INVESTIGATION OF FABRIC FRICTIONAL CHARACTERISTICS ON DIMENSIONAL PROPERTIES OF KNITTED FABRICS

A PROJECT REPORT

Submitted by

NAME

REGISTER NUMBER

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

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BONAFIDE CERTIFICATE

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20/4/05

INTERNAL EXAMINER

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ACKNOWLEDGEMENT

We wish to express our sincere thanks to Dr.K.K.Padmanabhan, Principal, Kumaraguru College of Technology for the ample facilities made to available for the completion of the project.

We wish to express our extreme gratefulness to Dr.V.Natarajan, Head of the Department, Department of Textile Technology, Kumaraguru College of Technology for the inspiration and moral support for carrying out this project.

We wish to express our deep gratitude to the guide Mr.N.D.Karthikeyan, Lecturer, Department of Textile Technology, Kumaraguru College of Technology for his valuable guidance and suggestions throughout the course of this project work.

We convey sincere thanks to M/s Sangu Knit Lands, Tirupur and M/s Super Spinning Mills, M/s Rubika Spinning Mills, Coimbatore for providing necessary raw material required for our project.

Finally, we thank one and all who helped in our project.

ABSTRACT

This project titled “Investigation of fabric frictional characteristics on dimensional properties of knitted fabrics” deals about the influence of frictional characteristics of knitted fabrics contributed by various parameters such as count, twist and fiber denier combinations on fabric dimensional and surface characteristics.

The objective of the project is optimizing the process parameters which influence the friction values of yarns as well as fabrics so that comfort as well as stability is achieved. The yarns are spun into three different counts with three different twist levels and three different fiber combinations. These yarns are knitted in to plain and rib structures with other parameters being constant. The knitted structures are subjected to friction, dimension and abrasion testing.

Fabrics with higher coefficient of friction have better resistance to change in dimensions, i.e., they have a better dimensional stability.

திட்டப்பணிச் சுருக்கம்

பின்னலாடைத் துணிகளின் தன்மைகளில் மிக முக்கியமானது அதன் நீள மற்றும் அகல அளவு தக்க வைப்புத் திறனாகும். இத்தன்மையானது துணிகளின் ஒட்டு மொத்த செயல் திறன் மற்றும் அதன் நேர்த்தியையும் தோற்றத்தையும் நிர்ணயிக்கின்றது. இத்தன்மையானது நூலிழை தர காரணிகள், நூல் தயாரிப்பு காரணிகள் மற்றும் பின்னலாடை தயாரிப்பு காரணிகளையும் துணிகளின் பௌதீகப் பண்புகளையும் பொறுத்தே அமைகிறது.

இவ்வாய்வில் நூல் மற்றும் துணி தயாரிப்பு காரணிகளால் துணிகளின் மேற்பரப்பு உராய்வுத் தன்மையில் ஏற்படும் மாற்றங்கள் சோதிக்கப்பட்டது. துணிகளின் மேற்பரப்பின் உராய்வுத் தன்மையில் ஏற்படும் மாற்றங்கள் துணிகளின் அளவு தக்க வைப்புத் திறனில் எப்படிப்பட்ட மாறுதல்களை உண்டாக்குகிறது என்பதும் கண்டறியப்பட்டது.

இந்த ஆய்வுப்பணியில் பாலியஸ்டர் மற்றும் விஸ்கோஸ் நூலிழைகள் 50/50 சதவிகிதத்தில் கலக்கப்பட்டது. பாலியஸ்டர் இழைகளில் 1.0,1.2 & 1.4 டெனியர் இழைகள் 1.2 டெனியர் விஸ்கோஸ் இழைகளுடன் கலக்கப்பட்டு 20s, 40s & 60s ஆகிய மூன்று நூல் அளவைகளில் தயார் செய்யப்பட்டது. இம் மூன்று நூல் அளவைகளிலும் மூன்று அளவிலான முறுக்கு நிலையில் நூல் தயாரிக்கப்பட்டது. இந்நூல்ளை கொண்டு சிங்கிள் ஜெர்ஸி மற்றும் ரிப் ஆகிய பின்னல் அமைப்புகளில் பின்னலாடைத் துணிகள் தயாரிக்கப்பட்டது.

ஆய்வில் துணிகளின் உராய்வுக் குறுயீட்டு அளவைக்கும் அளவு தக்கவைப்புத் திறனுக்குமான தொடர்பு சோதிக்கப்பட்டது.

மேலும் இதன் காரணமாக துணிகளின் பின்னல் எண்ணிக்கை மற்றும் துணியின் சதுர பரப்பின் எடையில் ஏற்பட்ட மாற்றம் ஆகிய தன்மைகளும் சோதிக்கப்பட்டுள்ளது.

ஆய்வு முடிவில் கணமான மற்றும் அதிக முறுக்குத் தன்மையுள்ள நூல்களால் செய்யப்பட்ட துணிகளில் அதிக உராய்வுத் திறனும் அதனால் துணிகளின் அளவு தக்க வைப்புத் திறனும் அதிகமாக உள்ளது கண்டறியப்பட்டுள்ளது.

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1. INTRODUCTION

1.1 Friction :

Friction is the resisting force of a body offered to the movement of another body moving or sliding over it. Cohesion is a form of friction and it enables the fibers to hold on in a yarn and prevents it from getting untwisted. Similarly yarns in the fabric have friction between them providing a resistive force. This friction is essential in preventing the fabric from losing its shape and thereby rendering dimensional stability.

The frictional properties of textile yarns and of machinery components such as yarn guides are of general interest and have many applications. Because the frictional properties of yarns will affect the performance and life of yarn guides, sewing and knitting needles, and other contact surfaces, the modifying effects of surface finishes and lubricants are of special interest. Frictional properties also affect the quality and performance of yarns and subsequently of products made from them. As a consequence, frictional properties are of interest in research, control, and product design.

Among various factors, few important factors which affect the dimensional stability of knitted fabrics are

- Yarn-metal friction.
- Yarn-yarn friction.

In the above cases yarn to metal friction should be less during knitting to minimize the end breakages during fabric production. On the other hand, yarn to yarn friction should be high in the fabric to achieve better cohesion between the yarns in the fabrics.

1.2 Dimensional Stability:

Dimensional stability is defined as the ability of a fabric to retain or hold its shape. It is one of the properties that determine the performance and aesthetic appeal of a fabric, making it essential that a fabric has a reasonable dimensional stability. There are various parameters influencing the stability of a fabric. They are:

- Fiber parameters : Nature of fiber, fineness, surface Characteristics, denier etc.
- Yarn parameters : Spinning method, Count, Twist level, etc
- Fabric parameters : Loop length, tightness factor, take-down Tension etc

While comparing the woven fabrics & knitted fabrics, shrinkage is a main property which affects the overall performance of the fabrics.

1.3 Scope of the Project:

Yarn count and twist levels play a vital role in influencing the yarn and fabric friction. As the count gets coarser the diameter of the yarn increases and also the yarn becomes hairier. This implies that coarser yarns have a larger surface area which results in a larger area of contact between yarns or surface. The hair fibers mean that during further processing they abrade with each other and friction is produced.

Yarns used in knitting are usually of low twist in order to provide a softer handle and also avoid needle breakage. When the twist is higher, the yarn surface roughness increases and results in yarns with higher friction values. The type of fibre and its denier, in case of synthetic fibers, used in yarn production also influences friction.

The friction cannot be altogether eliminated as they are a requisite to keep the fabrics dimensionally stable and increasing friction will make the fabric more stable. However, if the friction is too high it will reduce the comfort for the user by being stiff and restrict movements. Thus the objective of the project is optimizing the process parameters which influence the friction values of yarns as well as fabrics so that comfort as well as stability is achieved.

2. LITERATURE SURVEY

The contribution of inter-fibre or fibre to other material friction in controlling fibre flow during spinning process, affecting physical properties of yarn and fabric with deformation behavior of fibre assembly have been recognized. The behavior of yarn to yarn and yarn to metal friction in determining the fabric stability has to be explored in detail. The knowledge of the frictional values of individual fibres and yarns are very important to predict whether the processing will be satisfactory or not, when other physical properties are satisfactory. The processability of a staple fibre is affected, in general, by two factors – (i) Geometrical structure of each fibre and (ii) surface properties. In some previous works [6] detailed studies have been reported on the frictional properties of fibres.

Fabrics knitted from OE spun yarns and ring spun yarn possess different properties and particularly that the amount of relaxation shrinkage observed [4] in fabrics knitted from OE spun yarns is greater than that which occurs in fabrics knitted from ring spun yarns. The aesthetic properties of fabrics made from OE spun yarns are inferior to those of fabrics made from ring spun yarns, particularly with regard to a lack of stitch clarity and a somewhat harsher handle, although the latter effect is shown to be apparently unrelated to differences in the frictional properties of the two types of yarns.

The properties of the resultant yarns have been examined and concluded that open-end –spun yarns are more even, more extensible, bulkier, and weaker than corresponding ring-spun yarns.

Open-end-spun yarns also have greater resistance to abrasion and fatigue and better thermal-insulation properties than ring-spun yarns, and, owing to their greater volume, they have a better affinity for dyes and sizes. Despite the obviously attractive yarn properties, fabrics knitted from open-end-spun yarn have a somewhat harsh handle and, owing no doubt to the yarn structures, often do not exhibit good stitch clarity. This paper investigates the dimensional properties of cotton fabrics knitted from open-end-spun yarns and compares them with fabrics made from ring-spun yarns.

The dimensional and certain physical properties of a series of plain jersey and lacoste fabrics made from both cotton ring and open-end spun yarns have been investigated [2]. As seen before, the results show that structural differences in the yarn play a large part in determining the dimensions and behavior of these two fabric types. It is apparent that the amount of relaxation shrinkage occurring with open-end spun yarns is greater than that with ring spun yarn. Furthermore, open-end spun yarns tend to be weaker, which results in lower bursting strength and also the fabrics tend to pill more. As far as abrasion resistance is concerned, ring spun knits perform slightly better than open-end spun knits.

For each fabric type, the courses/cm decreases with increased stitch length, and there is a significant decrease in the loop height as the relaxation process progresses. The change in the loop length seems to have little effect on wales/cm. The areal density of the knits from open-end spun yarns is higher than that of the ring spun yarns and this can be attributed to the higher shrinkage of open-end spun knitted fabrics. Regression analyses of both plain jersey and lacoste fabrics made from ring spun yarns as well as from open-end spun yarns have been made. From the correlation coefficients it is evident that, the stable dimensional properties of cotton single jersey pique fabrics very much depend on the length of the knitted loop.

The amount of relaxation shrinkage occurring with open-end spun yarn is greater than that occurring with ring spun yarns. Ring spun yarns, in general, have more hairiness compared to open-end yarns and as a result tend to pill more. As far as abrasion resistance is concerned, ring spun fabrics perform better than open-end spun knits.

Munden and earlier workers [12] established that in plain knitted fabrics the fabric dimension parameters namely Kc, Kw and Ks are constant dry and wet relaxed state for wool , cotton, orlon and nylon yarns. But in the presence study of cotton/ lycra core spun yarn single jersey knitted fabrics the values for Kc, Kw and Ks varies with loop length. The ratio of Kc/ Kw also varies with loop length

Dimensional, pilling and abrasion properties of a series of plain jersey, lacoste and two-thread fleece fabrics made from cotton ring and open-end spun yarns as well as from blend yarns (50/50 cotton/ polyester, dyed) have been studied [1].The structural differences and fibre type play a large part in determining the dimensions of these fabrics. It is apparent that the knits from blend yarns have a lower dimensional stability when compared to fabrics from 100% cotton ring and open-end spun yarns. Two-thread fleece fabrics, knitted using the above said yarns, have been tested and the findings suggest that the inlay yarn mainly governs their dimensional behavior in the widthwise direction. The pilling tendency of the samples and their resistance to abrasion is evaluated with the ICI pilling box and the Martindale abrasion tester, respectively. It is seen that lacoste fabrics perform very well, and that in general fabrics knitted from open-end spun yarns have a lower propensity to pilling.

In the case of the two-thread fleece structure, 100% cotton open-end yarn samples have higher pilling rates compared to 50/50 cotton/PET yarns. SEM studies reveal that for the same number of test revolutions, the degree of damage to fibres within the fuzz entanglements tends to increase with an increased number of launderings, and that the kind of damage varies from small cracks and fractures to slight flaking, depending on the fabric and yarn type. It is also observed that lacoste fabrics have the least resistance to abrasion.

Open-end, twist less and ring spun yarns made from cotton and spun to different twists knitted into single-jersey fabrics and performance is assessed [3]. A variety of yarn and fabric relaxations were used and it was evident that unrelieved torque was the primary cause for loop distortion, spirality and fabric shrinkage. Properly relaxed, open-end yarn makes a fabric with good appeal, reasonable shrinkage, and acceptable strength and abrasion resistance. Twist less yarns gave good fabric hand, high luster, zero spirality, and little shrinkage, but there was some loss in strength for the fabric tested.

Fibre type appeared to have little effect on the stitch density although there were significant differences between ring and OE yarn. The angle of spirality did increase with the percentage polyester in the blend, and this shows that an increase in polyester tends to make the yarn more torque lively whatever method of yarn relaxation or yarn manufacture is used. Also with OE yarns, the fabrics became permeable as the percentage polyester was increased; however, the behavior in this respect was unlike that of ring yarns where there were variations of the order of ±20%, which seemed to follow no logical pattern.

It has been found that twist lively yarns produce distortion in plain knitted fabrics which lead to spirality and shrinkage. The use of twist less yarns prevents these defects.OE yarns do not behave in the same manner as ring yarns, and this is thought to be partly because of the higher twists used and partly due to structural differences in the yarn. Abrasion resistance seems to improve as the twist multiple is increased, and OE yarns seem to be slightly better than ring yarns.

An investigation is described [5] in which the stable dimensional properties of cotton single-jersey pique fabrics of the Lacoste type were studied and found to depend on the yarn run-in ratio in such a way that it enabled considerable variations in fabric width, length, thickness, mass per unit area, and aesthetics to be made at constant structural-knitted-cell length.

This paper is concerned with the study of the stable dimensional properties of cotton single-jersey pique fabrics and the way in which they may be affected by changes in structural-knitted-cell length, run-in ratio, and yarn linear density. The dimensional behavior of a stable single-jersey pique fabric is determined by the geometry and length of its structural knitted cell, which includes tuck stitches in alternate courses and alternate wales. The geometry, however, may be altered by changes in the relationship between the lengths of yarn introduced at alternate courses within the structural knitted cell even though the structural-knitted-cell length may remain constant.

The stable dimensional properties of cotton single-jersey pique fabrics may be predicted by using U parameters, which are dependent on R. The run-in ratio is found to be a very useful parameter for fabric engineering, since it enables fabric dimensions and aesthetics to be altered while the average structural-knitted-cell length is kept constant.

Where,

R – Run-in ratio

U – Relation between structural courses per unit length and reciprocal of structural-knitted-cell length.

The frictional properties of fabrics have been accepted for a long time in the subjective evaluation of smoothness or roughness and perhaps taken for granted. One of the factors which influence the subjective judgment of fabrics is undoubtedly the static and/ or kinetic coefficient of friction between the cloth surface and the fingers.

It has been widely reported that the classical friction laws by Amontons fail to describe the frictional behavior of materials that deform Visco-Elastically, such as textiles. Firstly, the coefficient of friction of both fabric to fabric [10] and fabric to other material [11] is not independent of the normal force but decreases with increase in normal force upto some constant value. Secondly, the friction is dependent on the geometric value of contact between the two bodies.

Inspite of its great importance in textiles, measurement of friction has been given least importance for practical purpose. A large number of works have been reported on frictional behavior of textiles and most of the workers have used either some attachments fitted with common tensile tester like Instron [10], where chances of errors are there due to friction between connecting thread and pulley, or they have used some complex systems to carry out specific friction related studies [9].

Three popular cotton 100% knitted fabrics were subjected to five cycles of four different washing and drying regimes [13]. This was in order to investigate the effect of laundering with detergent as opposed to water, and tumble drying against line drying. The main aim of this work was to systematically investigate the effect of the principal washing and drying variables on the dimensional stability and distortion of knitted fabrics. The work demonstrated the changes occurring after laundering were largely due to alterations in the loop shape, rather than yarn or loop shrinkage. The fabrics had taken up their fully relaxed dimensions after five wash dry cycles and appropriate conditions for laundering had been applied, as no significant yarn stitch length, or linear density changes occurred.

3. MATERIALS AND METHODS

In this study, Polyester and Viscose fibers are blended in 50/50 ratio. Polyester fibers having 1.0, 1.2 and 1.4 deniers and Viscose fibers of 1.2 denier with a cut length of 44 mm are blended in the draw frame stage. The fiber combinations are given in Table 3.1.1. The yarns are spun into three different counts with three different twist levels and three different fiber combinations as shown in the Table 3.1.2 and totally 15 yarn samples based on Box-Behnken experimental design as given in Table 3.1.3 were produced. These yarns are knitted into two fabric structures: Plain & Rib. as per the specifications given in Table 3.1.4. the fabric construction details are given in Table 3.1.5.

Table 3.1.1 Fiber Combinations

S.No	Combination	Viscose Denier (D)	Polyester Denier (D)
1.	A	1.2	1.0
2.	B	1.2	1.2
3.	C	1.2	1.4

Table 3.1.2 Yarn Specifications

S. No	Mixing	Count	Twist
1.	A	20	2.7
2.	B	40	3.1
3.	C	60	3.5

Table 3.1.3 Sample Specifications

The table shows the specifications of the yarn sample based on Box-Behnken experimental design and re-arranged according the ascending order of yarn linear density.

Variables	**Coded levels of the variables**		
	-1	**0**	**+1**
X1 = Count (Ne)	20	40	60
X2 = Fiber combination	A	B	C
X3 = Twist Multiplier	2.7	3.1	3.5

Table 3.1.4 Fabric Specifications

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Sample No.	Count (Ne)	Fiber Combination	T.M
1	20	A	3.1
2	20	B	2.7
3	20	B	3.5
4	20	C	3.1
5	40	A	2.7
6	40	A	3.5
7	40	B	3.1
8	40	B	3.1
9	40	B	3.1
10	40	C	2.7
11	40	C	3.5
12	60	A	3.1
13	60	B	2.7
14	60	B	3.5
15	60	C	3.1

Table 3.1.5 Fabric Construction Details

Sl.No	Plain			Rib		
	CPI	WPI	GSM	CPI	WPI	GSM
1	44	32	198	44	24	241
2	48	34	195	40	22	220
3	46	32	201	44	26	225
4	46	32	180	44	26	235
5	50	44	91	44	26	122
6	52	42	100	40	30	125
7	50	42	94	48	28	121
8	52	40	93	46	30	120
9	50	42	94	48	32	121
10	54	42	93	44	26	119
11	48	40	95	42	30	105
12	50	52	73	38	26	70
13	50	52	79	42	30	73
14	56	52	72	42	26	72
15	50	46	80	38	32	71

3.2 Testing

The fabrics are produced based on the specifications provided in the Table 3.1.3 and have been tested for the following properties:

1) Dimensional Change: Length, Width, Area.
2) Weight per unit Area.
3) Coefficient of friction of fabric.
4) Abrasion resistance.

3.2.1 Relaxation and Dimensional Changes of Knitted Fabrics

This method covers the accelerated determination of the relaxation of the dimensional change of knit fabrics, and designed to be shrink resistant. Fabric specimens are subjected to wet relaxation treatment and dried under specified conditions. The distances between bench marks on the specimen in wale and course directions are measured before immersion and after drying. The changes in dimensions are calculated from these measurements.

- **Apparatus and Materials**
  - Washing machine with Centrifugal Extractor having a perforated drum approximately 11 in. Deep by 17in. diameter, with an operating speed of approximately 1000 rpm.
  - Tray – 30 by 24 by 6 in. or a suitable substitute.
  - Steel Rule – Graduated in 0.1 in.
  - Drying Racks – Made of plastic screening with 16 openings per inch.
  - Non – Anionic Wetting Agent

- **Sample Preparation**

➢ The fabric in roll form was unwound and allowed to relax in a flat surface for 24 hours at standard room temperature to enable the fabric to attain moisture equilibrium and to relieve of strain.

➢ The properly conditioned specimens were laid on a flat surface without tension, wrinkles, or creases.

➢ Six 100 mm distances were marked on each specimen parallel to both the wale and course directions and atleast 1 in. from the edges.

➢ Indelible ink was used to make the markings, as the specimens will be subjected to subsequent washing.

➢ An alternate method to make the markings is to sew using fine threads or use staple gun to make the marks.

- **Relaxation Treatments**
- **Dry Relaxation**

The knitted samples in the tubular form were laid free from constraint, on a flat surface and allowed to condition for atleast, 48 hour in an atmosphere of 65 ± 2 % r.h and a temperature of 20 ± 2 ° C.

- **Washing**

Samples were washed in a washing machine for 60 minutes at a temperature of 60°C in water in which wetting agent had been added. After washing, the samples were rinsed three times at 60 O C. Each rinsing cycle was carried out for 10 minutes.

➢ Total weight of the fabrics – 2.5 KGS

➢ Detergent Powder – 10 % on weight of material

- ➢ Wetting agent – 0.1 % on weight of material
- ➢ Washing Time – 1 hour

- **Rinsing**

➢ After the washing cycle is completed, the machine is set to C and start the cycle.

➢ The specimens are rinsed with as little agitation as possible in 3 successive baths of clean water at 60 ° C.

➢ The specimen is transferred from bath to bath giving one gentle squeeze to express liquor.

- **Hydro - extracting**

➢ Each specimen is folded and laid flat against the side of the hydro extractor drum to avoid stretching during spinning.

➢ The specimens are hydro extracted for about 10 seconds at full speed.

- **Drying**
  - ➢ The specimens are laid flat without blocking or distortion on the drying racks to air – dry or oven – dry then at approximately 60 ° C.
- **Measuring**
  - ➢ Before measuring, the specimens were conditioned from the dry side in the standard atmosphere.
  - ➢ The specimens were allowed to attain moisture equilibrium for testing in the standard atmosphere for testing.(RH – 65 ± 2% and Temperature - 21±1°C).
  - ➢ Each specimen was laid without tension on a flat surface, and the distances that were marked off were measured to the nearest 0.05 in (1.3 mm).

- **Report**

From the results obtained the following reports are made,

1) % Change in dimension in wale direction
2) % Change in dimension in course direction
3) % Change in total area.

1) % Change in dimension in wale direction = $\mathbf{\frac{(L - F)}{L} \times 100}$

2) % Change in dimension in course direction = $\mathbf{\frac{(W - D)}{W} \times 100}$

3) % Change in total area = $\mathbf{\frac{(A - C)}{C} \times 100}$

Where,

L – Actual length marked in wale direction
F – Final length along wale direction
W – Actual length marked in course direction
D – Final length along course direction
A – Original area of the marked portion
C – Changed area

Measurement of Fabric Dimensions

Courses per inch and wales per inch were counted with a ½ square inch counting glass. Ten measurements for each dimension were made at different places on each side of the tubular fabric. Circular samples of radius 10 cm were cut using GSM cutter and weighed on an optical balance.

3.2.2 Coefficient of Friction for Fabrics

This method covers the determination of static friction of woven and knitted fabrics based on inclined plane method. An excessively high or low coefficient of friction may be detrimental to many products in which polyolefin fabrics are used. This method provides a measure of the coefficient of static friction of one fabric on another.

- **Summary of Method**
    - ➢ The coefficient of static friction is determined on woven or knitted, polyolefin fabric, using an inclined-plane method.
    - ➢ One specimen is attached to a plane, which can be raised at one end, and another specimen is attached to a test sled.
    - ➢ The fabric-covered sled is placed crosswise on the fabric-covered plane, and the plane inclined until sliding occurs.
    - ➢ The tangent of the angle is reported as an index of static friction.

- **Procedure**

    ➢ An Inclined Plane having a smooth, incompressible top surface, with a width atleast 1 in. wider than the test sled, and a sufficient length to permit the sled to move by atleast 0.5 in was used.

    ➢ It was provided with clamps for the test specimen, and an inclinometer to indicate the angular displacement of the plane within 0.5 deg. The inclination of the plane from the horizontal was increased smoothly through an arc of atleast 45 deg. at a rate of 1.5 ± 0.5 deg/ s.

    ➢ A Test Sled of rectangular metal piece with a flat lower surface 3.5 by 4 in. with a weight to provide a pressure of 0.2 psi, when horizontal.

- Three specimens, 5 by 10 in, are cut across the fabric, with no specimen cut closer to the edge than one-tenth of the width of the fabric. The specimen was cut into two 5 in squares.
- One half of one specimen was clamped to the plane with the wale direction parallel to the direction of the slide, and the surface to be tested upwards. The fabric was held flat with no creases and wrinkles. The other half of the specimen was clamped to the bottom of the sled, with the filling parallel to the long dimension and the surface to be tested facing downward.
- The test sled was placed on the plane with the long dimension parallel to the direction of slide. The two surfaces of the specimen should be now in contact with their wale directions at right angles.
- A dwell time of 30 ± 3 s was allowed, and then inclined the plane at a rate 1.5 ± 0.5 deg/ sec. stop the plane when the test sled starts to move.
- The procedure was repeated twice and the angle was noted to the nearest 0.5 deg at which the test slide begins to slide on the third trial was recorded. This is repeated with each of the specimens.
- The average angle required to produce the movement of the test sled was calculated. The trigonometric tangent of the average angle was expressed as the coefficient of static friction.

3.2.3 Abrasion Resistance of Knitted Fabrics

The wearing away of any part of a material by rubbing against any surface is called abrasion. Abrasion may be classified as follows,

- Plane or flat abrasion – a flat area of material is abraded.
- Edge abrasion – the kind of abrasion which occurs at collars and folds.
- Flex abrasion – in this case, rubbing is accompanied by flexing and bending.

This test method covers the determination of resistance to abrasion of woven and knitted textile fabrics using the Martindale Abrasion Tester. In this method, the samples are given a multi-direction movement and are rubbed against a standard fabric.

- The resistance to abrasion is affected by many factors, such as the inherent mechanical properties of the fibres; the dimensions of the fibres; the structure of the yarns; the construction of the fabrics; and the type, kind, and amount of the finishing material added to the fibres, yarns, or fabric.
- The resistance of a fabric to abrasion is also greatly affected by the conditions of the tests, such as the nature of aberadant, variable action of the abradant over the area of specimen abraded the tension of the specimen, the pressure of the specimen and abradant, and the dimensional changes in the specimens.
- Abrasion tests are all subject to variation due to changes in the abradant during specific tests. The abradant must accordingly be discarded at frequent intervals or checked periodically against a standard.

- **Method Adopted**

- A specimen is abraded by rubbing either unidirectionally or multidirectionally against an abradant having specific surface characteristics.
- The specimen is held in a fixed position and supported by an inflated rubber diaphragm which is held under constant pressure.
- Resistance to abrasion is evaluated by calculating the weight loss.

- **Procedure**

- The template was used to mark the sample size in the specimen. The fabric was cut along the marking with a spacing of 1mm from the marking, to provide a better grip for the clamp.
- The cut specimen was weighed prior to the abrasion to three decimal places.
- The specimen was placed on the specimen clamp and the pressure ring placed over the specimen. The whole assembly was loaded on the tester with a load of 200 g being placed over the clamp assembly.
- The sample was abraded on an emery surface for 50 revolutions or until the fabric is completely torn at the base of the clamp.
- The abraded fabric is weighed to ascertain the % loss in weight.

$$\textbf{\% Loss in weight} = \frac{\mathbf{W1 - W2}}{\mathbf{W_1}} \mathbf{X\ 100}$$

Where,

W_1 - weight of the sample before abrasion,

W_2 – weight of the sample after abrasion

4. RESULTS AND DISCUSSION

4.1 Dimensional Change

The results for changes in dimensions after wet relaxation and washing have been analyzed below:

Table 4.1.1 Dimensional Change of Plain Fabrics

S. No	% Decrease in Course Direction	% Decrease in Wales Direction	% Decrease in Area
1	6.00	8.63	20.42
2	4.33	10.83	21.31
3	7.17	14.50	22.30
4	6.67	15.00	18.56
5	7.67	14.33	21.46
6	9.50	13.01	20.38
7	9.50	12.17	20.79
8	10.17	12.00	20.35
9	10.25	10.96	19.00
10	6.17	9.56	19.00
11	6.83	12.83	19.09
12	5.36	11.50	15.36
13	4.67	11.33	14.69
14	3.00	8.67	12.16
15	2.00	5.50	7.36

Table 4.1.2 Dimensional Change of Rib Fabrics

S. No	% Decrease in Course Direction	% Decrease in Wales Direction	% Change in Area
1	9.83	-0.50	9.50
2	13.83	-7.83	7.75
3	14.83	-8.15	8.09
4	9.53	0.50	10.35
5	11.17	-2.33	7.75
6	13.33	-6.33	5.50
7	14.00	-9.17	2.69
8	14.83	-9.50	3.81
9	13.67	-8.83	2.56
10	13.33	-9.83	1.68
11	19.67	-19.33	2.50
12	7.50	2.17	8.84
13	5.17	2.50	7.38
14	9.83	6.50	8.23
15	8.50	2.17	7.47

Note: Negative Values indicate increase in the length after washing.

From Table 4.1.1 and Figure 4.1.1, it is observed that % decrease in bench marked length in the plain fabrics are more pronounced along wale direction in the samples 1 – 4, whereas samples 12 – 15 have showed a decreasing trend of the shrinkage%. In the course direction, the % shrinkage is less in the coarse counts, i.e., samples 1 – 4, than that observed from samples 12 – 15. This can be justified by the fact that coarser yarns have a larger surface area under contact and hence provide resistance to movement of yarn in the fabrics.

When samples 1 – 4 (20s) and 12 – 15 (60s) are compared, it is observed that as the twist increases, the coarser counts experience a lesser amount of % decrease in length along wale wise direction and course wise direction, when compared to the finer counts in plain fabrics. The samples 5 – 11 (40s) show a moderate % decrease in length. They do not increase as much as the samples 12-15 and do not decrease as much as samples 1-4. This is justified by as the twist increases, the surface friction between the yarn increases, thereby, rendering more stability. Hence we could see that the coarser count shows a less % decrease in length when compared to finer counts as the latter has less stability.

From the Fig 4.1.2, we could observe that the corresponding increase of length in course wise direction leads to a considerable decrease in the wale wise direction. This is due to the fact that the rib structures have a relatively more dimensional stability.

Fig 4.1.1 % Decrease in Dimensions of Plain Fabrics

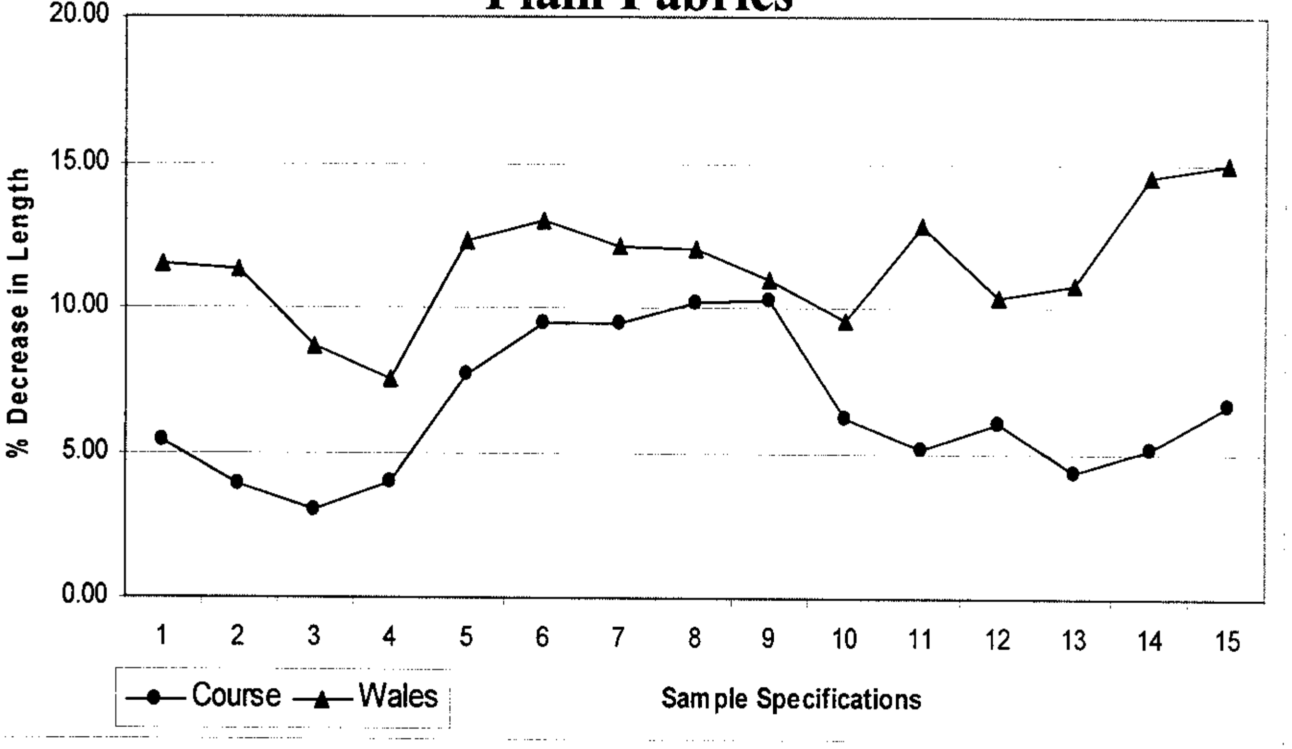
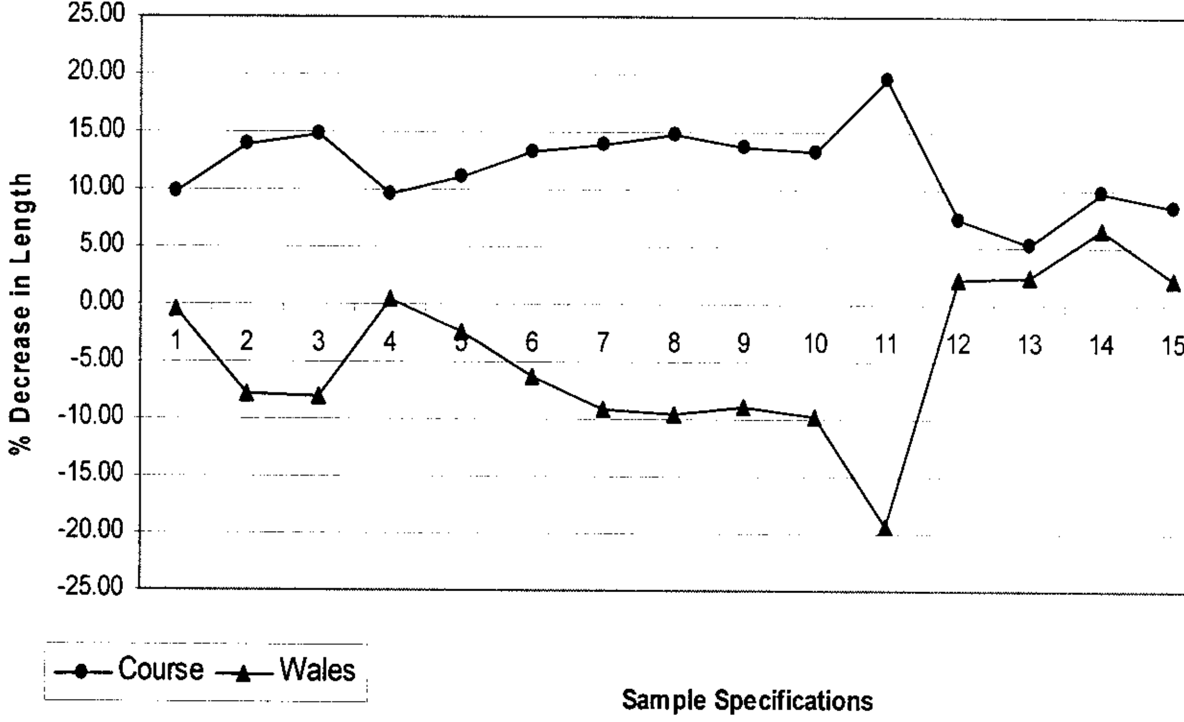


Fig 4.1.2 % Decrease in Dimensions of RIB Fabrics



4.2 Abrasion Resistance

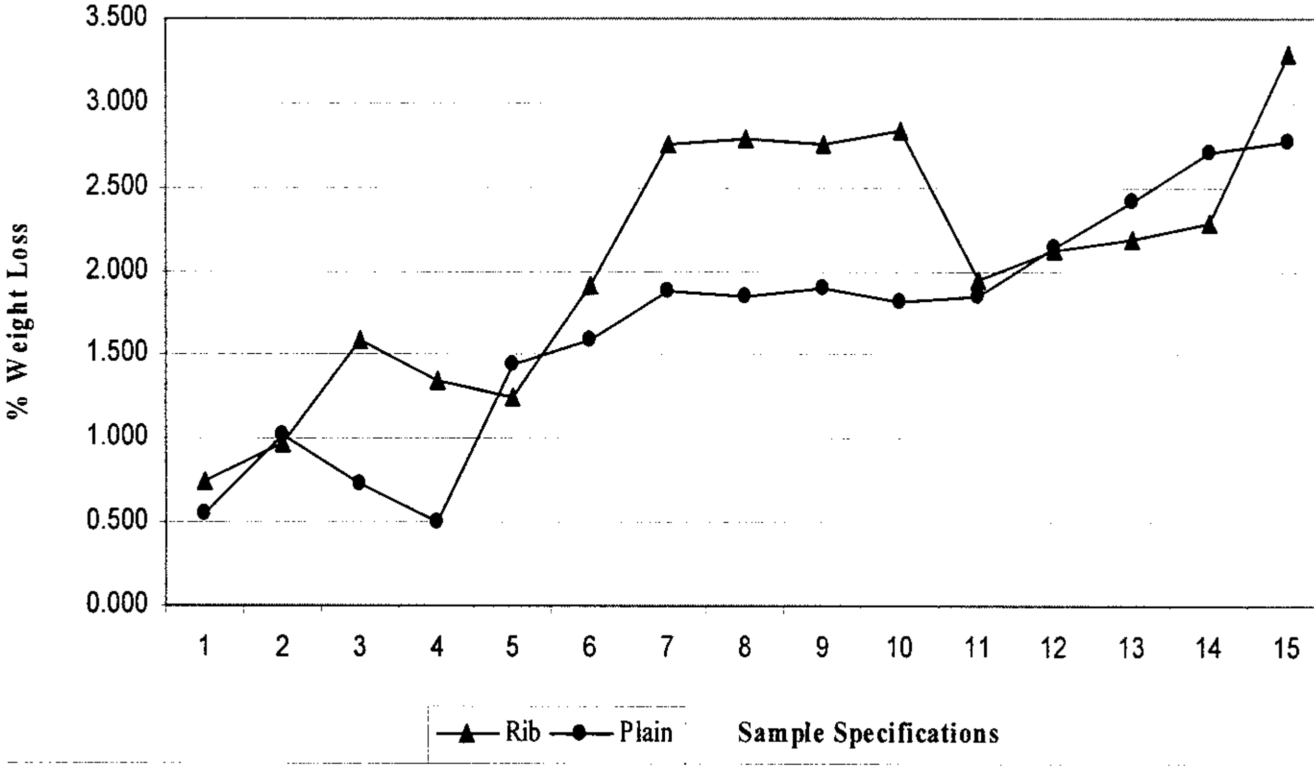
Table 4.2.1 Abrasion Resistance for Plain Fabrics

S. No	Weight of the Sample (g)		% Weight Loss
	Before	After	
1	0.366	0.364	0.546
2	0.39	0.386	1.026
3	0.434	0.433	0.730
4	0.394	0.392	0.508
5	0.207	0.204	1.449
6	0.252	0.248	1.587
7	0.215	0.209	1.879
8	0.214	0.208	1.844
9	0.215	0.209	1.891
10	0.166	0.163	1.807
11	0.162	0.159	1.852
12	0.212	0.209	2.143
13	0.185	0.18	2.415
14	0.175	0.173	2.703
15	0.18	0.175	2.778

Table 4.2.2 Abrasion Resistance for Rib Fabrics

S. No	Weight of the Sample (g)		% Weight Loss
	Before	After	
1	0.535	0.531	0.748
2	0.515	0.51	0.971
3	0.521	0.478	1.583
4	0.446	0.44	1.345
5	0.239	0.236	1.255
6	0.181	0.177	1.910
7	0.266	0.264	2.752
8	0.252	0.25	2.792
9	0.265	0.263	2.755
10	0.247	0.24	2.834
11	0.206	0.202	1.942
12	0.152	0.147	2.124
13	0.175	0.171	2.190
14	0.155	0.153	2.286
15	0.174	0.171	3.289

Fig 4.2 Abrasion Resistance



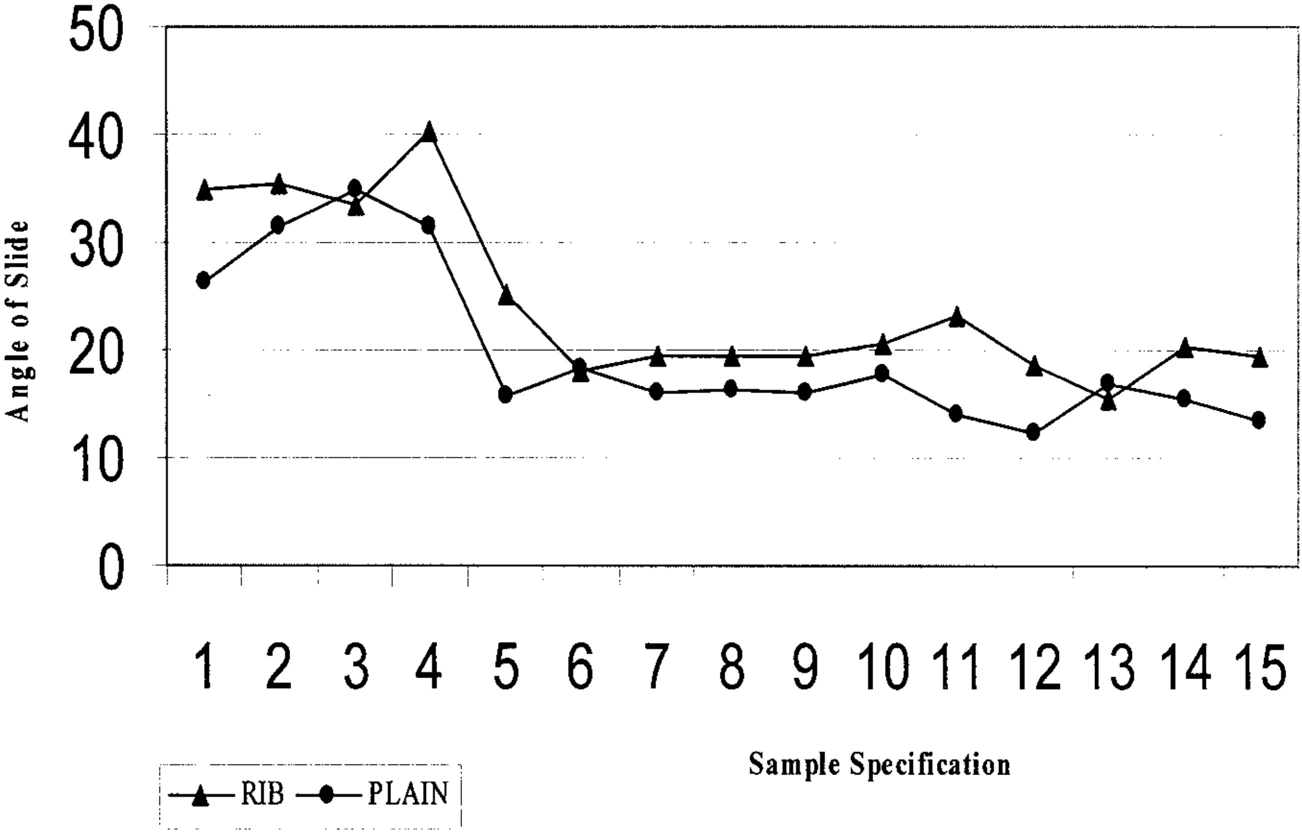
From this graph, we could observe that the fabrics with finer count yarn have experienced a greater amount of weight loss when compared to coarser counts and the samples 5-11 are found to be intermediate. This is observed in both the plain and rib structures. On comparison, plain fabrics have experienced more weight loss than rib fabrics.

4.3 Coefficient of Friction

Table 4.3.1 Coefficient of Friction Values and Angle of Slide

S. No	Values for Plain Fabrics		Values for Rib Fabrics	
	θ	μ	θ	μ
1	26.2	0.492	35	0.700
2	31.3	0.608	35.3	0.708
3	34.8	0.695	33.5	0.662
4	31.3	0.608	40.2	0.845
5	15.8	0.283	25.2	0.471
6	18.2	0.329	18	0.325
7	16	0.287	19.5	0.354
8	16.2	0.291	19.3	0.350
9	16	0.287	19.5	0.354
10	17.8	0.321	20.5	0.374
11	14	0.249	23.2	0.429
12	12.2	0.216	18.5	0.335
13	17	0.306	15.5	0.277
14	15.5	0.277	20.3	0.370
15	13.3	0.236	19.5	0.354

Fig 4.3.1 Angle of Slide



From this fig 4.3.1 and Table 4.3.1, we can understand that the sliding angle is greater for fabrics with coarser count yarns than finer counts. This is because coarser count fabrics have the tendency to hold the sliding material due to their rough surface. This can also be justified as finer count fabrics have less cohesion and a smoother surface.

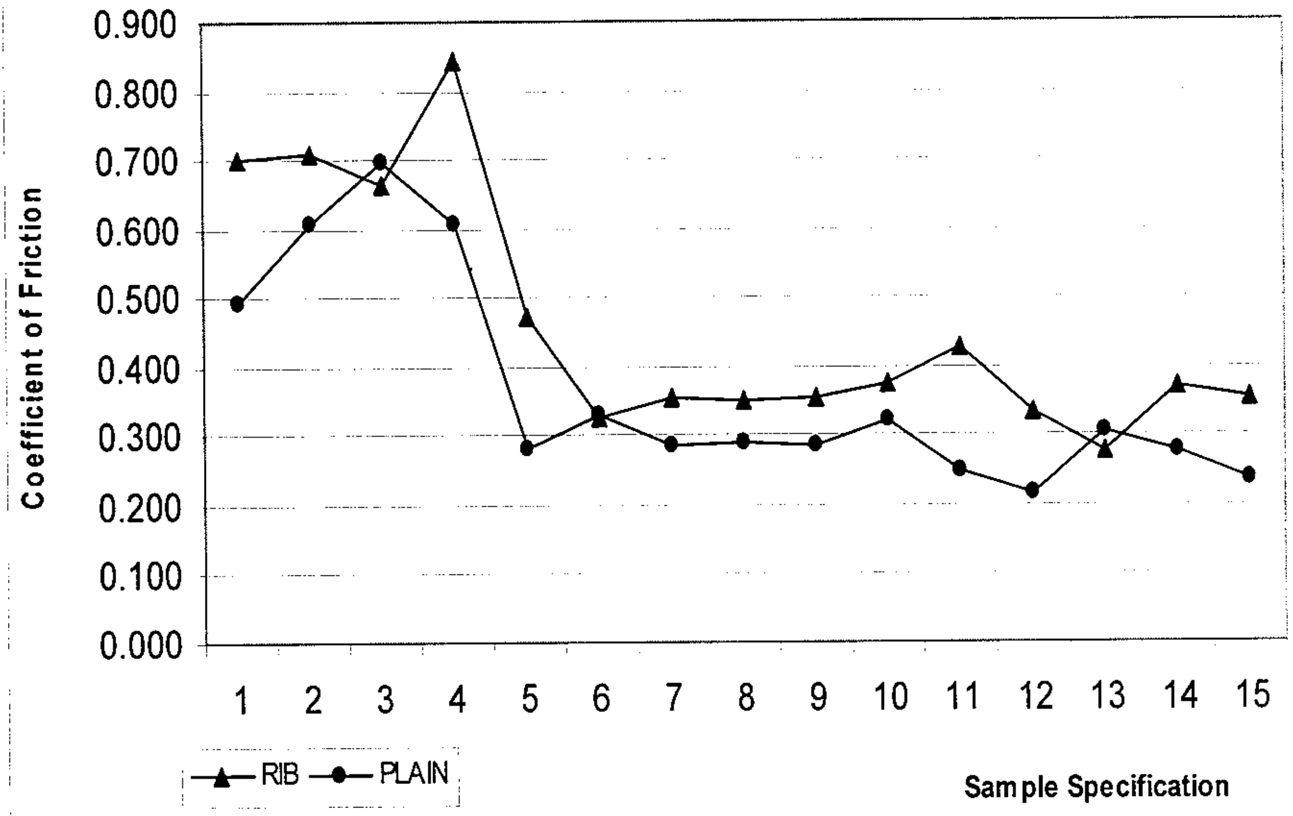


Fig 4.3.2 Fabric Friction

Fig 4.3.2 clearly shows that the coarser count fabrics have more coefficient of friction when compared to finer counts. This is due to the fact that the surface of the coarser count fabrics is rough, more number of hair fibers, and larger area of contact between the yarns. These properties account for more friction in the fabrics having coarser count yarns.

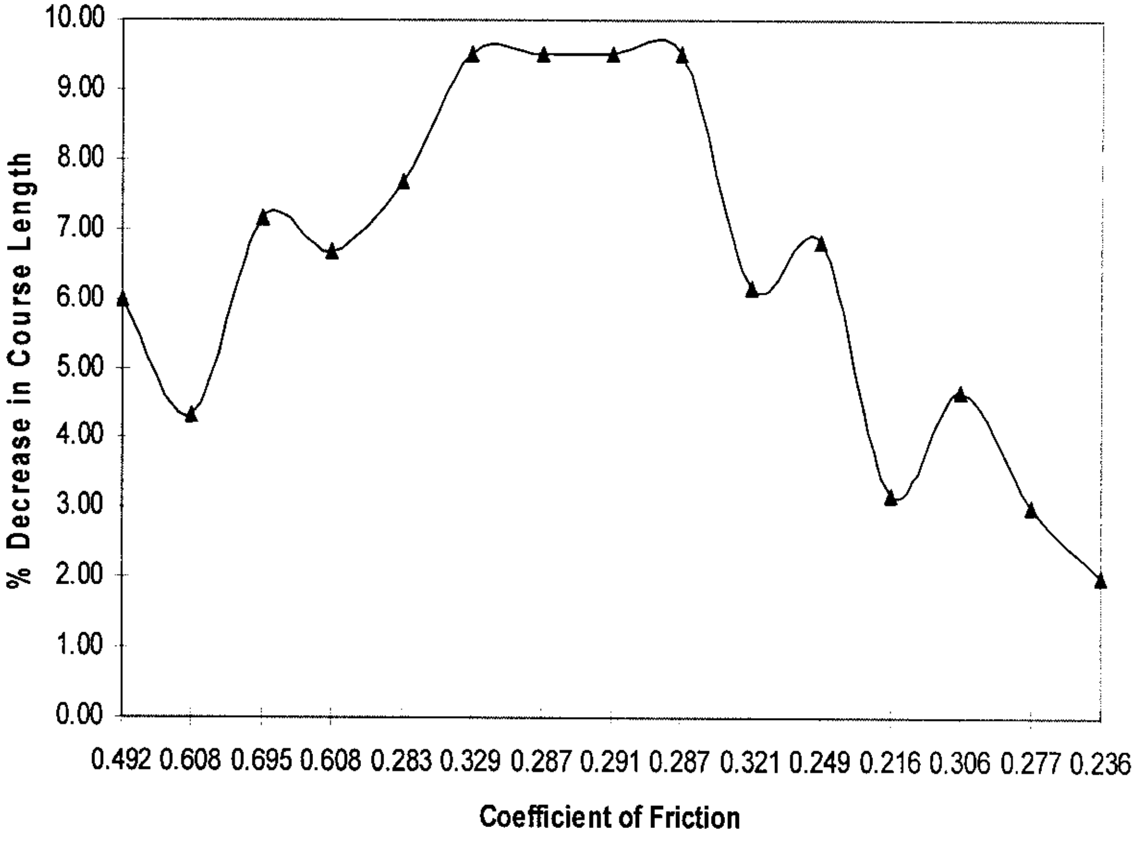
Also, it can be observed that, on comparison, rib fabrics have more friction than plain fabrics. This is because the yarns have a complex structure, which results in more contact points, in rib fabrics.

The coefficient of friction of yarns has a major influence on yarn strength. A low coefficient of friction allows yarns and strands to realign under load, thus redistributing stresses and increasing yarn strength. A high coefficient of friction contributes to the strength and durability of splices. Very high or very low friction can accordingly reduce yarn strength.

Table 4.3.2 Coefficient of Friction and Dimensional Changes in Plain Fabrics

S.No.	Course	Wales	Friction
1	6.00	13.67	0.492
2	4.33	10.83	0.608
3	7.17	14.50	0.695
4	6.67	9.50	0.608
5	7.67	14.33	0.283
6	9.50	9.17	0.329
7	9.50	12.17	0.287
8	9.50	11.83	0.291
9	9.50	10.50	0.287
10	6.17	7.17	0.321
11	6.83	12.83	0.249
12	3.17	7.50	0.216
13	4.67	11.33	0.306
14	3.00	8.67	0.277
15	2.00	5.50	0.236

Fig 4.3.3 Friction Vs % Decrease in Length in Course Direction for Plain Fabrics



Apart from count, twist and denier also influence friction values to a considerable extent. it is also observed that samples 5 – 11 (40s) show decrease in friction values when there is % decrease in course length

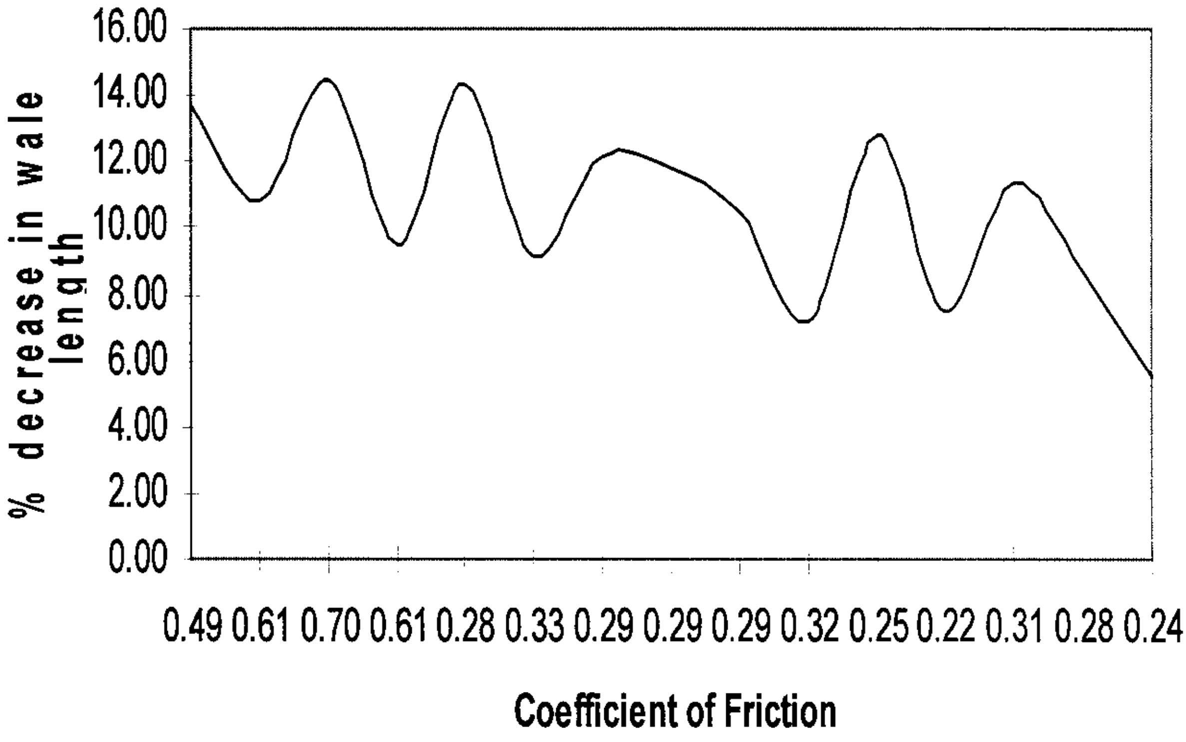


Fig 4.3.4 Friction Vs % decrease in Length in Wale Direction for Plain Fabrics

Table 4.3.3 Coefficient of Friction and Dimensional Changes in Rib Fabrics

S.No.	Course	Wales	Friction
1	9.83	-0.50	0.700
2	13.83	-7.83	0.708
3	14.83	-8.15	0.662
4	9.53	0.50	0.845
5	11.17	-2.33	0.471
6	13.33	-6.33	0.325
7	14.00	-9.17	0.354
8	14.83	-9.50	0.350
9	13.67	-8.83	0.354
10	13.33	-9.83	0.374
11	19.67	-19.33	0.429
12	7.50	2.17	0.335
13	5.17	2.50	0.277
14	9.83	6.50	0.370
15	8.50	2.17	0.354

Fig 4.3.5 Friction Vs % Change in Length in Wales Direction for Rib Fabrics

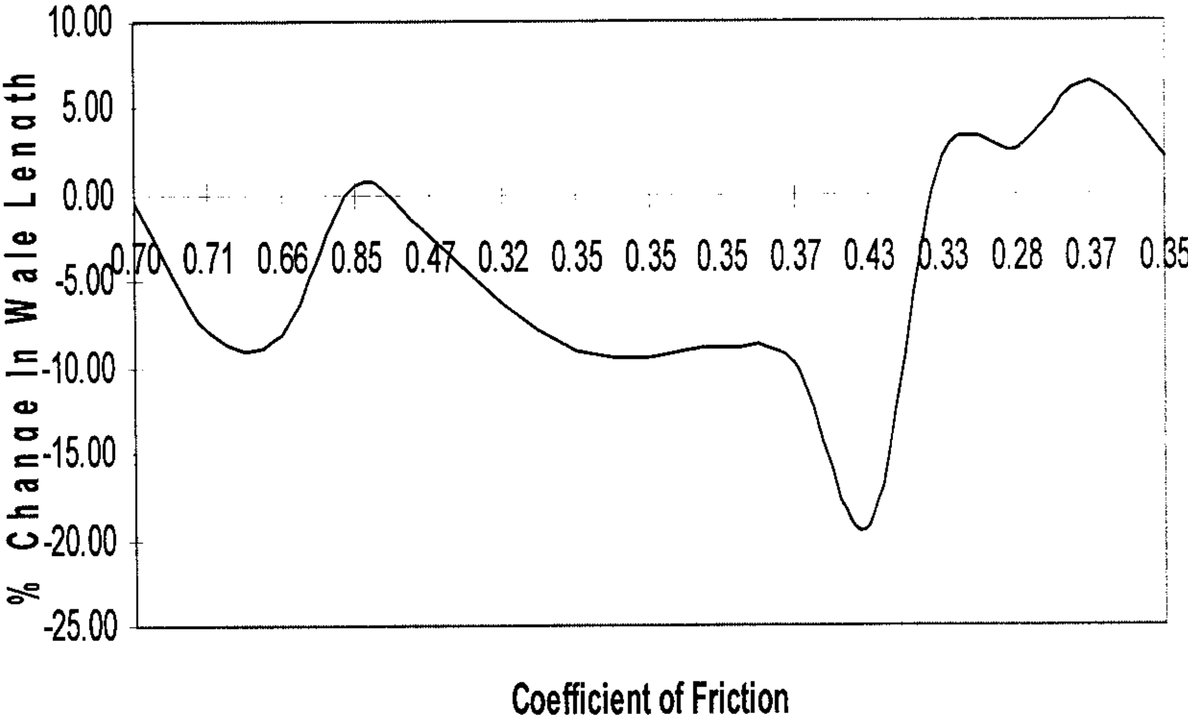
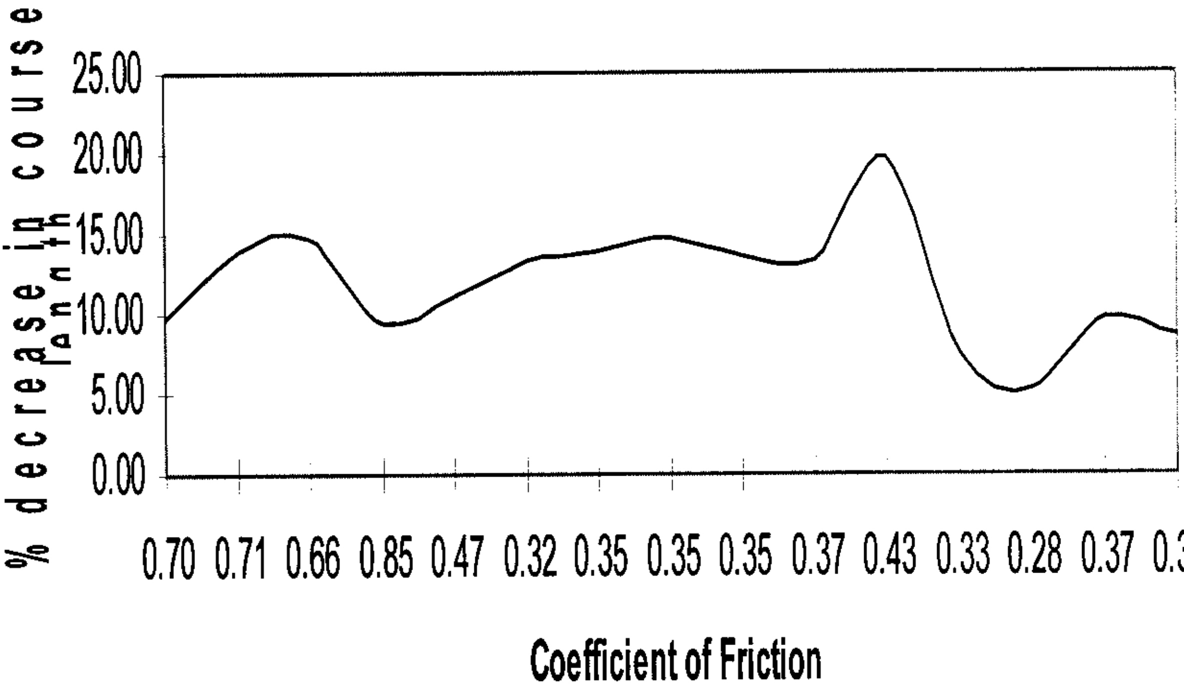


Fig 4.3.6 Friction Vs %decrease in Length in Course Direction for Rib Fabrics



5. CONCLUSION

This project is concluded with the following results,

- Yarns of higher twists have a higher coefficient of friction. This is attributed mainly due to their surface characteristics, with uneven surface characteristics.
- Fabrics with higher coefficient of friction have better resistance to change in dimensions, i.e., they have a better dimensional stability.
- Fabrics with coarser count yarns have a greater coefficient of friction resulting in dimensional stability.
- The sliding angle is greater for fabrics with coarser count yarns than finer counts. This can be justified by the fact that coarser yarns have a larger surface area under contact and hence provide resistance to movement of yarn in the fabrics.
- As the twist increases, the surface friction between the yarn increases, thereby, rendering more stability.

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