by using testing techniques which have been classified as follows:

a. Methods in which the free end of yarn held from other end is left to rotate.
b. Methods based on the snarl formation procedure.

The steps in testing includes the following:

a. When the 2 ends of a known length of yarn tensioned with a weight suspended from the middle of the yarn and brought together.
b. Allowing the formed loop to rotate until reaching "immobility state" and
c. Counting the number of turns of the loop.

3.7.3 NOVEL TECHNIQUE FOR MEASURING YARN TWIST LIVELINESS

In all the instruments available for testing the yarn twist liveliness, one end is fixed and the other end of yarn is moving towards the fixed end. This system causes in balance in moving end and the reading varies often. In a novel technique, an instrument is fabricated in which both ends are moving in a similar fashion results in a balanced way of measuring the twist liveliness.

3.7.3.1 Description about the instrument

The instrument has a screw rod driven by a motor. 50% screw rod is having LH thread and the rest is having RH thread. Fixed on bearings, the screw rod is kept about 500 mm from the table. Two yarn clamps are kept 1000 mm apart. The motor rotation is reversible and controlled by a special electronic circuit. Yarn is pretensioned with suitable arrangements. Since the screw rod pitch is 1 mm, the counter attached to the screw rod shows direct reading of the number of rotations. The details of the parts are shown in figures 3.2 and 3.3.

3.7.3.2 Principle

This instrument works on the principle that when two ends of a certain length of yarn, which is twist lively, is brought towards each other, after a certain distance, the first loop starts forming due to the residual torque present in it. The distance between the yarn clamps at the moment of formation of first loop by the yarn is taken as a measure to express twist liveliness in the yarn. The yarn clamps are clearly shown in figure 3.7

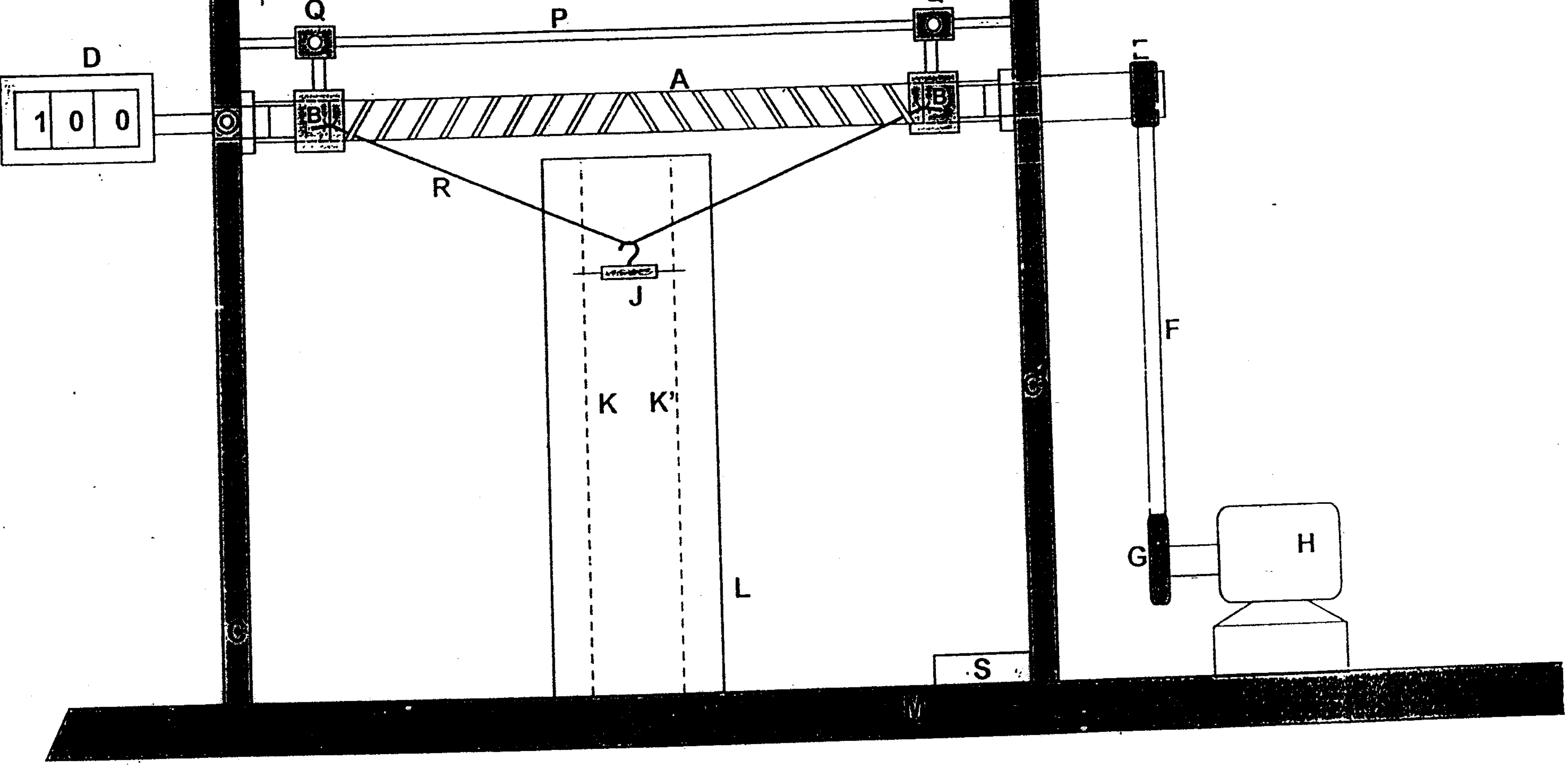


Figure 3.7 Twist Liveliness Meter

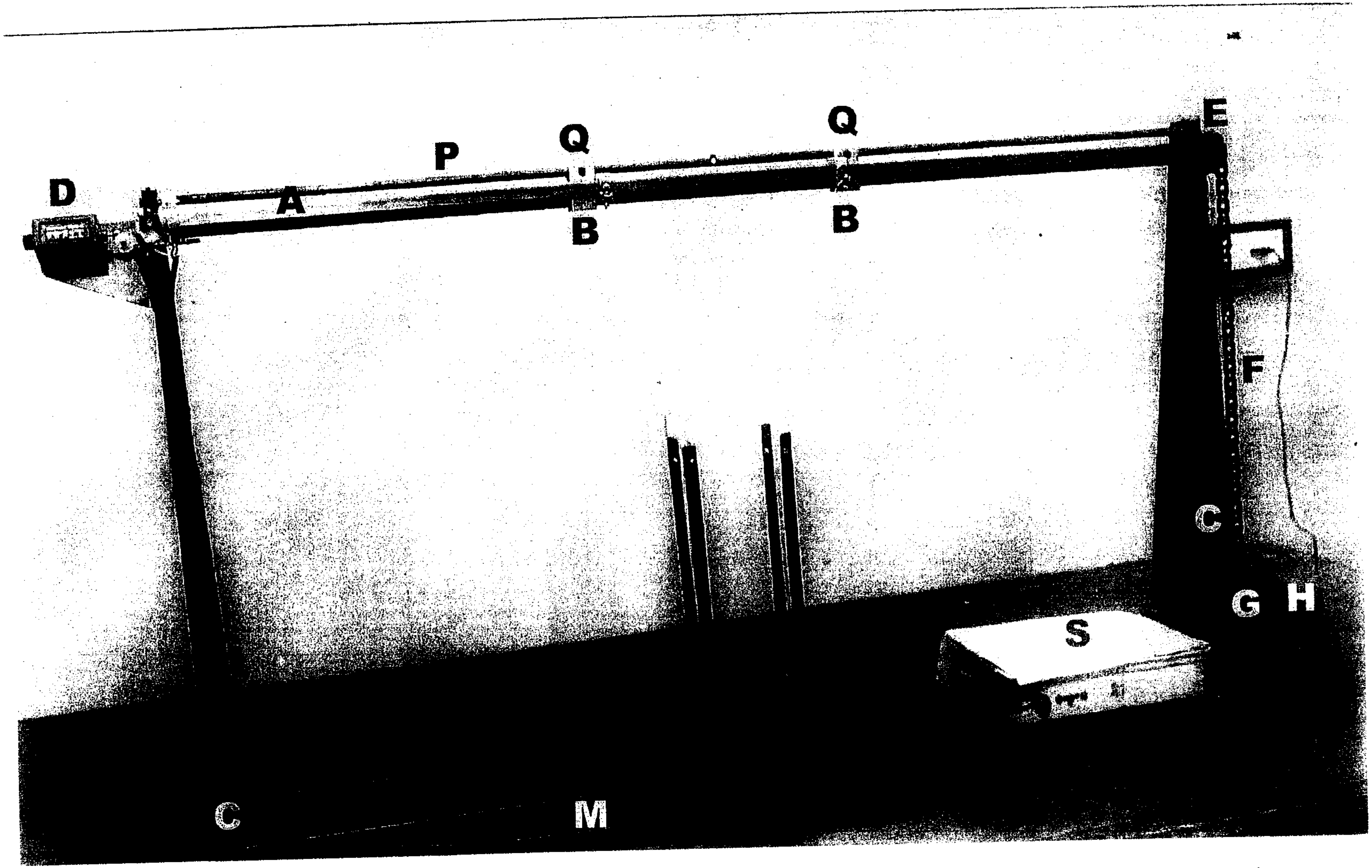


Figure 3.8 Twist Liveliness Meter

PARTS OF THE INSRUMENT

A. Double threaded(two directional) shaft
B. Spring loaded clamps
C. M/C frame
D. Mechanical meter
E. Driven wheel 13 teeth
F. Chain drive
G. Driving wheel 26 teeth
H. Motor
J. Flat metal weight (0.2 grams)
K. Continuous metal wire connected to relay
L. U shaped transparent plastic tube with two sides open
M. Base board
P. Guide rod
Q. Guiding bracket
R. Yarn sample
S. Control box

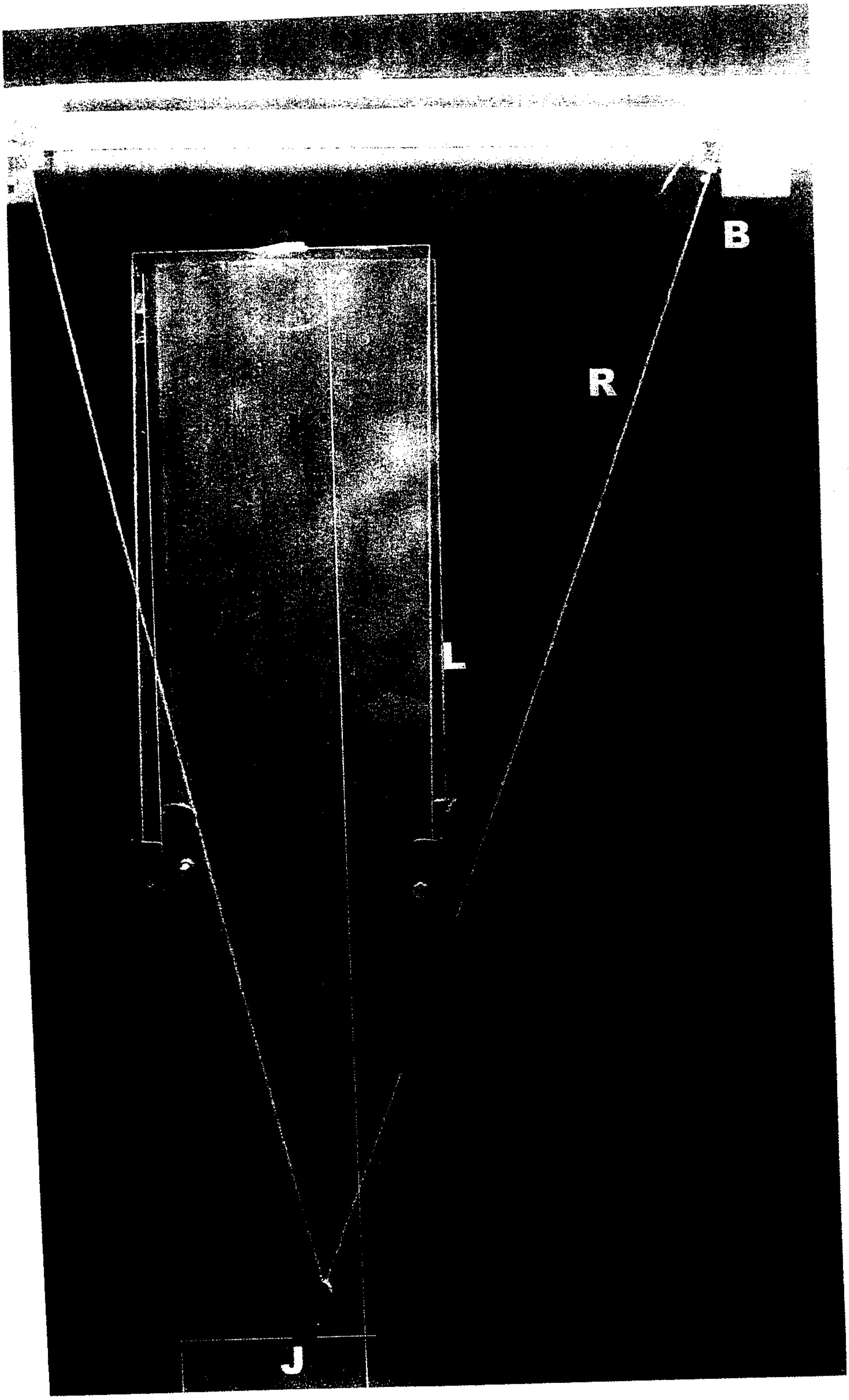


Figure 3.9 Yarn being tested in Twist Liveliness Meter

3.7.3.3 Working

Initially, the distance between the two clamps is 1000 mm i.e yarn sample length of 1 metre is used. When the motor rotates in forward direction, the threaded shaft rotates at a speed of 120 RPM as driven to driving gear wheel ratio is 2:1. Hence each of the clamps will move at 120 mm/minute towards the center. A dead weight of 0.2 gram is hung at the middle of the yarn 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 x Counter Reading) mm

Where, Counter reading = distance moved by either clamps

3.5.4 MACHINERY DETAILS-TWIST LIVELINESS TESTER

3.5.4.1 Specimen for testing

- Length of yarn tested = 100cm
- Maximum test duration = 240 seconds
- Speed of moveable part = 0.4 cm/sec
- Atmospheric conditions = 65±2 % r.h and 25±2°c

3.5.4.2 Electrical components

- Motor: 220v, AC, Synchronous Motor, Reversible, 60 RPM
- Gear (Driver) = 26 Teeth
- General switch, on-off button, indication lamp, DPST Switch.

After the test is over the motor is 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.

3.5.5 OPERATIONAL INSTRUCTIONS

During testing it should be ensured that standard testing atmosphere i.e. RH% = 65±2% and 25±2°c should be maintained. Care should be also taken so that no external air disturbance is there to prevent turbulence to the yarn sample.

Initially the yarn sample should be carefully withdrawn from the supply package without causing any stretch to the yarn. The end of the yarn is fixed to the right hand clamp of the instrument and then carefully drawn over the left hand clamp without releasing the spring. Now pretension weight is attached to the left hand end of the yarn and the left side clamp is closed. Now the dead weight of 0.2 gram is hung at the middle of the yarn and the yarn is cut from the left side clamp and power supply is switched on. Now forward rotation of the motor is selected by the selector switch. After the test is over, the yarn sample is removed from the clamps and reverse rotation of the motor is selected by the selector switch.

3.7 FABRIC PRODUCTION

The produced yarn is converted into fabric in a single jersey weft knitting machine. The machine details are as follows:

3.7.1 KNITTING MACHINE PARAMETERS

CIRCULAR KNITTING MACHINE

Make	: KNITMAC
Year	: 1999
Gauge	: 20
Cylinder dia	: 16″
Feeders	: 22
Speed	: 24rpm
Total needles	: 996
Needle type	: 102 52.GO3 102 52.GO3
Total sinker	: 996

3.8 FABRIC TESTING

3.8.1 METHOD TO MEASURE SPIRALITY (WET RELAXATION)

The fabrics were washed and tumble dried for 5 times following the procedure suggested by STARFISH project undertaken by the International Institute Of Cotton(IIC),Manchester, U.k. Heap et al(1983)and Knapton et al(1975) have provided guidelines for carrying out full relaxation.

The steps involved are:

a. Washing in domestic washing machine

b. Tumble dry until the fabric is dried
c. Wet-out in washing machine(rinse cycle)
d. Repeat steps(b) and (c) three times
e. Conditioning the sample

The desired fabric parameters were subsequently measured and recorded after conditioning the samples at 25°c, 65% r.h for several days. This procedure was followed for both regular and wet samples.

3.8.2 ANGLE OF SPIRALITY

For measuring spirality, the pillow case method as suggested by AATCC-179 2001 standard was used. In this from a specimen consisting of two layers of 380 x 380mm, pairs of 250 x 250mm were marked perpendicular to the length of the specimen. A line is drawn through each of the four sets of adjacent benchmarks so that a square is formed. The figure shows the details of the method used.

3.8.3TECHNIQUE FOR MEASURING FABRIC SPIRALITY

The specimen was tumble washed in a tumbler. The temperature for the washing cycle and rinsing temperature for the washing cycle was about 30°c. the washer was set for the selected washing cycle and time. Then the fabric was fully relaxed. Twelve tests were made in each sample.

All the samples were conditioned and tested under the standard atmospheric condition i.e., 25±2°c and relative humidity 65±2%. Number of wales and courses were counted at three random places with a pick glass of size 2.54cm x 2.54cm

3.10.Technique for measuring fabric spirality

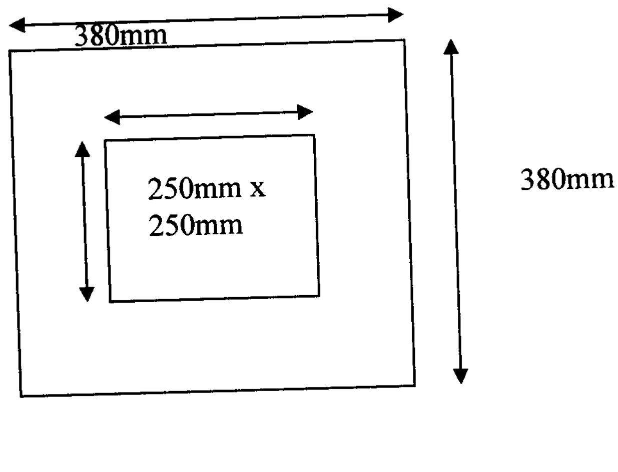
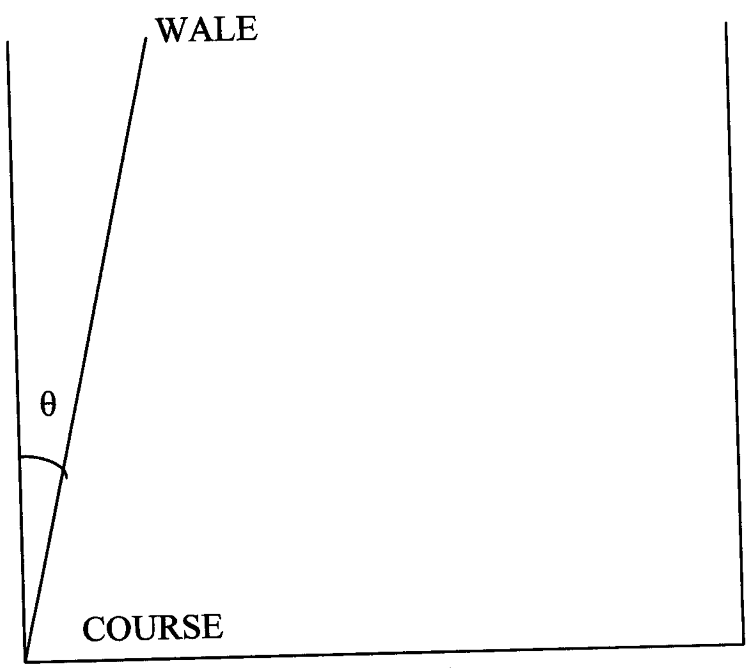


Figure 3.11 Fabric making



θ-Angle of spirality

4. RESULTS AND DISCUSSION

Using fibre wetting concept in R/F as discussed in chap 3 yarn samples were produced from 100%C , P/C (65/35) , P/V(60/40) and 100% poly roving in conventional R/F. All the yarns were physically tested to find out the influence of fibre wetting . Also yarn samples were converted into weft knit fabric and spirality was investigated in all the samples .This chapter discuss about various yarn and fabric parameters influenced by fibre wetting

4.1 COUNT

The count was tested and the following results are tabulated in Table 4.1 .The average count obtained was 38^s.

Table 4.1

COUNT

Material	**Regular**	**Wet**
P/V(60/40)	37.54	39.35
P/C(65/35)	37.33	38.69
POLYESTER (100%)	37.94	39.32
COTTON (100%)	38.62	37.45

The table shows a the count value for 100% polyester , p/c, p/v and cotton .The count is compared for both regular spun yarn and fibre produced in wet condition . The graph is been plotted in Fig4.1.

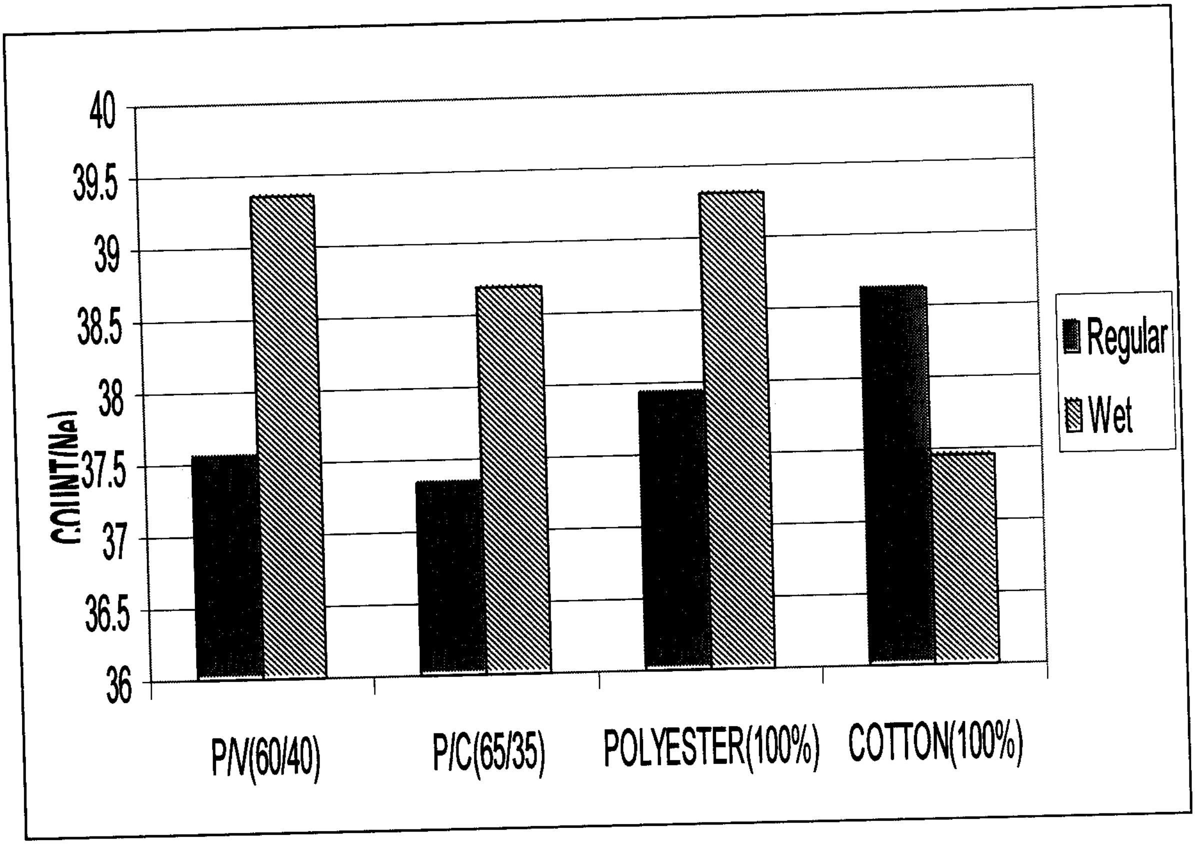


FIGURE 4.1 EFFECT OF FIBRE WETTING ON COUNT

4.2 CSP

The CSP values are nothing but the product of count and strength . The values are obtained for various blends P/V, P/C, 100%cotton ,100% polyester .These readings are tabulated in Table 4.2.

Table 4.2

CSP

Material	**Regular**	**Wet**
P/V (60/40)	4503	2866
P/C (65/35)	3573	3348
POLYESTER (100%)	4859	4734
COTTON (100%)	2299	2495

The Table 4.2 shows that the csp values have shown that wetting of cotton yarn has improved the value, but in other hand the P/V has shown 50% decrease in the when compared to regular spun yarn. P/C and polyester has shown only marginal difference. The trend is shown in Figure 4.2.

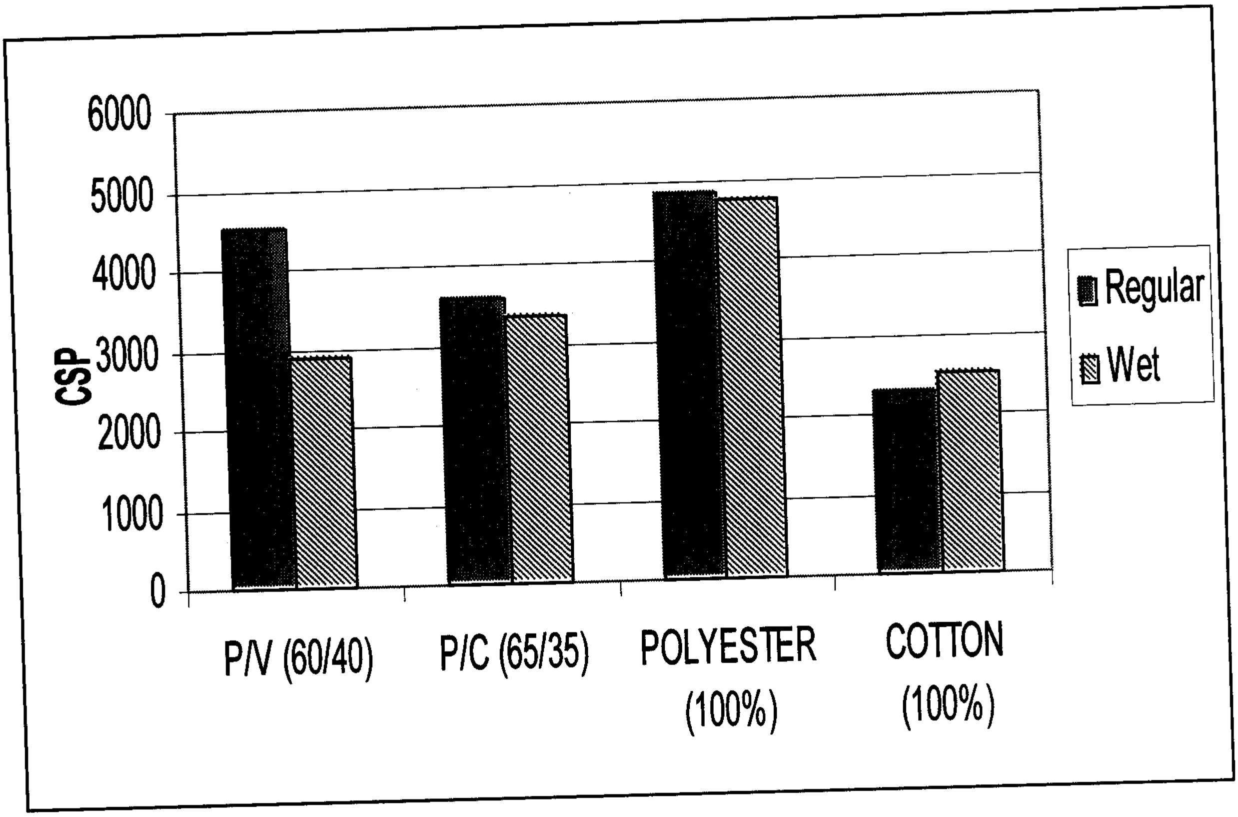


Figure 4.2 Effect of fibre wetting on CSP

4.3 SINGLE YARN STRENGTH (Tenacity kgf*Nm)

The yarn tenacity was tested using UsterTensorapid. The results are provided in Table 4.3.

Table 4.3

Single yarn strength (Tenacity kgf*Nm)

Material	**Regular**	**Wet**
P/V (60/40)	30.24	25.4
P/C (65/35)	23.73	22.89
POLYESTER (100%)	32.93	28
COTTON (100%)	15.01	18.33

The table shows a reduction in strength for 100% polyester,P/C and P/V yarns spun in wet condition compared to regular spun yarns. As far as cotton yarn is concerned fibre wetting has improved the strength by 20%.The important factor behind this increase is the fibre wetting has improved the twisting behaviour of the fibres to reach compact stage. The blends and 100%polyester did not show any improvement due to their poor water absorbing characterstics. The following results are discussed in Appendix 1. The trend is shown in Figure 4.3

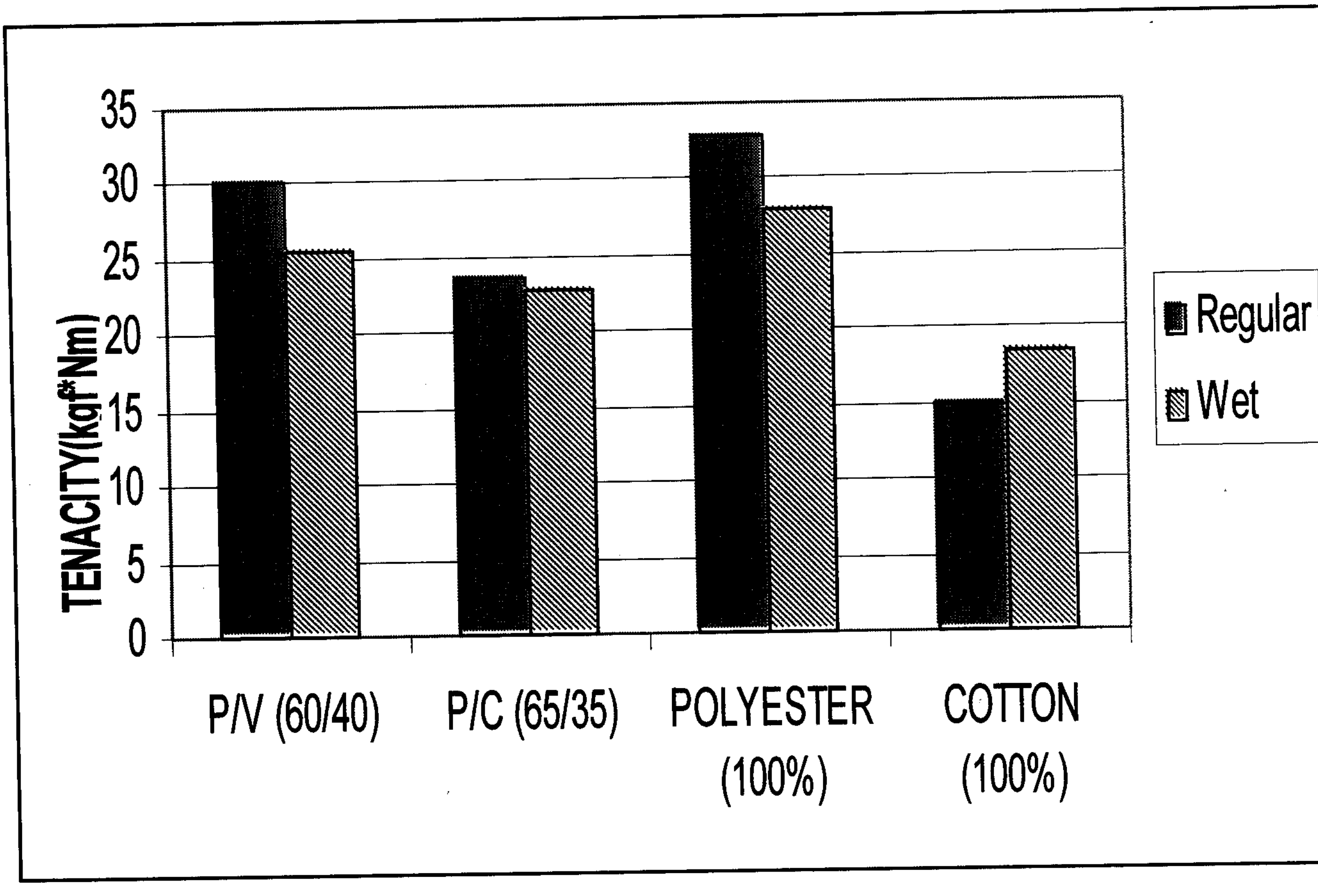


Figure 4.3 Effect of fibre wetting on single yarn strength

4.4 U%

The U% of 100% polyester, 100% cotton, P/C and P/V are obtained from Uster Tester 4. The values are tabulated in Table 4.4.

Table 4.4

U%

Material	**Regular**	**Wet**
P/V(60/40)	11.01	13.32
P/C(65/35)	11.79	12.48
POLYESTER (100%)	11.74	11.48
COTTON (100%)	13	14.62

The table shows increase in U% for all the yarns spun in wet condition compared to regular spun yarn. The important factor behind this increase is during spinning the increase in moisture causes roller lapping. This in turn results in increase in the U%. The following results are discussed in Appendix 1.The trend is shown in figure 4.4

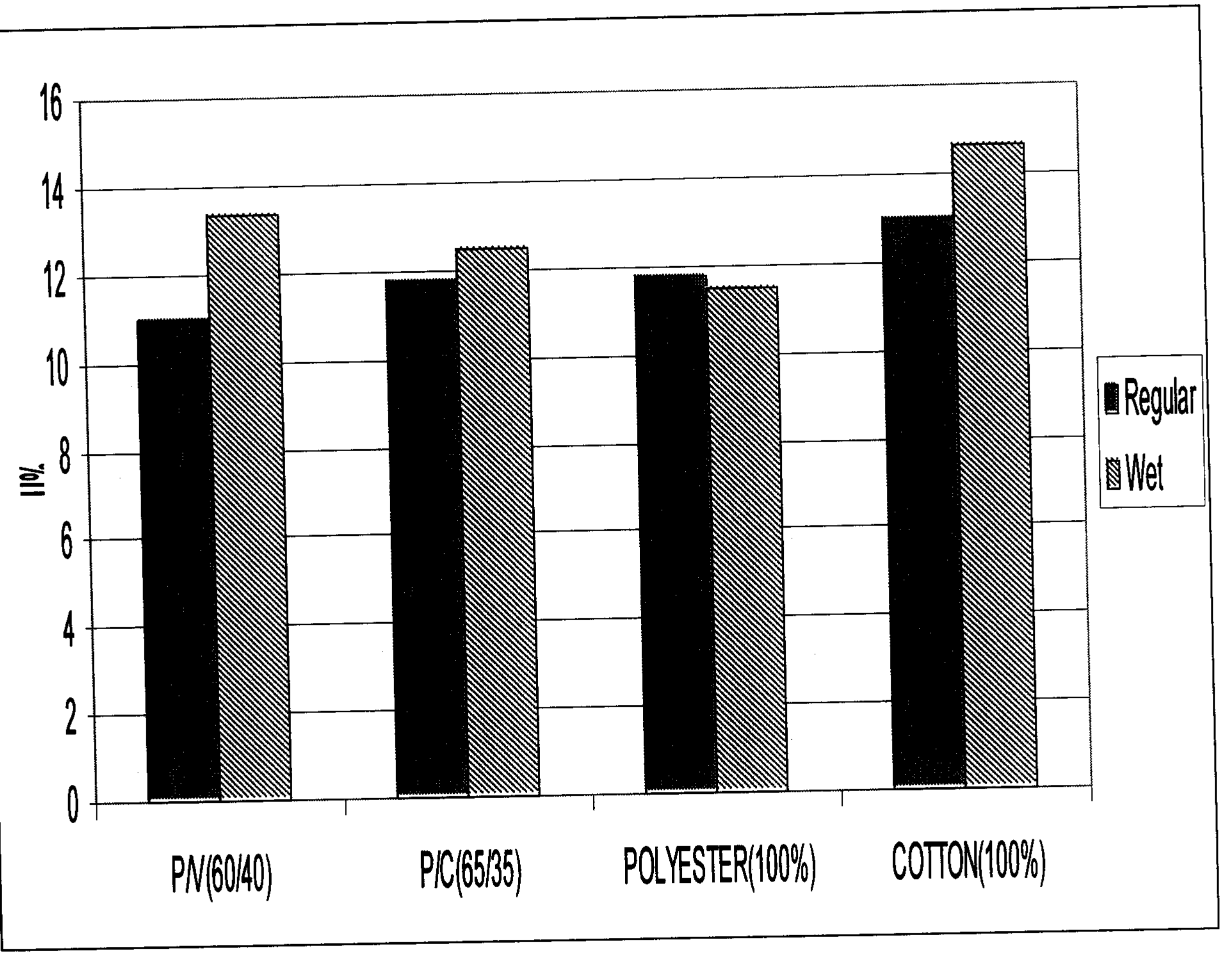


Figure 4.4
Effect of fibre wetting in ring frame on U%

4.5 YARN HAIRINESS(S3)

The yarn hairiness was tested using Zweigle . The results are provided in table 4.5

Table 4.5

Yarn hairiness

Material	**Regular**	**Wet**
P/V(60/40)	974.50	753.50
P/C(65/35)	1109.50	1061.50
POLYESTER (100%)	327	566
COTTON (100%)	433	225

The table reduction in hairiness for blends namely P/C & P/V. In case of 100% polyester hairiness has increased. As far as cotton is concerned hairiness has reduced to about 50%. The important factor behind this decrease is due to excellent water absorbing characteristic of cotton. 100%polyester did not show any improvement due to their poor water absorbing characteristics. The following results are discussed in Appendix 1.

The trend is shown in Figure 4.5

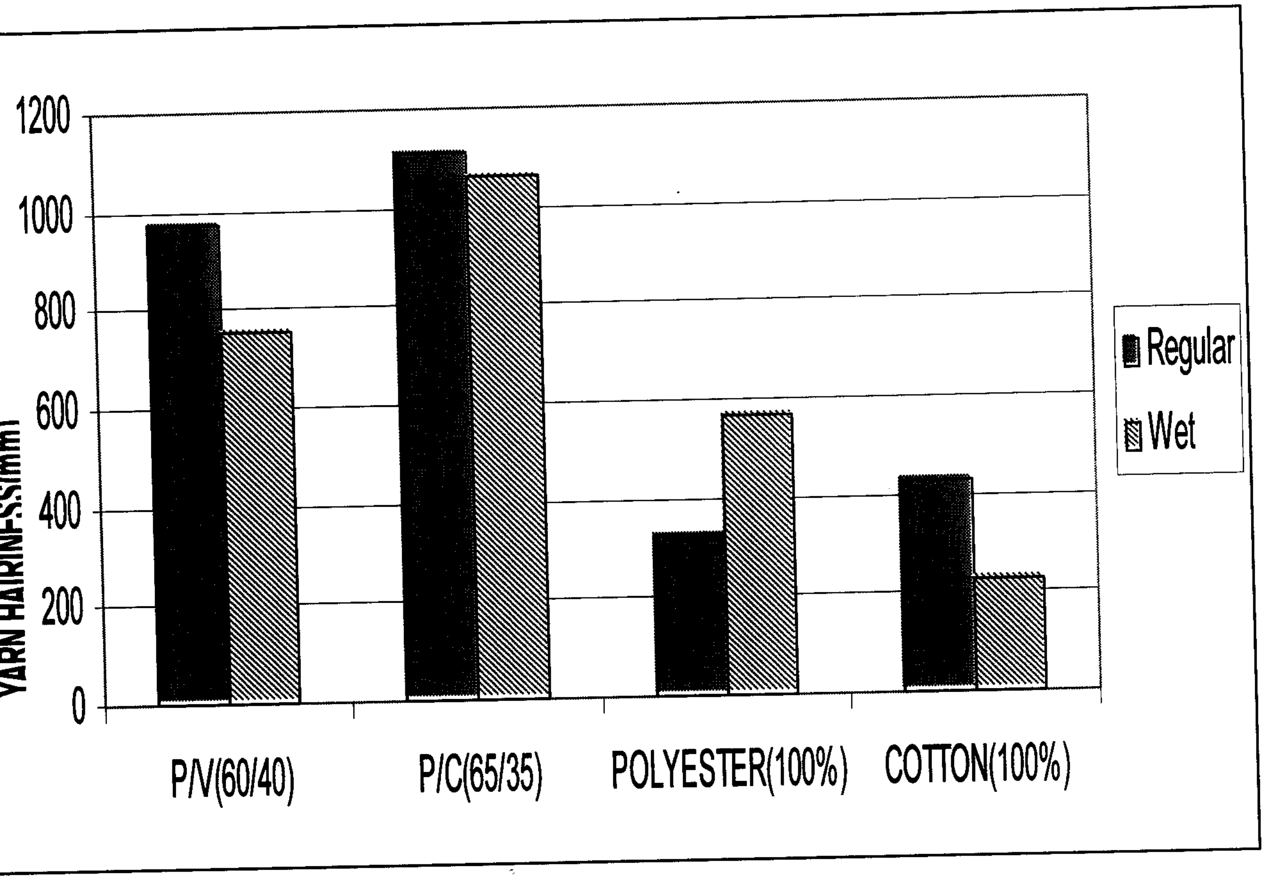


Figure 4.5

Effect of fibre wetting on yarn hairiness(s3)

4.6 PACKING DENSITY(G/CM^3)

The packing density was tested using Uster Tester 4. The results UT4 are provided in table 4.6

Table 4.6

Packing density

Material	Regular	Wet
P/V(60/40)	0.52	0.51
P/C(65/35)	0.52	0.52
POLYESTER (100%)	0.57	0.58
COTTON (100%)	0.42	0.54

The table shows a marginal increase in packing density value in case of 100% polyester and for P/C & P/V it is almost equal for yarn spun in wet condition .As far as cotton is concerned packing density has increased. The blends and 100%polyester did not show any improvement due to their poor water absorbing characteristics. The following results are discussed in Appendix 1.The trend is shown in Figure 4.6

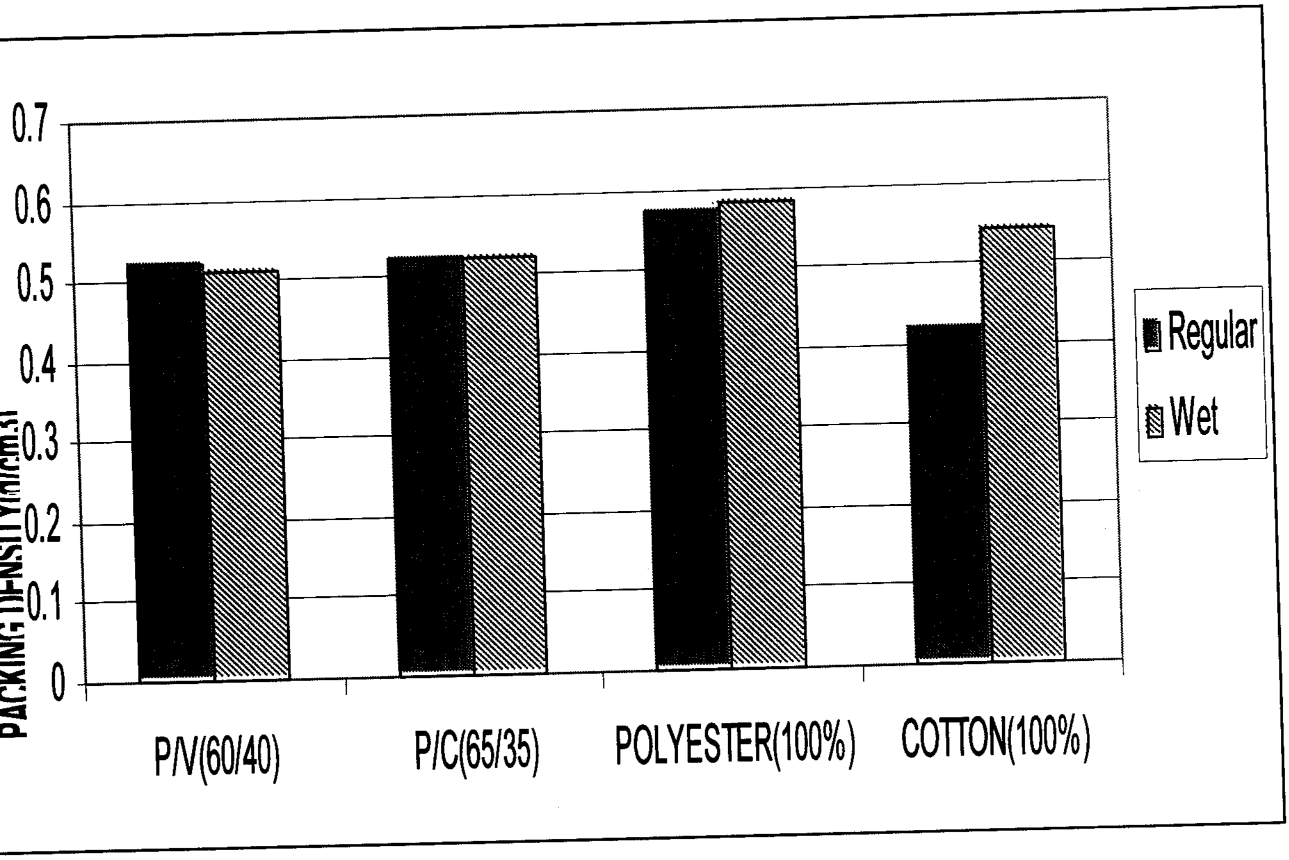


Figure 4.6

Effect of fibre wetting on packing density(g/cm^3)

4.7 YARN DIAMETER(mm)

The yarn diameter was tested using Uster Tester 4.The results of UT4 are provided in table 4.7.

Table 4.7

Yarn diameter

Material	**Regular**	**Wet**
P/V(60/40)	0.195	0.196
P/C(65/35)	0.196	0.194
POLYESTER (100%)	0.186	0.185
COTTON (100%)	0.217	0.192

The table shows a marginal decrease in yarn diameter for 100% polyester and P/C, marginal increase for P/V.As far as cotton is concerned yarn dia has relevantly decreased . The important factor behind this is that the fibre wetting has improved the twisting behaviour of the fibres to reach compact stage. The blends and 100%polyester did not show any improvement due to their poor water absorbing characteristics. The following results are discussed in Appendix 1.The trend is shown in Figure 4.7.

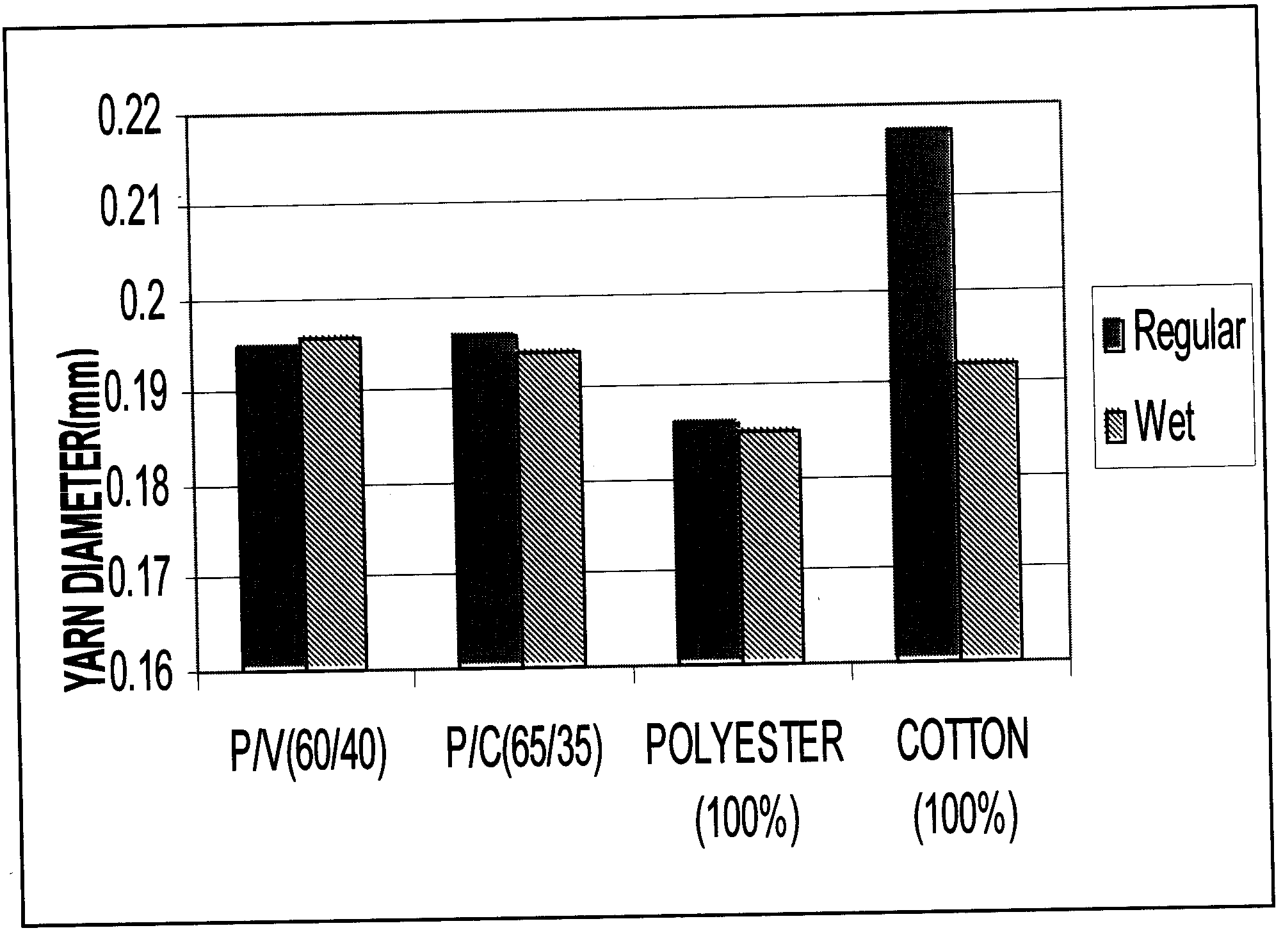


Figure 4.7 Effect of fibre wetting on yarn diameter(mm)

4.8 YARN APPEARANCE

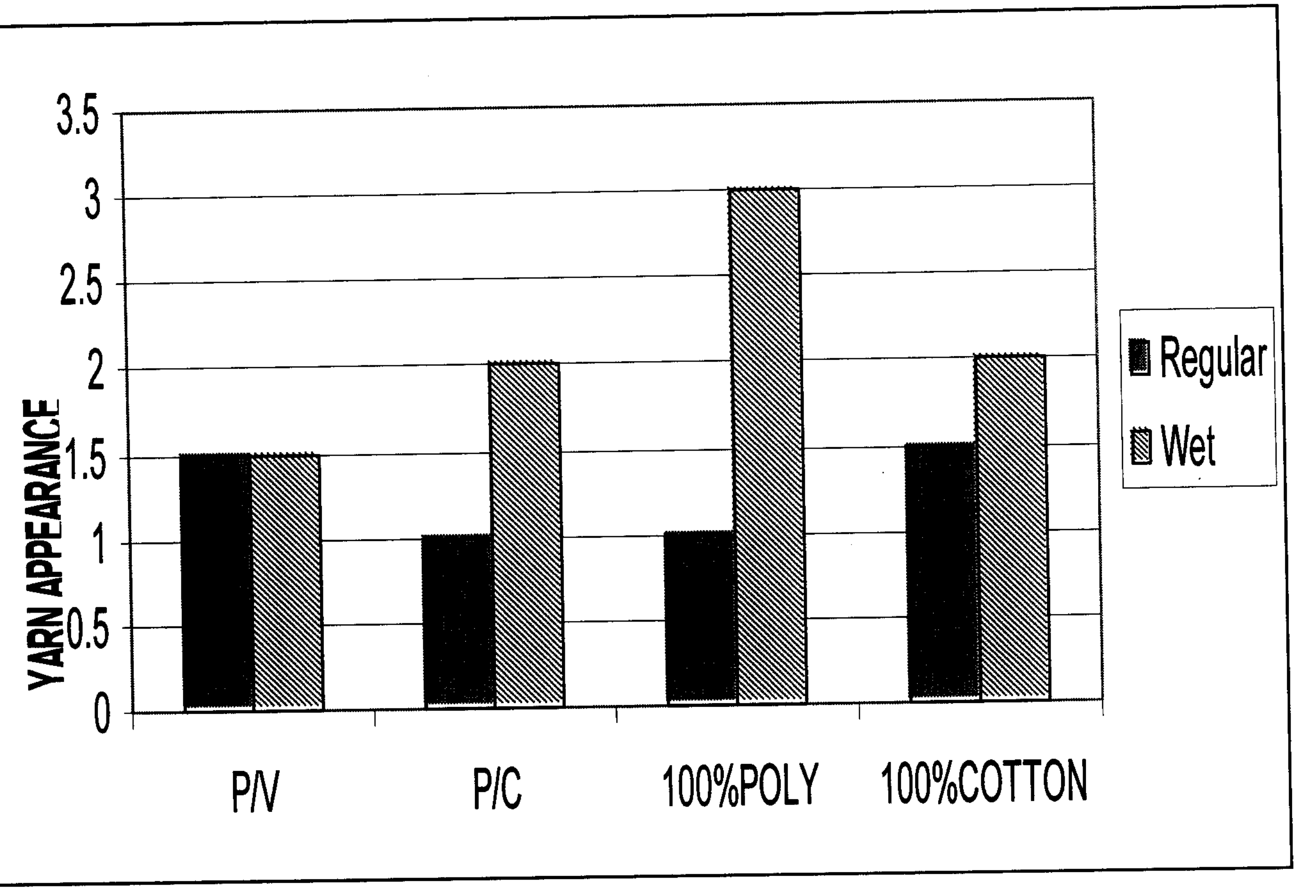
The appearance was compared and listed in table 4.8.The following grades was assigned to the spun yarns .

Table 4.8

Yarn appearance

Material	**Regular**	**Wet**
P/V	A+	A+
P/C	A	B
100%POLY	A	C
100%COTTON	A+	B

The table shows that the appearance of yarn spun in wet condition has detoriated compared to regular spun yarn. The main cause for this is that thick , thin places and neps has increased due to the use of frictionizer in spinning. The following results are discussed in Appendix 1. The trend is shown in figure 4.8.



1=A 1.5=A+

2=B 2.5=B+

3=C

Figure 4.8

Effect of fibre wetting on yarn appearance

4.9 TWIST LIVELINESS (cm)

The twist liveliness value of each yarn samples was tested using in-house developed twist liveliness meter. The results of twist liveliness are provided in Table 4.9

Table4.9

Twist liveliness

Material	**Regular**	**Wet**
P/V(60/40)	14.16	14.12
P/C(65/35)	15.1	15
POLYESTER (100%)	20.54	23.38
COTTON (100%)	19.16	7.8

The table shows only a marginal reduction in twist liveliness value for P/C [60/40], P/V [65/35] yarns spun in wet condition compared to regular spun yarn. As far as cotton is concerned fibre wetting has prominently reduced the twist liveliness value by . The important factor behind this reduction is the fibre wetting helps in easy propagation of twist during the spinning. The blends showed very less reduction and 100% polyester showed increasing values due to their poor water absorbing characteristics. This trend is shown in figure 4.9.The following results are discussed in Appendix 1

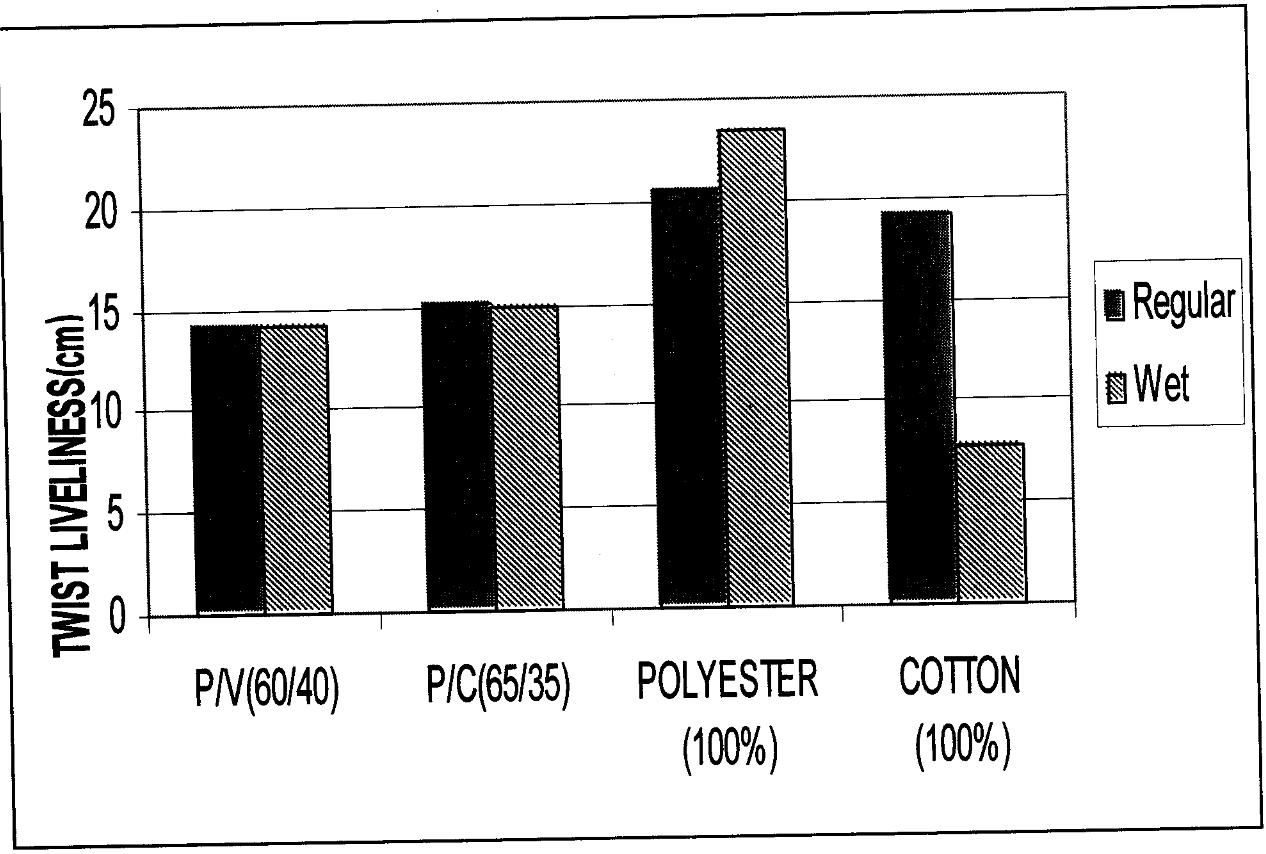


Figure4.9 Effect of fibre wetting on twist liveliness (cm)

4.10 SPIRALITY

The spirality was tested by pillow case method as suggested by AATCC 179/2001.The results are provided in Table 4.10.

Table4.10

Spirality

Material	Regular	Wet
P/V(60/40)	3.2	8.2
P/C(65/35)	9.4	15.4
POLYESTER (100%)	5	5.8
COTTON (100%)	12.5	6.3

The table 4.10 shows that the synthetic yarn does not reduce the spirality value even after using frictionizer during spinning.On the other hand the value of cotton has shown 50%decrease in spirality.The main cause behind this is that the twist liveliness influences spirality.

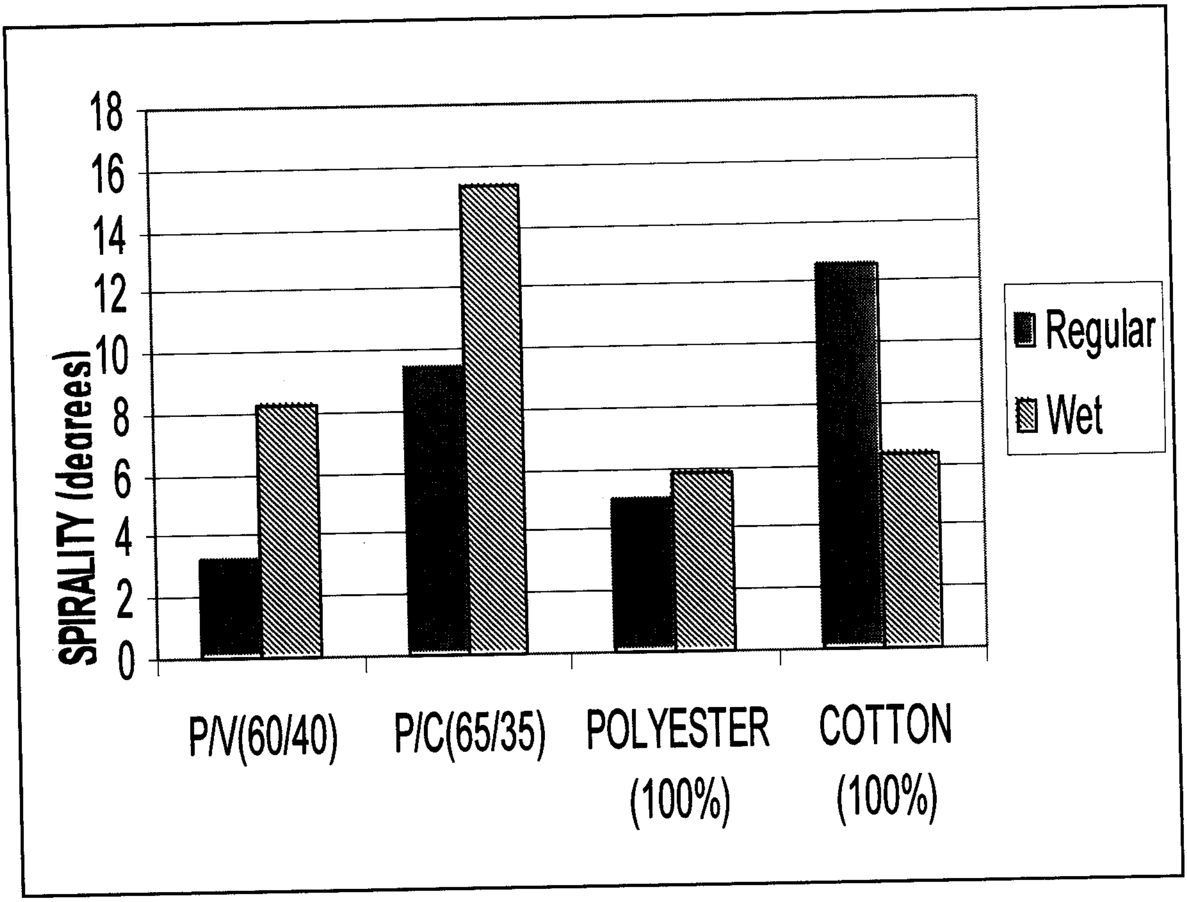


Figure 4.10Effect of fibre wetting on spirality (degrees)

5.CONCLUSION

Our attempt of using frictionizer during spinning process has concluded the following.

The effect of fibre wetting on various yarn parameters has been tested and it is found that strength has shown an increase incase of wetting the fibres in the cotton yarn than the regular spun yarn. On the other hand it showed a decreasing value in synthetic yarn.

The packing density has increased in 100% cotton yarn produced by fibre wetting than the regular yarn. It is almost equal in the synthetic yarns. Yarn diameter is inversely proportional to packing density.

Hairiness is an important yarn property which showed good result after adding frictionizer. Cotton yarn produced by fibre wetting has shown 50% reduction in yarn hairiness. Incase of P/C and P/V it is reduced upto 10-20% but in polyester yarn hairiness has increased due to fibre wetting.

Cotton has shown a tremendous reduction in the value of twist liveliness. There is only marginal decrease in the blends namely p/c and p/v. In 100% polyester the twist liveliness has increased.

Spirality is an important fabric parameter affected due to fibre wetting it has shown almost 50% reduction in 100% cotton yarn produced by fibre wetting. On the other hand the spirality value has increased in p/c, p/v and 100% polyester.

Thus we conclude that fibre wetting in ring spinning has improved the physical properties of cotton yarn. Whereas it does not have much influence on the physical properties of yarn produced from blends namely p/c, p/v and for 100% polyester.

APPENDIX

TER TESTER 4 - SX   R 1.8   Tue 01.03.05 15:08   Operator   DEEPA   Page 1
shmi Machine Works Limited   PILOT MILL, Perianaickenpalayam   Coimbatore 20   INDIA

le   KUMARAGURU   Sample ID   00435   Nom. count   Nec 38   Nom. twist   0 T/inch
sts   2 / 1   v= 100 m/min   t= 1 min   Meas. slot   4   Long staple

NG FRAME PROJECTS

icle   Material class   Yarn   Mach. Nr.
ter Statistics
er   Polyester 1.2den 40mm 65%   Cotton 1.2den 30mm 35%
MARAGURU,38sP,DRY
P/c

Nr	U%	CVm	CVm 1m	CVm 10m	Index	Thin -50%	Thick +50%	Neps +200%	Thin -30%	Thin -40%	Thick +35%	Neps +140%
	%	%	%	%		/km	/km	/km	/km	/km	/km	/km
1	11.93	14.97	4.70		1.62	10.0	50.0	90.0	2250	250.0	280.0	450.0
2	11.64	14.80	4.57		1.60	0.0	20.0	100.0	1980	250.0	220.0	480.0
Mean	11.79	14.89	4.64		1.61	5.0	35.0	95.0	2115	250.0	250.0	465.0
CV												
Q95												
Max	11.93	14.97	4.70		1.62	10.0	50.0	100.0	2250	250.0	280.0	480.0
Min	11.64	14.80	4.57		1.60	0.0	20.0	90.0	1980	250.0	220.0	450.0

Nr	Rel. Cnt ±	H	sh	DR 1.5m 5%	2DØ	CV2D 8mm	Shape	D	Trash count	Trash size	Dust count	Dust size	CvFS
	%			%	mm	%		g/cm3	/km	um	/km	um	%
1	-2.8	5.64	1.55	26.9	0.194	11.74	0.80	0.53	0.0		0.0		10.43
2	2.8	5.69	1.58	34.3	0.198	12.21	0.83	0.50	0.0		0.0		10.49
Mean	0.0	5.67	1.57	30.6	0.196	11.98	0.81	0.52	0.0		0.0		
CV													
Q95													
Max	2.8	5.69	1.58	34.3	0.198	12.21	0.83	0.53	0.0		0.0		
Min	-2.8	5.64	1.55	26.9	0.194	11.74	0.80	0.50	0.0		0.0		

USTER TESTER 4 - SX R 1.8 Tue 01.03.05 15:12 Operator DEEPA
Lakshmi Machine Works Limited PILOT MILL, Perianaickenpalayam Coimbatore 20 INDIA

Style KUMARAGURU Sample ID 00436 Nom. count Nec 38 Nom. twist 0 T/inch
Tests 2 / 1 v= 100 m/min t= 1 min Meas. slot 4 Long staple

RING FRAME PROJECTS

Article Material class Yarn Mach. Nr.
Uster Statistics
Fiber Polyester 1.2den 40mm 65% Cotton 1.2den 30mm 35%
KUMARAGURU,38sP/C,WET

Nr	U% %	CVm %	CVm 1m %	CVm 10m %	Index	Thin -50% /km	Thick +50% /km	Neps +200% /km	Thin -30% /km	Thin -40% /km	Thick +35% /km	Neps +140% /km
1	12.77	16.76	3.47		1.81	50.0	300.0	680.0	2770	560.0	810.0	1980
2	12.20	15.61	5.49		1.69	60.0	120.0	240.0	2390	370.0	320.0	980
Mean	12.48	16.19	4.48		1.75	55.0	210.0	460.0	2580	465.0	565.0	1480
CV												
Q95												
Max	12.77	16.76	5.49		1.81	60.0	300.0	680.0	2770	560.0	810.0	1980
Min	12.20	15.61	3.47		1.69	50.0	120.0	240.0	2390	370.0	320.0	980

Nr	Rel. Cnt ± %	H	sh	DR 1.5m 5% %	2DØ mm	CV2D 8mm %	Shape	D g/cm3	Trash count /km	Trash size um	Dust count /km	Dust size um	CVFS %
1	0.8	5.40	1.74	18.5	0.193	16.46	0.83	0.53	0.0		10.0	393.8	13.79
2	-0.8	6.01	1.80	38.6	0.196	14.31	0.83	0.52	0.0		0.0		12.59
Mean	0.0	5.71	1.77	28.5	0.194	15.38	0.83	0.52	0.0		5.0	393.8	
CV													
Q95													
Max	0.8	6.01	1.80	38.6	0.196	16.46	0.83	0.53	0.0		10.0	393.8	
Min	-0.8	5.40	1.74	18.5	0.193	14.31	0.83	0.52	0.0		0.0	393.8	

tyle KUMARAGURU Sample ID 00431 Nom. count Nec 38 Nom. twist 0 T/inch
ests 2 / 1 v= 100 m/min t= 1 min Meas. slot 4 Long staple

ING FRAME PROJECTS

rticle Material class Yarn Mach. Nr.
ster Statistics
ber Polyester 1den 44mm 60% Viscose 1den 44mm 40%
UMARAGURU,38sPV , DRY

Nr	U% %	CVm %	CVm 1m %	CVm 10m %	Index	Thin -50% /km	Thick +50% /km	Neps +200% /km	Thin -30% /km	Thin -40% /km	Thick +35% /km	Neps +140% /km
1	11.42	14.54	5.29		1.72	10.0	60.0	150.0	1330	130.0	430.0	380.0
2	10.60	13.44	5.30		1.59	10.0	20.0	70.0	920	140.0	150.0	220.0
Mean	11.01	13.99	5.30		1.65	10.0	40.0	110.0	1125	135.0	290.0	300.0
CV												
Q95												
Max	11.42	14.54	5.30		1.72	10.0	60.0	150.0	1330	140.0	430.0	380.0
Min	10.60	13.44	5.29		1.59	10.0	20.0	70.0	920	130.0	150.0	220.0

Nr	Rel. Cnt ± %	H	sh	DR 1.5m 5% %	2DØ mm	CV2D 8mm %	Shape	D g/cm3	Trash count /km	Trash size um	Dust count /km	Dust size um
1	-1.2	6.29	1.64	32.3	0.194	11.97	0.84	0.52	0.0		0.0	
2	1.2	6.33	1.55	31.3	0.196	10.84	0.84	0.51	0.0		0.0	
Mean	0.0	6.31	1.60	31.8	0.195	11.41	0.84	0.52	0.0		0.0	
CV												
Q95												
Max	1.2	6.33	1.64	32.3	0.196	11.97	0.84	0.52	0.0		0.0	
Min	-1.2	6.29	1.55	31.3	0.194	10.84	0.84	0.51	0.0		0.0	

CVF
%
10.5
10.1

R TESTER 4 - SX R 1.8 Tue 01.03.05 14:07 Operator DEEPA

mi Machine Works Limited PILOT MILL, Perianaickenpalayam Coimbatore 20 INDIA

KUMARAGURU Sample ID 00432 Nom. count Nec 38 Nom. twist 0 T/inch

2 / 1 v= 100 m/min t= 1 min Meas. slot 4 Long staple

G FRAME PROJECTS

Material class Yarn Mach. Nr.

e

Statistics

Polyester 1den 44mm 60% Viscose 1den 44mm 40%

IARAGURU,38sPV , WET

Nr	U%	CVm	CVm 1m	CVm 10m	Index	Thin -50%	Thick +50%	Neps +200%	Thin -30%	Thin -40%	Thick +35%	Neps +140%
	%	%	%	%		/km	/km	/km	/km	/km	/km	/km
1	13.39	17.38	6.23		2.06	160.0	230.0	170.0	2510	670.0	640.0	650.0
2	13.25	18.26	6.06		2.16	420.0	470.0	170.0	2430	890.0	750.0	510.0
Mean	13.32	17.82	6.15		2.11	290.0	350.0	170.0	2470	780.0	695.0	580.0
CV												
Q95												
Max	13.39	18.26	6.23		2.16	420.0	470.0	170.0	2510	890.0	750.0	650.0
Min	13.25	17.38	6.06		2.06	160.0	230.0	170.0	2430	670.0	640.0	510.0

Nr	Rel. Cnt ±	H	sh	DR 1.5m 5%	2DØ	CV2D 8mm	Shape	D	Trash count	Trash size	Dust count	Dust size
	%			%	mm	%		g/cm3	/km	um	/km	um
1	-1.0	6.31	1.73	26.9	0.200	15.17	0.84	0.50	0.0		0.0	
2	1.0	5.43	1.54	40.4	0.193	15.06	0.85	0.53	0.0		0.0	
Mean	0.0	5.87	1.63	33.6	0.196	15.12	0.84	0.51	0.0		0.0	
CV												
Q95												
Max	1.0	6.31	1.73	40.4	0.200	15.17	0.85	0.53	0.0		0.0	
Min	-1.0	5.43	1.54	26.9	0.193	15.06	0.84	0.50	0.0		0.0	

USTER TESTER 4 - SX R 1.8 Tue 01.03.05 14:12 Operator DEEPA
Lakshmi Machine Works Limited PILOT MILL, Perianaickenpalayam Coimbatore 20 INDIA

Style KUMARAGURU Sample ID 00433 Nom. count Nec 38 Nom. twist 0 T/inch
Tests 2 / 1 v= 100 m/min t= 1 min Meas. slot 4 Long staple

RING FRAME PROJECTS

Article Material class Yarn Mach. Nr.
Uster Statistics
Fiber Polyester 1den 44mm 100%
KUMARAGURU,38sP,DRY

Nr	U%	CVm	CVm 1m	CVm 10m	Index	Thin -50%	Thick +50%	Neps +200%	Thin -30%	Thin -40%	Thick +35%	Neps +140%
	%	%	%	%		/km	/km	/km	/km	/km	/km	/km
1	11.88	15.02	5.55		1.78	40.0	60.0	70.0	1610	250.0	380.0	170.0
2	11.60	14.61	4.76		1.73	0.0	20.0	20.0	1540	250.0	300.0	100.0
Mean	11.74	14.82	5.16		1.75	20.0	40.0	45.0	1575	250.0	340.0	135.0
CV												
Q95												
Max	11.88	15.02	5.55		1.78	40.0	60.0	70.0	1610	250.0	380.0	170.0
Min	11.60	14.61	4.76		1.73	0.0	20.0	20.0	1540	250.0	300.0	100.0

Nr	Rel. Cnt ±	H	sh	DR 1.5m 5%	2DØ	CV2D 8mm	Shape	D	Trash count	Trash size	Dust count	Dust size
	%			%	mm	%		g/cm3	/km	um	/km	um
1	-1.2	5.20	1.33	32.4	0.186	12.39	0.85	0.57	0.0		0.0	
2	1.2	4.72	1.16	21.3	0.186	11.11	0.85	0.57	0.0		0.0	
Mean	0.0	4.96	1.24	26.8	0.186	11.75	0.85	0.57	0.0		0.0	
CV												
Q95												
Max	1.2	5.20	1.33	32.4	0.186	12.39	0.85	0.57	0.0		0.0	
Min	-1.2	4.72	1.16	21.3	0.186	11.11	0.85	0.57	0.0		0.0	

CVFS
90
9.77
8.77

USTER TESTER 4 - SX R 1.8 Tue 01.03.05 14:18 Operator DEEPA
Lakshmi Machine Works Limited PILOT MILL, Perianaickenpalayam Coimbatore 20 INDIA

Style KUMARAGURU Sample ID 00434 Nom. count Nec 38 Nom. twist 0 T/inch
Tests 2 / 1 v= 100 m/min t= 1 min Meas. slot 4 Long staple

RING FRAME PROJECTS

Article Material class Yarn Mach. Nr.
Uster Statistics
Fiber Polyester 1den 44mm 100%
KUMARAGURU,38sP,WET

Nr	U% (%)	CVm (%)	CVm 1m (%)	CVm 10m (%)	Index	Thin -50% /km	Thick +50% /km	Neps +200% /km	Thin -30% /km	Thin -40% /km	Thick +35% /km	Neps +140% /km
1	11.36	14.39	5.15		1.70	0.0	80.0	130.0	1570	230.0	240.0	410.0
2	11.61	15.11	3.97		1.79	40.0	130.0	190.0	1890	350.0	420.0	600.0
Mean	11.48	14.75	4.56		1.74	20.0	105.0	160.0	1730	290.0	330.0	505.0
CV												
Q95												
Max	11.61	15.11	5.15		1.79	40.0	130.0	190.0	1890	350.0	420.0	600.0
Min	11.36	14.39	3.97		1.70	0.0	80.0	130.0	1570	230.0	240.0	410.0

Nr	Rel. Cnt ± %	H	sh	DR 1.5m 5% %	2DØ mm	CV2D 8mm %	Shape	D g/cm3	Trash count /km	Trash size um	Dust count /km	Dust size um
1	3.3	5.62	1.57	26.3	0.188	15.50	0.85	0.56	0.0		0.0	
2	-3.3	5.78	1.81	11.7	0.182	15.89	0.85	0.60	0.0		0.0	
Mean	0.0	5.70	1.69	19.0	0.185	15.70	0.85	0.58	0.0		0.0	
CV												
Q95												
Max	3.3	5.78	1.81	26.3	0.188	15.89	0.85	0.60	0.0		0.0	
Min	-3.3	5.62	1.57	11.7	0.182	15.50	0.85	0.56	0.0		0.0	

CV FS %
13.03
13.60

USTER TESTER 4 - SX R 1.8 Thu 17.03.05 14:20 Operator DEEPA Page 1
Lakshmi Machine Works Limited PILOT MILL, Perianaickenpalayam Coimbatore 20 INDIA

Style COTTON Sample ID 00796 Nom. count Nec 38 Nom. twist 21.6 T/inch
Tests 2 / 1 v= 400 m/min t= 1 min Meas. slot 4 Short staple

RING FRAME ROCOS

Article KUMARAGURU Material class Yarn Mach. Nr.
Uster Statistics
Fiber Cotton 3.8Micr 29mm 100%
KUMARAGURU,100% COTTON, DRY SAMPLE

Nr	U%	CVm	CVm 1m	Index	Thin -50%	Thick +50%	Neps +200%	Thin -30%	Thin -40%	Thick +35%	Neps +140%	Rel. Cnt ±
	%	%	%		/km	/km	/km	/km	/km	/km	/km	%
1	13.05	16.77	5.11	1.71	25.0	390.0	627.5	3405	527.5	1568	2453	-0.2
2	12.94	16.58	4.76	1.69	55.0	387.5	730.0	3368	495.0	1545	2688	0.2
Mean	13.00	16.68	4.94	1.70	40.0	388.8	678.8	3386	511.3	1556	2570	0.0
CV												
Q95												
Max	13.05	16.77	5.11	1.71	55.0	390.0	730.0	3405	527.5	1568	2688	0.2
Min	12.94	16.58	4.76	1.69	25.0	387.5	627.5	3368	495.0	1545	2453	-0.2

Nr	H	sh	DR 1.5m 5%	2DØ	CV2D 8mm	CV FS	Shape	D	Trash count	Trash size	Dust count	Dust size
			%	mm	%	%		g/cm3	/km	um	/km	um
1	5.18	1.39	30.9	0.216	14.22	12.48	0.81	0.42	12.5	541.4	690.0	231.3
2	5.29	1.37	24.3	0.217	13.83	12.94	0.80	0.42	12.5	549.1	795.0	229.1
Mean	5.24	1.38	27.6	0.217	14.02	12.71	0.80	0.42	12.5	545.3	742.5	230.2
CV												
Q95												
Max	5.29	1.39	30.9	0.217	14.22	12.94	0.81	0.42	12.5	549.1	795.0	231.3
Min	5.18	1.37	24.3	0.216	13.83	12.48	0.80	0.42	12.5	541.4	690.0	229.1

STER TESTER 4 - SX R 1.8 Thu 17.03.05 14:25 Operator DEEPA Page 1
kshmi Machine Works Limited PILOT MILL, Perianaickenpalayam Coimbatore 20 INDIA

yle COTTON Sample ID , 00798 Nom. count Nec 38 Nom. twist 21.6 T/inch
sts 2 / 1 v= 400 m/min t= 1 min Meas. slot 4 Short staple

ING FRAME ROCOS

ticle KUMARAGURU Material class Yarn Mach. Nr.
ter Statistics
per Cotton 3.8Micr 29mm 100%
JMARAGURU,100% COTTON, WET SAMPLE

Nr	U%	CVm	CVm 1m	Index	Thin -50%	Thick +50%	Neps +200%	Thin -30%	Thin -40%	Thick +35%	Neps +140%	Rel. Cnt ±
	%	%	%		/km	/km	/km	/km	/km	/km	/km	%
1	14.61	18.85	4.99	1.92	190.0	860.0	1325	5445	1430	2448	4170	-0.1
2	14.63	19.03	5.77	1.94	140.0	875.0	1390	5203	1245	2538	4250	0.1
Mean	14.62	18.94	5.38	1.93	165.0	867.5	1358	5324	1338	2493	4210	0.0
CV												
Q95												
Max	14.63	19.03	5.77	1.94	190.0	875.0	1390	5445	1430	2538	4250	0.1
Min	14.61	18.85	4.99	1.92	140.0	860.0	1325	5203	1245	2448	4170	-0.1

Nr	H	sh	DR 1.5m 5%	2DØ	CV2D 8mm	CV FS	Shape	D	Trash count	Trash size	Dust count	Dust size
			%	mm	%	%		g/cm3	/km	um	/km	um
1	2.94	1.05	28.7	0.190	14.76	12.56	0.83	0.55	12.5	541.8	912.5	229.5
2	3.77	1.49	33.6	0.193	15.06	13.21	0.84	0.53	17.5	568.6	825.0	225.4
Mean	3.35	1.27	31.2	0.192	14.91	12.88	0.84	0.54	15.0	555.2	868.8	227.5
CV												
Q95												
Max	3.77	1.49	33.6	0.193	15.06	13.21	0.84	0.55	17.5	568.6	912.5	229.5
Min	2.94	1.05	28.7	0.190	14.76	12.56	0.83	0.53	12.5	541.8	825.0	225.4

LAKSHMI MACHINE WORKS LTD

PILOT MILL — Coimbatore - 641 020

Perianaickenpalayam — India

G 566

STATISTICS

3/1/2005 PAGE 1 (1)

DESIGN. : Kumaraguru

DATE	3/1/2005	MACHINE CODE	G566 NR240	38sPC DRY
TIME	02:26:03 PM	MATERIAL CODE	TEST	
MATERIAL	P/C	BOBBINS	2	
FINENESS	38	TESTS	1	
PRETENSION	1 cN	LENGTH	50 m	

BOBBIN	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
1 MEAN	11808.00	246.00	501.00	477.00	87.00	11.00	2.00	0.00	0.00	0.00	0.00	0.00	1078.00	54.00
1 S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 CV%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 MAX	11808.00	246.00	501.00	477.00	87.00	11.00	2.00	0.00	0.00	0.00	0.00	0.00	1078.00	54.00
1 MIN	11808.00	246.00	501.00	477.00	87.00	11.00	2.00	0.00	0.00	0.00	0.00	0.00	1078.00	54.00
2 MEAN	11401.00	186.00	435.00	568.00	113.00	22.00	3.00	0.00	0.00	0.00	0.00	0.00	1141.00	103.00
2 S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 CV%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 MAX	11401.00	186.00	435.00	568.00	113.00	22.00	3.00	0.00	0.00	0.00	0.00	0.00	1141.00	103.00
2 MIN	11401.00	186.00	435.00	568.00	113.00	22.00	3.00	0.00	0.00	0.00	0.00	0.00	1141.00	103.00

OVERALL

	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
MEAN	11604.50	216.00	468.00	522.50	100.00	16.50	2.50	0.00	0.00	0.00	0.00	0.00	1109.50	78.50
S	287.79	42.43	46.67	64.35	18.38	7.78	0.71	0.00	0.00	0.00	0.00	0.00	44.55	34.65
CV%	2.48	19.64	9.97	12.32	18.38	47.14	28.28	0.00	0.00	0.00	0.00	0.00	4.02	44.14
MAX	11808.00	246.00	501.00	568.00	113.00	22.00	3.00	0.00	0.00	0.00	0.00	0.00	1141.00	103.00
MIN	11401.00	186.00	435.00	477.00	87.00	11.00	2.00	0.00	0.00	0.00	0.00	0.00	1078.00	54.00
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LAKSHMI MACHINE WORKS LTD

PILOT MILL
Perianaickenpalayam

Coimbatore - 641 020
India

G 566

STATISTICS
3/1/2005 PAGE 1 (1)

DESIGN. : Kumaraguru_311429

DATE	3/1/2005				
TIME	02:29:24 PM	MACHINE CODE	G566 NR240		38sPC,WET
MATERIAL	P/C	MATERIAL CODE	TEST		
FINENESS	38	BOBBINS	2		
PRETENSION	1 cN	TESTS	1		
		LENGTH	50 m		

BOBBIN	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
1 MEAN	11403.00	199.00	480.00	406.00	71.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	966.00	46.00
1 S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 CV%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 MAX	11403.00	199.00	480.00	406.00	71.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	966.00	46.00
1 MIN	11403.00	199.00	480.00	406.00	71.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	966.00	46.00
2 MEAN	12774.00	141.00	415.00	612.00	111.00	17.00	2.00	0.00	0.00	0.00	0.00	0.00	1157.00	83.00
2 S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 CV%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 MAX	12774.00	141.00	415.00	612.00	111.00	17.00	2.00	0.00	0.00	0.00	0.00	0.00	1157.00	83.00
2 MIN	12774.00	141.00	415.00	612.00	111.00	17.00	2.00	0.00	0.00	0.00	0.00	0.00	1157.00	83.00
OVERALL														
MEAN	12088.50	170.00	447.50	509.00	91.00	13.00	1.00	0.00	0.00	0.00	0.00	0.00	1061.50	64.50
S	969.44	41.01	45.96	145.66	28.28	5.66	1.41	0.00	0.00	0.00	0.00	0.00	135.06	26.16
CV%	8.02	24.12	10.27	28.62	31.08	43.51	141.42	0.00	0.00	0.00	0.00	0.00	12.72	40.56
MAX	12774.00	199.00	480.00	612.00	111.00	17.00	2.00	0.00	0.00	0.00	0.00	0.00	1157.00	83.00
MIN	11403.00	141.00	415.00	406.00	71.00	9.00	0.00	0.00	0.00	0.00	0.00	0.00	966.00	46.00
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LAKSHMI MACHINE WORKS LTD

zweigle

PILOT MILL — Coimbatore - 641 020

Perianaickenpalayam — India — G 566

STATISTICS
3/1/2005 PAGE 1 (1)

DESIGN. : Kumaraguru_311441

DATE	3/1/2005	MACHINE CODE	G566 NR240	38sPV,WET
TIME	02:41:59 PM	MATERIAL CODE	TEST	
MATERIAL	P/V	BOBBINS	2	
FINENESS	38	TESTS	1	
PRETENSION	1 cN	LENGTH	50 m	

BOBBIN	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
1 MEAN	11677.00	240.00	412.00	283.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	711.00	0.00
1 S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 CV%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 MAX	11677.00	240.00	412.00	283.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	711.00	0.00
1 MIN	11677.00	240.00	412.00	283.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	711.00	0.00
2 MEAN	10657.00	181.00	342.00	369.00	84.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	796.00	6.00
2 S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 CV%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 MAX	10657.00	181.00	342.00	369.00	84.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	796.00	6.00
2 MIN	10657.00	181.00	342.00	369.00	84.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	796.00	6.00

OVERALL

MEAN	11167.00	210.50	377.00	326.00	50.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	753.50	3.00
S	721.25	41.72	49.50	60.81	48.08	0.71	0.00	0.00	0.00	0.00	0.00	0.00	60.10	4.24
CV%	6.46	19.82	13.13	18.65	96.17	141.42	0.00	0.00	0.00	0.00	0.00	0.00	7.98	141.42
MAX	11677.00	240.00	412.00	369.00	84.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	796.00	6.00
MIN	10657.00	181.00	342.00	283.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	711.00	0.00
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LAKSHMI MACHINE WORKS LTD

zweigle

PILOT MILL
Perianaickenpalayam

Coimbatore - 641 020
India.

G 566

STATISTICS
3/1/2005 PAGE 1 (1)

DESIGN. : Kumaraguru_311445

DATE	3/1/2005	MACHINE CODE	G566 NR240	38sPOLY,DRY
TIME	02:45:24 PM	MATERIAL CODE	TEST	
MATERIAL	POLY	BOBBINS	2	
FINENESS	38	TESTS	1	
PRETENSION	1 cN	LENGTH	50 m	

BOBBIN	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
1 MEAN	8513.00	113.00	157.00	136.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	311.00	0.00
1 S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 CV%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 MAX	8513.00	113.00	157.00	136.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	311.00	0.00
1 MIN	8513.00	113.00	157.00	136.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	311.00	0.00
2 MEAN	9932.00	94.00	166.00	156.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	343.00	0.00
2 S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 CV%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 MAX	9932.00	94.00	166.00	156.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	343.00	0.00
2 MIN	9932.00	94.00	166.00	156.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	343.00	0.00

OVERALL	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
MEAN	9222.50	103.50	161.50	146.00	19.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	327.00	0.00
S	1003.38	13.44	6.36	14.14	2.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.63	0.00
CV%	10.88	12.98	3.94	9.69	10.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.92	0.00
MAX	9932.00	113.00	166.00	156.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	343.00	0.00
MIN	8513.00	94.00	157.00	136.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	311.00	0.00
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LAKSHMI MACHINE WORKS LTD

zweigle

PILOT MILL
Perianaickenpalayam

Coimbatore - 641 020
India

G 566

STATISTICS
3/1/2005 PAGE 1 (1)

DESIGN. : Kumaraguru_311457

DATE	3/1/2005	MACHINE CODE	G566 NR240	38sPOLY,WET
TIME	02:57:01 PM	MATERIAL CODE	TEST	
MATERIAL	POLY	BOBBINS	2	
FINENESS	38	TESTS	1	
PRETENSION	1 cN	LENGTH	50 m	

BOBBIN	1 mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
1 MEAN	11257.00	79.00	254.00	298.00	37.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	590.00	6.00
1 S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1 CV%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	590.00	6.00
1 MAX	11257.00	79.00	254.00	298.00	37.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	590.00	6.00
1 MIN	11257.00	79.00	254.00	298.00	37.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	590.00	6.00
2 MEAN	10804.00	97.00	226.00	287.00	29.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	542.00	0.00
2 S	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 CV%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2 MAX	10804.00	97.00	226.00	287.00	29.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	542.00	0.00
2 MIN	10804.00	97.00	226.00	287.00	29.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	542.00	0.00
OVERALL														
MEAN	11030.50	88.00	240.00	292.50	33.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	566.00	3.00
S	320.32	12.73	19.80	7.78	5.66	0.71	0.00	0.00	0.00	0.00	0.00	0.00	33.94	4.24
CV%	2.90	14.46	8.25	2.66	17.14	141.42	0.00	0.00	0.00	0.00	0.00	0.00	6.00	141.42
MAX	11257.00	97.00	254.00	298.00	37.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	590.00	6.00
MIN	10804.00	79.00	226.00	287.00	29.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	542.00	0.00
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

PILOT MILL
PERIANAICKEN PALAYAM

COIMBATORE

Zweigle

G 566

INDIVIDUAL VALUES

17/03/05 PAGE 1 (1)

DESIGN. : Kumaraguru_3171419

DATE	17/03/05	MACHINE CODE	G566 NR240	38s 100% COTTON , DRY SAMPLE
TIME	14:19:32	MATERIAL CODE	TEST	
MATERIAL	COTTON	BOBBINS	2	
FINENESS	30s	TESTS	1	
PRETENSION	1 cN	LENGTH	50 m	

BOBBIN	TEST	1mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
1	1	6906	359	183	137	33	18	2	0	0	0	0	0	373	87
2	1	7204	404	216	175	77	25	0	0	0	0	0	0	493	112

OVERALL

	1mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm	12mm	15mm	18mm	21mm	25mm	S3	Index
MEAN	7055.00	381.50	199.50	156.00	55.00	21.50	1.00	0.00	0.00	0.00	0.00	0.00	433.00	99.50
S	210.72	31.82	23.33	26.87	31.11	4.95	1.41	0.00	0.00	0.00	0.00	0.00	84.85	17.68
CV%	2.99	8.34	11.70	17.22	56.57	23.02	141.42	0.00	0.00	0.00	0.00	0.00	19.60	17.77
MAX	7204.00	404.00	216.00	175.00	77.00	25.00	2.00	0.00	0.00	0.00	0.00	0.00	493.00	112.00
MIN	6906.00	359.00	183.00	137.00	33.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00	373.00	87.00
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LAKSMI MACHINE WORKS LTD

PILOT MILL — COIMBATORE

PERIANAICKEN PALAYAM

Zweigle

G 566

INDIVIDUAL VALUES
17/03/05 PAGE 1 (1)

DESIGN. : Kumaraguru_3171423

DATE	17/03/05	MACHINE CODE	G566 NR240	38s 100% COTTON , WET SAMPLE
TIME	14:23:22	MATERIAL CODE	TEST	
MATERIAL	COTTON	BOBBINS	2	
FINENESS	38s	TESTS	1	
PRETENSION	1 cN	LENGTH	50 m	

BOBBIN	TEST	1mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm.	12mm	15mm	18mm	21mm	25mm	S3	Index
1	1	1701	103	16	11	3	1	0	0	0	0	0	0	31	7
2	1	4525	285	195	161	44	19	2	0	0	0	0	0	421	89

OVERALL

	1mm*	2mm*	3mm*	4mm*	6mm*	8mm*	10mm.	12mm	15mm	18mm	21mm	25mm	S3	Index
MEAN	3113.00	194.00	105.50	86.00	23.50	10.00	1.00	0.00	0.00	0.00	0.00	0.00	225.00	48.00
S	1996.87	128.69	126.57	106.07	28.99	12.73	1.41	0.00	0.00	0.00	0.00	0.00	275.77	57.98
CV%	64.15	66.34	119.97	123.33	123.37	127.28	141.42	0.00	0.00	0.00	0.00	0.00	122.02	120.80
MAX	4525.00	285.00	195.00	161.00	44.00	19.00	2.00	0.00	0.00	0.00	0.00	0.00	421.00	89.00
MIN	1701.00	103.00	16.00	11.00	3.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	31.00	7.00
F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

STER TENSORAPID 3 V6.1 TH 1-03-05 14:39 Operator: DEEPA
AKSHMI MACHINE WORKS LTD. UNIT-1 R&D, PILOT MILLS

ticle number: KUMARAGU Test number: P/C Mean count: 38.00 Nec
MARAGURU, 38S P/C, DRY
sts: 2/20 v = 5000 mm/min. FV = 7.9 gf LH = 500 mm P_{c1} = 338 N/cm² (30%)
mits: F: 0.00 / 50.00 kgf E: 0.00 / 20.00 %

OVERALL REPORT:

	Time to Br. (s)	B-Force (gf)	Elongation (%)	Rkm (kgf*Nm)	B-Work (gf.cm)
Test 1:	20 Single test(s)		(Outside limit values:		0)
Mean value	0.5	376.3	9.14	24.21	937.6
Test 2:	20 Single test(s)		(Outside limit values:		0)
Mean value	0.6	361.4	9.19	23.25	915.1
Overall results: (total)					
2 Test(s) /	40 Single test(s)		(Outside limit values:		0)
Mean value	0.6	368.9	9.16	23.73	926.4
CV%		9.32	8.43	9.32	16.44
Q95% +/-		11.0	0.25	0.71	45.7
Min. value		292.5	7.23	18.32	606.3
Max. value		440.2	11.11	28.32	1293.4
Weak values (3)		302.9			

USTER TENSORAPID 3 V6.1 TH 1-03-05 14:45 Operator: DEEPA
LAKSHMI MACHINE WORKS LTD. UNIT-1. R&D, PILOT MILLS

Article number: KUMARAGU Test number: P/C Mean count: 38.00 Nec
KUMARAGURU, 38S P/C, WET
Tests: 2/20 v = 5000 mm/min. FV = 7.9 gf LH = 500 mm P_{c1} = 338 N/cm² (30%)
Limits: F: 0.00 / 50.00 kgf E: 0.00 / 20.00 %

OVERALL REPORT:

	Time to Br. (s)	B-Force (gf)	Elongation (%)	Rkm (kgf*Nm)	B-Work (gf.cm)
Test 1:	20 Single test(s)		(Outside limit values:		0)
Mean value	0.5	386.4	9.05	24.36	999.9
Test 2:	20 Single test(s)		(Outside limit values:		0)
Mean value	0.5	325.1	8.01	20.91	822.4
Overall results: (total)					
2 Test(s) /	40 Single test(s)		(Outside limit values:		0)
Mean value	0.5	355.7	8.53	22.39	911.1
CV%		12.59	12.93	12.59	20.65
Q95% +/-		14.3	0.35	0.72	60.2
Min. value		263.4	4.99	16.95	401.9
Max. value		435.2	10.03	28.00	1211.7

USTER TENSORAPID 3 V6.1 TH 1-03-05 14:57 Operator: DEEPA Page:
LAKSHMI MACHINE WORKS LTD.UNIT-1 R&D,PILOT MILLS

Article number:KUMARAGU Test number:P/V Mean count: 38.00 Nec
KUMARAGURU;38S P/V;DRY
Tests: 2/20 v = 5000 mm/min. FV = 7.9 gf LH = 500 mm p_{e1} = 338 N/cm² (30%)
Limits: F: 0.00 / 50.00 kgf E: 0.00 / 20.00 %

OVERALL REPORT:

	Time to Br.	B-Force	Elongation	Rkm	B-Work
	(s)	(gf)	(%)	(kgf*Nm	(gf.cm)
Test 1:	20 Single test(s)		(Outside limit values:		0)
Mean value	0.7	463.2	11.47	29.30	1300.9
Test 2:	20 Single test(s)		(Outside limit values:		0)
Mean value	0.7	477.0	11.55	30.69	1344.5
Overall results: (total)					
2 Test(s) /	40 Single test(s)		(Outside limit values:		0)
Mean value	0.7	470.1	11.51	30.24	1322.7
CV%		8.26	5.97	8.26	12.62
Q95% +/-		12.4	0.22	0.30	53.4
Min. value		370.5	9.52	23.04	898.8
Max. value		526.4	12.84	33.97	1641.5
Weak values (3)		382.6			

USTER TENSORAPID 3 V6.1 TH 1-03-05 15:02 Operator: DEEPA Page
LAKSHMI MACHINE WORKS LTD.UNIT-1 R&D,PILOT MILLS

Article number:KUMARAGU Test number:P/V Mean count: 38.00 Nec
KUMARAGURU,38S P/V,WET
Tests: 2/20 v = 5000 mm/min. FV = 7.9 gf LH = 500 mm p_{c1} = 338 N/cm² (30%)
Limits: F: 0.00 / 50.00 kgf E: 0.00 / 20.00 %

OVERALL REPORT:

	Time to Br.	B-Force	Elongation	Rkm	B-Work
	(s)	(gf)	(%)	(kgf*Km)	(gf.cm)
Test 1:	20 Single test(s)		(Outside limit values:		0)
Mean value	0.6	380.4	9.51	24.47	975.9
Test 2:	20 Single test(s)		(Outside limit values:		0)
Mean value	0.6	409.2	10.15	26.32	1057.3
Overall results: (total)					
2 Test(s) /	40 Single test(s)		(Outside limit values:		0)
Mean value	0.6	394.8	9.83	25.40	1016.6
CV%		13.69	9.07	13.69	18.87
Q95% +/-		17.3	0.29	1.11	61.4
Min. value		290.1	7.87	18.66	620.5
Max. value		548.3	11.44	35.28	1460.2
Weak values (3)		301.3			

USTER TENSORAPID 3 V6.1 TH 1-03-05 15:09 Operator: DEEPA Page:
LAKSHMI MACHINE WORKS LTD.UNIT-1 R&D,PILOT MILLS

Article number:KUMARAGU Test number:POLYESTR Mean count: 38.00 Nec
KUMARAGURU,38S POLYESTER,DRY
Tests: 2/20 v = 5000 mm/min. FV = 7.9 gf LH = 500 mm p_{c1} = 338 N/cm² (30%)
Limits: F: 0.00 / 50.00 kgf E: 0.00 / 20.00 %

OVERALL REPORT:

	Time to Br.	B-Force	Elongation	Rkm	B-Work
	(s)	(gf)	(%)	(kgf*Nm)	(gf.cm)
Test 1: 20 Single test(s)			(Outside limit values:		0)
Mean value	0.6	508.0	10.66	32.68	1282.2
Test 2: 20 Single test(s)			(Outside limit values:		0)
Mean value	0.6	515.8	10.75	33.19	1305.5
Overall results: (total)					
2 Test(s)/ 40 Single test(s)			(Outside limit values:		0)
Mean value	0.6	511.9	10.71	32.93	1293.8
CV%		10.85	7.22	10.85	16.18
Q95% +/-		17.8	0.25	1.14	67.0
Min. value		355.5	8.37	22.87	739.2
Max. value		635.7	11.97	40.90	1722.2
Weak values (3)		401.9			

USTER-TENSORAPID 3 V6.1 TH 1-03-05 15:14 Operator: DEEPA Page:
LAKSHMI MACHINE WORKS LTD.UNIT-1 R&D,PILOT MILLS

Article number:KUMARAGU Test number:POLYESTR Mean count: 38.00 Nec
KUMARAGURU,38S POLYESTER,WET
Tests: 2/20 v = 5000 mm/min. FV = 7.9 gf LH = 500 mm p_{c1} = 338 N/cm² (30%)
Limits: F: 0.00 / 50.00 kgf E: 0.00 / 20.00 %

OVERALL REPORT:

	Time to Br.	B-Force	Elongation	Rkm	B-Work
	(s)	(gf)	(%)	(kgf*Nm)	(gf.cm)
Test 1: 20 Single test(s)			(Outside limit values:		0)
Mean value	0.6	425.3	9.78	27.36	1018.4
Test 2: 20 Single test(s)			(Outside limit values:		0)
Mean value	0.6	445.1	10.39	28.64	1080.2
Overall results: (total)					
2 Test(s)/ 40 Single test(s)			(Outside limit values:		0)
Mean value	0.6	435.2	10.09	28.00	1049.3
CV%		18.46	12.55	18.46	26.86
Q95% +/-		25.7	0.40	1.65	90.2
Min. value		226.0	6.40	14.54	393.1
Max. value		679.9	12.53	43.74	1927.9
Weak values (3)		282.6			

USTER TENSORAPID 3 V6.1 SA 7-03-05 14:29 Operator: DEEPA Page:
LAKSHMI MACHINE WORKS LTD.UNIT-1 R&D,PILOT MILLS

Article number:KUMARGUR Test number:100% COT Mean count: 38.00 Nec
100% COTTON,DRY SAMPLE ,38sCOUNT
Tests: 2/50 v = 5000 mm/min. FV = 7.9 gf LH = 500 mm p_{e1} = 338 N/cm² (30%)
Limits: F: 0.00 / 2.00 kgf E: 0.00 / 20.00 %

OVERALL REPORT:

	Time to Br. (s)	B-Force (gf)	Elongation (%)	Rkm (kgf*Nm)	B-Work (gf.cm)
Test 1:	50 Single test(s)		(Outside limit values:		0)
Mean value	0.2	222.5	3.59	14.32	215.9
Test 2:	50 Single test(s)		(Outside limit values:		0)
Mean value	0.3	244.0	4.27	15.70	277.9
Overall results: (total)					
2 Test(s) /	100 Single test(s)		(Outside limit values:		0)
Mean value	0.2	233.2	3.93	15.01	246.9
CV%		9.77	11.92	9.77	20.05
Q95% +/-		4.5	0.09	0.29	9.8
Min. value		161.5	2.94	10.39	127.2
Max. value		283.7	4.99	18.25	367.9
Weak values (3)		173.7			

USTER TENSORAPID 3 V6.1 SA 7-03-05 14:40 Operator: DEEPA Page:
LAKSHMI MACHINE WORKS LTD.UNIT-1 R&D,PILOT MILLS

Article number:KUMARGUR Test number:100% COT Mean count: 38.00 Nec
KUMARAGURU COLLEGE OF TECHNOLOGY 100% COTTON , WET SAMPLE,38sCOUNT
Tests: 2/50 v = 5000 mm/min. FV = 7.9 gf LH = 500 mm p_{e1} = 338 N/cm² (30%)
Limits: F: 0.00 / 2.00 kgf E: 0.00 / 20.00 %

OVERALL REPORT:

	Time to Br. (s)	B-Force (gf)	Elongation (%)	Rkm (kgf*Nm)	B-Work (gf.cm)
Test 1:	50 Single test(s)		(Outside limit values:		0)
Mean value	0.2	270.1	3.26	17.38	221.6
Test 2:	50 Single test(s)		(Outside limit values:		0)
Mean value	0.2	299.7	3.29	19.28	242.9
Overall results: (total)					
2 Test(s) /	100 Single test(s)		(Outside limit values:		0)
Mean value	0.2	284.9	3.27	18.33	232.2
CV%		11.46	9.42	11.46	19.98
Q95% +/-		6.5	0.06	0.42	9.2
Min. value		222.1	2.56	14.29	146.7
Max. value		369.1	4.16	23.75	360.5
Weak values (3)		224.2			

TEXTILES COMMITTEE

(Ministry of Textiles, Govt. of India)

Textile Testing Services

'Raj Chambers', 978-A, Thadagam Road,
Coimbatore - 641 002
Tel : 2473094 Fax : 2472689
E.mail : tccbe@eth.net

NABL ACCREDITED LABORATORY
Vide No : T-0429 & T-0430

nat No. 04/32/00

TEST REPORT

12/04/05

report No : 256 / 2005 - 2006

e and address of Customer	:	Kumaraguru College of Technology Coimbatore-641006
ple forwarding letter No. & date	:	12/04/05
of receipt of Sample	:	12/04/05
ers Name & address (Optional)	:	
omer sample Ref.	:	CD
ple description	:	Fibre
Sample No.	:	CT - 256
ple colour	:	
e/s of Testing	:	12/04/05

Sample swatch

TEST RESULTS

. **Moistur Content**

IS:199:1989

Avg. Moisture Content % 5.11

R. Balu

R. BALU
Quality Assurance Officer

Sample is not drawn by Textiles Committee. Results relate only to the samples tested.
est report is not to be published in any form without the explicit written consent of the Textiles Committee.

TEXTILES COMMITTEE

(Ministry of Textiles, Govt. of India)
Textile Testing Services
'Raj Chambers', 978-A, Thadagam Road,
Coimbatore - 641 002
Tel : 2473094 Fax : 2472689
E.mail : tccbe@eth.net

NABL ACCREDITED LABORATORY
Vide No : T-0429 & T-0430

rmat No. 04/32/00

TEST REPORT

12/04/05

t report No : 255 / 2005 - 2006

me and address of Customer	:	Kumaraguru College of Technology Coimbatore-641006
mple forwarding letter No. & date	:	12/04/05
e of receipt of Sample	:	12/04/05
yers Name & address (Optional)	:	
stomer sample Ref.	:	CW
mple description	:	Fibre
Sample No.	:	CT - 255
mple colour	:	
te/s of Testing	:	12/04/05

Sample swatch

TEST RESULTS

. **Moisture Content**

IS:199:1989

Avg. Moisture Content % 20.54

Page 1 of 1

R. Balu

R. BALU
Quality Assurance Officer

Sample is not drawn by Textiles Committee. Results relate only to the samples tested.
s test report is not to be published in any form without the explicit written consent of the Textiles Committee

100 % COTTON
WET

100% COTTON
REGULAR.

P/C
REGULAR

P/V
REGULAR

P/C
WET

REFERENCE:

(1)Belov E.B,S.V.Lomov,N.N.Truevtsev,M.S.Bradshaw and R.J.Harwood(2002) in "Studt of Yarn snarling –Part 1:Critical parameters of snarling"

(2)Carnaby G.C. and Postle R.(1974)"Shear properties of weft knitted fabrics",J.Text.Inst., vol 65, pp.87-101

(3)Davis W,Edwards C.H(1934) "Spirality in knitted fabrics" J.Text. Inst., vol25,pp122-132

(4)Krishnakumar .V(2004) "A Novel technique for the reduction of spirality in weft-knitted fabrics"-Ph.D thesis

(5) Lingli chang,Zheng-xue,Tang, and Xungai wang(2003) in "Effect of yarn hairiness on energy on consumption in rotating a ring spun yarn package" Textile Res. J.,pp 949-953

(6)Lord P.R., Mohamed M.H & Ajgaonakar D.B.(1974) "The performance of OE twistless and ring yarns in weft knitted fabrics",Textile Res.J.,vol45,pp.405-415

(7)Nutting T.S(1960) "Spirality in weft knitted fabrics", Hosiery Res.Bull,vol 4,p18

(8)Platt M.M.,Klein W.G. and Hamburger W.J(1951) "Mechanics of elastic performance of textile materials" Textile Res J., vol 28

(9)Postle R. Burton P. & Chaikin M(1964), "The torque in twisted singles yarn",J.Text.Inst.,vol55,pp448-461

(10)Primentas .A in "Spirality of wet knitted fabric:Part i-Descriptive approach to the effect." Indian journal of fibre and Textile Research ., vol28,pp.55-59

(11)Primentas .A in “Spirality of wet knitted fabric:Part ii-Methods of the reduction of the effect” .” Indian journal of fibre and Textile Research ., vol28,pp. 60-64

(12) Primentas .A& C.Iype in “Spirality of wet knitted fabric:Part iii.An innovative method for the reduction of the effect” Indian journal of fibre and Textile Research ., vol28,pp.202-208

(13) Primentas .A & C.Iype in“Spirality of wet knitted fabric:Part iv Effect of yarn partial detwisting on yarn and fabric properties” Indian journal of fibre and Textile Research ., vol28,pp.209-215

(14) Sheikh .H.A(2001) in “Causes and consequences of hairy yarn”

(15)Wei Q.F, R.R.Mather, A.F.Fotheringham, and R.D.Yang(2003) in “Dynamic wetting of fibers observed in an environmental scanning electron microscope” Textile Res. J.,pp 557-561