A STUDY ON LOW- STRESS PROPERTIES OF VISCOSE / SPANDEX PLATED KNITTED FABRICS

A PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this project report titled **"A STUDY ON LOW-STRESS PROPERTIES OF VISCOSE / SPANDEX PLATED KNITTED FABRICS"** is the bonafide work of **Mrs. SASIREKA.T** who carried out the research under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

For the viva-voce examination held on.....03.07.2006...........

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INTERNAL EXAMINER

03/07/06.

EXTERNAL EXAMINER

ABSTRACT

An increase in need for woven and knitted garments with elastic properties for shape retention, fit and comfort has been gradually rising now a days. This is mainly due to the shift in consumer's preference from durability to comfort and fashion.

One of the main objectives of knitted garments is to provide enough comfort to the human body and required stretch to body movements however; the power of recovery in single jersey fabrics that have been stretched is generally inadequate. To rectify these drawbacks, spandex, an elastane is used along with the base yarn as in core-spun form or through plating during knitting, to impart a greater level of stretch and more dimensional recovery.

Viscose, well known for its highly soft and comfortable nature, luster and drapability is used as a base yarn. Spandex has satisfactory strength, good flexible property, adequate crease and wrinkle recovery where viscose lags. A viscose / spandex plated knitted fabric can be used widely in leisurewear, party wear and active wears due to its comfort, combined with good extensible and recovery property added with high luster and possibility of having vivid colors that gives an added bright look.

In this project, single jersey fabric's are produced from plain viscose yarn and using viscose yarn plated with spandex yarn on alternate feeds and all feeds. The study covers the testing of dimensional and mechanical properties of single jersey knitted fabric. The samples were obtained at three different loop length values representing a range of tight, medium, and loose fabrics. After the sample production, the fabrics are left for dry relaxation for two days at standard atmospheric conditions. After that, grey state testing i.e., Wales per inch, courses per inch, fabric width, loop length and fabric thickness are all measured.

The samples are then subjected to Heat setting accordingly to. their configurations and then washed and tumble dried to make it wet relaxed. The samples are now tested for low-stress properties and they are being compared.

From the work it is found that, as the amount of spandex increases, loop length values remain the same and the Wales per inch values also remains same, where as Courses per inch increases linearly. The lower Loop length full plated Viscose/Spandex knitted fabric is found to be better in many ways. The Full plating Of spandex on Viscose enhanced the properties and this fabric can be better used for active wears, casual wears etc. New applications can also be explored to use this fabric because of its Satisfactory results which will lead to increased use of viscose fibre as an alternative to cotton.

சாராம்சம்

இந்த ஆய்வு அறிக்கையானது நூலினால் ஆன பின்னலாடையின் தன்மையைப் பற்றியதாகும். பின்னலாடையின் தன்மையானது அதன் நூல்கள் மற்றும் பின்னலின் அளவுகள் ஆகியவற்றை பொருத்தே இருக்கிறது.

பின்னலாடையின் முக்கிய குறிக்கோள் அதனை அணிபவருக்கு வசதியாகவும் மற்றும் அவருடைய அசைவுக்கு ஏற்றவாறு நீளும் தன்மையை பெறுவதும் ஆகும். ஆனால் சிங்கிள் ஜெர்சி பின்னலாடையில் நீளும் தன்மையானது மிகவும் குறைவாக உள்ளது. இந்த குறையை நீக்குவதற்காக Spandex யை Viscose அடிப்படை Yarn உடன் சேர்த்து பின்னலாடை இயந்திரத்தல் நெசவு செய்யப்படுகிறது.

Viscose யை அதனுடைய அணியும் வசதிக்காகவும், பளபளக்கும் மற்றும் அதனுடைய மடிப்பு (drapability) தன்மைக்காகவும் அடிப்படை நூலாக உபயோகிக்கிறோம்.

Spandexயை அதனுடைய தேவைக்கேற்ப பலம் மற்றும் நீளம் தன்மையாகவும் உபயோகிக்கிறோம். Viscose, Spandex plated பின்னலாடையை விருந்து, சாதாரணமாகவும் மற்றும் விளையாட்டு நேரங்களிலும் பயன்படுத்தப்படுகிறது.

இந்த ஆய்வில் Viscose மற்றும் Spandex மூன்று விதமான வழிகளில் தயாரிக்கப்பட்டது.

1. நூறு சதவிகித Viscose அனைத்து Feedயிலும்
2. Viscose plated with spandex - அனைத்து Feedயிலும்
3. Viscose plated with spandex - ஒன்று விட்டு ஒன்று Feed யில்

பின்னலாடையினுடைய மாதிரிகள் மூன்று விதமான loop length யில் எடுக்கப்பட்டது.

1. மிகவும் நெருக்கமான பின்னலாடை
2. சாதாரணமான பின்னலாடை
3. மிகவும் தளர்ச்சியான பின்னலாடை

இந்த 9 விதமான பின்னலாடைகளும் Heat set செய்யப்பட்டு, பிறகு கழுவப்பட்டு மீண்டும் dry செய்யப்பட்டது.

பின்னர் அதனுடைய Low stress properties kawabata system யில் ஆய்வு செய்யப்பட்டது.

அதனுடைய முடிவுகளில் இருந்து Viscose/spandex பின்னலாடை மிகவும் குறைவான loop length யில் அதனுடைய தன்மைகள் மிகவும் சிறப்பானதாக உள்ளது. மற்றும் Viscose yarn ஆனது cotton yarnக்கு ஒரு மாற்றாக உபயோகிக்க தகுதியானது என தெரிய வருகிறது.

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CHAPTER 1

1. INTRODUCTION

1.1 OUTLINE OF PROJECT WORK

Fashion in clothing has always been a reflector of ranges in lifestyle and social and economic status. Feel good attitude is rapidly spreading. Today, the discerning consumer wants much more then just a garment, with the most luxurious look and superior comfort is an absolute need, spectrum of bright and vivid colors, comfortable to wear are consumers key purchase criteria. Durability is not given much importance in fashion trends. Due to the influence of fashion, the production of knitted goods has been expanded, with new fabric designs created with different fiber blends and knit structures.

Most RMG'S exported from India are of use and throw category and not wash and wear types, so viscose in spite of its poor wet strength satisfies all the above said requirements. The power of recovery in single jersey fabrics that have been stretched is generally inadequate, and therefore spandex is tried to impart a greater level of stretch and more dimensional recovery than can be achieved with viscose alone. The use of spandex has supposed to result in fabrics that fit better on the body like a second skin.

Textiles worn in direct contact with the skin must, especially with active wears, support the functions of the body. It should be comfort to the wearer defined by fit, elasticity in movement, tailored shape and feel. It should have better moisture absorbency and moisture regain. It should be dimensionally stable. It should have a high luster to *give* a value added look to the wearer. It should have at least the minimum strength.

The ongoing influence of casual clothing of lifestyle is boosting the popularity of spandex containing garment. Casual work attire becomes more popular; spandex allows these types of garments m ore comfort.

Viscose provides high moisture regain, very good thermal protection, good air permeability, very good softness, very good drape, ant pilling etc. Additionally spandex provides a greater degree of wear ability, wrinkle recovery and crease retention where *viscose* lacks making it the perfect compliment to garments.

In this project, studies have been done on low-stress mechanical properties of knitted fabrics of three varieties namely plain *viscose* fabric, half spandex plated *viscose* fabric, and all feeder spandex plated *viscose* fabric. Effect of spandex and its amount on knitted fabric is tested. The loop length and amount of spandex are used to determine the dimensions and properties of the knits.

1.2 OBJECT OF THE PROJECT

Today's clothing trend needs a perfect blend of comfort, fit, style, wrinkle resistance etc, so to make a garment in that fashion *viscose* and spandex combination is found to be best suit and this area is not potentially used. In this project this combination is tried and the performance is evaluated.

1.3 REVIEW OF THE LITERATURE

1.3.1 Garment Needs

Fashion, comfort, fit, extensibility are some of the key factors during purchase of a garment. Generally cotton is best preferred for its comfort and polyester for its durability. Viscose well known for its moisture absorbency, luster and comfort has its own market but with a small share due to its poor wet strength, in efficient crease recovery. So an ideal use of spandex will help the fabric in inheriting the advantages of both viscose and spandex in this case.

The garments made out of the fabrics consisting of spandex provide consistent shape, fit and comfort. These properties also help to develop the garments for "ready to wear". Because of the above properties, spandex fibers are found in light weight end uses especially in swim wear, sports wear, light weight support garments, ladies inner wear etc.,

Knitting is the process of making cloth with a single yarn or set of yarns moving in only one direction. Instead of two sets of yarns crossing each other as in weaving, the single knitting yarn is looped through itself to make a chain of stitches. These chains or rows are connected side by side to produce the knit cloth.

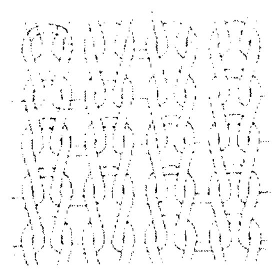
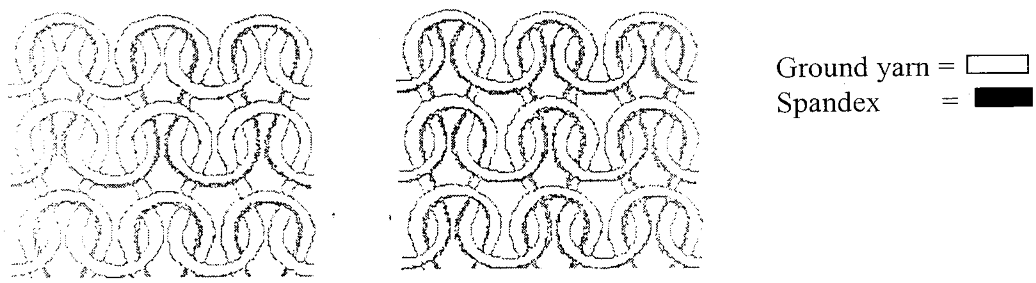


Figure 1.1 Knit fabric

1.3.2 Plated Fabrics

Daniels and Mc Intyre (1995) define plated fabrics as "A fabric knitted from two yarns of different properties, both of which are used in the same loop whilst positioned one behind the other. The special feature of the fabric is that each loop exhibits the characteristics of one yarn on the face side and the characteristics of the other yarn on the reverse side".



(a) (b)

Figure 1.2 Loop diagrams of Viscose/Spandex Jersey Fabrics
(a) In alternating courses (half plating), (b) In every course (full plating).

In the plating process, two separate yarns are fed into the knitting machine at the same time. The two yarns are in the same loop, one behind the other. By varying the type of yarn interesting effects can be achieved. One yarn is face yarn and the other is backing yarn as explained by Billie j. collier and Phyllis (2000).

Edward Menezes (2002) explains that Lycra can be laid in between rows of knitting, or knitted into every stitch, the later producing superb fit and uniformity.

A.Mukhopadhyay et al (2003) provides the experimental result as overall performance of Lycra blended fabrics is better than that of non-lycra cotton fabrics as the immediate recovery; resiliency and extension at peak load are higher, whereas delayed recovery and permanent set are lower for Lycra blended fabrics, irrespective of the direction of loading.

1.3.3 Properties of Viscose

Viscose rayon has a silk-like aesthetic with superb drape, feels and retains its rich colors. Its cellulosic base contributes many properties similar to those of cotton or other cellulosic fibers. Rayon is moisture absorbent (more so than cotton), breathable, comfort to wear, and easily dyed in vivid colors. It does not build up static electricity, soft to skin and has moderate dry strength and abrasion resistance, moderate resistance to acids and alkalis. Rayon will burn, but flame retardant finishes can be applied.

Viscose originates from regenerated cellulose sodium xanthate by wet spinning, with a tenacity varying between 1.8 to 2.4 grams per denier, with a extension at break varying from 16 to 20 %. Elastic recovery of viscose is poor compared to polyester and moreover equal to cotton. Viscose is made with a density of 1.52, mean refractive index value 1.534, moisture regain 11 % and with a dry/wet strength of 50%. Crystallinity is moderate with good resistance to heat, light, mildew and moths compared to cotton and polyester as suggested by F.T. Word (1947).

Grasim Technical Service Manual (1984) contains that Cotton and other natural cellulosic fibers have little inherent elasticity. Viscose at 2 % extension has an elastic recovery of about 60 %. Reduced crytallinity of cellulose in viscose staple fiber renders the fiber more responsive to water penetration. It will absorb twice as much water vapor from air as cotton does. When soaked in water, *viscose* staple fiber swells double its original volume. Viscose begins to Iose strength at 150 degree Celsius after prolonged heating. It gets charred at about 185 degree Celsius to 250 degree Celsius without melting.

It is also stated that crystalline areas decide modulus of elasticity, rigidity and tensile strength of the fiber, while the amorphous regions are responsible for flexibility, recovery, elongation and swelling. Therefore, low degree of crytallinity leads to low elasticity and wet strength in *viscose* fibers. The molecular alignment and their degree of crystallinity is not as high as in cotton.

J.F.Clark and J.M.Preston (1956) put forward to account the effects of temperature on wet viscose rayon as,

1. Swelling is a minimum between 50°C and 60° C
2. Breaking load starts to fall rapidly with rise of temperature above about 55° C
3. Breaking extension is a maximum between 50° C and 60° C
4. The rate of relaxation of stress in a stretched fiber increases sharply above about 55° C

These things have to be taken into account during dyeing or wet relaxing and laundering of viscose rayon fabrics.

1.3.4 Properties of Spandex

According to ISO 2076 or DIN 60001, elastane fibers "described by the generic name spandex" are synthetic fibers composed of linear macro~ molecules with at least 85% by mass, being segmented polyurethane as illustrated by H.U.Bhonde (2002).

He also narrates that elastane is insensitive to hydrolytic effects during normal washing and handling, and is unaffected by the use of normal solvents (e.g. perchloroethylene or benzene) during dry cleaning. Resistance to chlorinated water at concentrations of active chlorine typically found in swimming baths is good. Elastane yarns have good affinity for various classes of dyestuffs.

www.Dupont.com informs that spandex belongs to the generic elastane classification of man-made fibers. It is segmented polyurethane composed of soft or flexible segments Bonded together with hard or rigid segments giving lasting elasticity. The highly resilient elongation is the result of the combination of these two segments. It can be stretched four to seven times its initial length, yet springs back to its original length once tension is released. While spandex appears to be a single continuous thread, it is in reality a bundle of tiny filaments.

The hard segment consists of polyurethane, which is cross-linked crystalline and polar. The hard segments provide mechanical stability and flexibility.

The soft segment consists of polyol (polyester or polyether). These segments are easily deformed producing high extensions under low stress, which determines the high elongation. Few properties of spandex are high resilient, elongation, high modulus, good elastic recovery, mechanical stability and flexibility.

1.3.5 Loop Length, Shape and its Effects

Weft knitted structures has unique properties of form-fitting and elastic recovery based on the ability of knitted loops to change shape when subjected to tension. Unfortunately, dimensional changes can also occur during production, or washing and wearing.

Three basic laws governing the behavior of knitted structure are:

1. Loop length is the fundamental unit of weft knitted structure.
2. Loop shape determines the dimensions of the fabric, and this shape depends upon the yarn used and the treatment that the fabric has received.
3. The relationship between loop shape and loop length may be expressed in the form of simple equations.

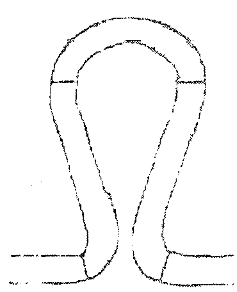


Figure 1.3 The Loop

Loop lengths combine in the form of course lengths and it is these that influence fabric dimensions and other properties, including weight. With the exacting demands of modern knitting technology, the need to maintain a constant loop length at one feed for long periods of time between one feed and another on the same machine, and between different machines knitting the same structure has become of major importance in the control of fabric quality.

The loop structure of a knit fabric changes as relaxation treatment progress. The contribution of the dry relaxation process to the dimensional stability of the fabrics is quite slow when compared to the laundering and tumble-drying treatments

F.T.Pierce (1947) derived the equations for length of yarn in one stitch and for weight per unit area,

I. Length of yarn L, in a unit cell: $L = 2p + w + 5.94d$ ----- 1.1

II. Weight W, per unit area of cloth: $W = Lg / wp$ ----- 1.2

Where

p = course spacing

w = wale spacing

g = weight per unit length of yarn

d = diameter of the yarn

P.J.Doyle (1953) was the first to show that the total number of loops per square unit of fabric was independent of the yarn material, structure, and system of knitting and dependent only on loop length.

For Munden (1959), a relaxed fabric has a definite configuration, and the fabric dimensions depend only on the stitch length and material. Therefore, fabric geometry has no relation to tightness and yarn physical properties.

Postle and Munden (1967) theoretically and Knapton (1968) experimentally brought to light the influence of yarn diameter relative to stitch length, i.e., the tightness or cover factor, on the loop shape.

According to J.J.F. Knapton et al (1968), W.E.Shinn (1955)15 and W.Zurek et al (1986), fabric thickness doesn't change with regard to stitch length.

Mohammed and Abou (2001) studied that fabric dimensional properties and found that the length of yarn in a loop is the dominating fact in controlling fabric dimensions.

A. Bayazit Marmarali (2003) studied the dimensional and physical properties of cotton/spandex single jersey fabrics and the results are compared with plain cotton knits. The loop length and the amount of spandex are used to determine the dimensions and properties of the knits. It is apparent that as amount of spandex increases, loop length remains nearly the same and the course and wale spacing values decrease. It is found that the amount of spandex and loop length influences the weight, thickness and low stress properties of fabrics.

D.L.Munden's (1959) major assumption is that the knitted loop, being a geometrically determined shape, takes up its shape in space independently of the yarn's physical properties or the mechanisms governing loop formation. Thus twist, fiber quality, elastic rigidity, etc, must have no effect on fabric dimensional properties.

D.L. Munden (1959) discussed the difficulties encountered in attempting to obtain relationship between the dimensions of knitted fabrics, the properties of the constituent yarns and the variable factors in knitting. It is suggested that the natural shape of the knitted loop is determined by minimum energy conditions, that the loop tends to this state on relaxation and that this shape is independent of the properties of the yarn or length of stitch. He found experimentally that the dimensional and weight properties of the knitted fabric in a relaxed state are determined uniquely by the length of yarn in the stitch and the width of a fabric in a relaxed state is dependent solely upon the length of yarn knitted into the course and is independent of the number of needles used to produce the fabric.

Nutting T. S. and Leaf G. A. V (1963) suggested that the loop shape was largely dependent on the ratio *FIG,* where, F and G are the yarn's flexural and torsional rigidities, respectively, but they did not support this theoretical conclusion with specific experimental evidence.

T.Dias et al (2002) investigated the tension build-up of the yarn on its way from the yarn package to the storage yarn feed wheel. The results show that the stitch length is largely affected by the winding tension to the storage yarn feed wheel.

Marie-Ange Bueno et al (2004) studied that even if yarn physical properties and knitting process have a very small influence on fabric geometric characteristics relative to stitch length and fabric tightness, the effect must not be neglected on fabric roughness and thickness, i.e., the 3D loop shape. Even a very small change in loop shape can change fabric tactility and quality. After full relaxation, the loop shape depends on yarn characteristics, stitch length, and tensile stress wale wise due to the knitting process. It is also concluded that the yarn bending rigidity and inter yarn friction co-efficient are very important for loop shape.

When bending rigidity decreases and the frictional co-efficient increases, tensile stress in the knitting process is more influential. Any modification of fiber fineness or yarn structure affects yarn bending rigidity and the therefore yarn behavior during fabric relaxation. The influence of these parameters on fabric tactility cannot be neglected.

1.3.6 Low - Stress Properties of Fabric

It is generally agreed that the stimuli leading to the psychological response of fabric handle are entirely determined by the physical and mechanical properties of fabrics. IN particular the properties of a fabric that affect its handle are dependent on its behaviour at low loads an extensions and not at the level of load and extension at which fabric failure occurs. It is this region of fabric behaviour that had traditionally been measured and for which specifications have been written.

Subjective assessment of fabric handle

The first part of Kawabata's work was to find agreement among experts on what aspects of handle were important and how each aspect contributed to the overall rating of the fabric. For each category of fabric four or five properties such as stiffness, smoothness and fullness were identified and given the title of primary hand. The original Japanese terms for primary hand together with their approximate English meaning are shown in Table 1.4. These terms demonstrate the difficulty of describing handle and the apparent overlap of some of the terms used.

Primary hand values were rated on a ten point scale where ten is a high value of that property and one is its opposite. The properties that are regarded as primary hand and the values of these that are considered satisfactory differ among fabric categories such as men's summer suiting, men's winter suiting and ladies' dress fabrics. Some of the properties considered primary for these categories are shown in Tables 10.2 – 10.4. The primary hand values are combined to give an overall rating for the fabric in its category. This is known as the total value and it is rated on five point scale where fir is the best rating. The primary hand values are converted to a total hand value using a translation equation for a particular fabric category which has been determined empirically.

A problem with the system as originally conceived is that of there being a 'best' fabric in each category; that is, a fabric that scored the maximum points for total hand value in a particular category would be universally regarded as the best fabric that could be produced for that end use. It has been found [19] that although this may be true within one country there are differences between countries in their perception of the mix of properties required for a particular end use.

Objective evaluation of fabric handle

The second stage of Kawabata's work was to produce a set of instruments with which to measure the appropriate fabric properties and then to correlate these measurements with the subjective assessment of handle. The aim was that the system would then enable any operator to measure reproducibly the total hand value of a fabric.

The system which was produced is known as the KESF system and consists of four specialized instruments.

FBI Tensile and shearing
FBI Bending
FBI Compression
FBI Surface friction and variation

These instruments measure the tensile, compression, shear and bending properties of the fabric together with the surface roughness and friction. A total of 16 parameters are measured, all at low levels of force, which are intended to mimic the actual fabric deformations found is use. The quantities measured are listed in Table 10.5

The properties are measured in the following ways.

The tensile properties are measured by plotting the force extension curve between zero and a maximum force of 500gf/cm (4.9N.cm), the recover curve as the sample is allowed to return to its original length is also plotted to give the paid of curves shown in Fig. 1.4 . From these curves the following values are calculated:

Tensile energy WT = the area under the load strain curve (load increasing) --- 1.3

$$\text{Linearity LT} = \frac{\text{WT}}{\text{area triangle OAB}} \quad \text{---- 1.4}$$

$$\text{Resilience RT} = \frac{\text{area under load decreasing curve}}{\text{WT}} \text{ X } 100\% \quad \text{----- 1.5}$$

The compressional properties are measured by placing the sample between two plates and increasing the pressure while continuously monitoring the sample thickness up to a maximum pressure of $50gf/cm^2$ ($0.49N/cm^2$). The quantities LC, WC and RC are then calculated in the same manner as LT, WT and RT above.

In order to measure the shear properties a sample of dimensions 5 cm x 20 cm is sheared parallel to its long axis keeping a constant tension of 10gf / cm (98.1 mN/cm) on the clamp. The following quantities are then measured from the curve as shown in Fig. 1.5.

Shear stiffness G = slope of shear force - shear strain curve

Force hysteresis at shear angle of 0.5^0 2HG = hysteresis width of curve at 0.5^0

Force hysteresis at shear angle of 5° 2HG5 = hysteresis width of curve at 5°

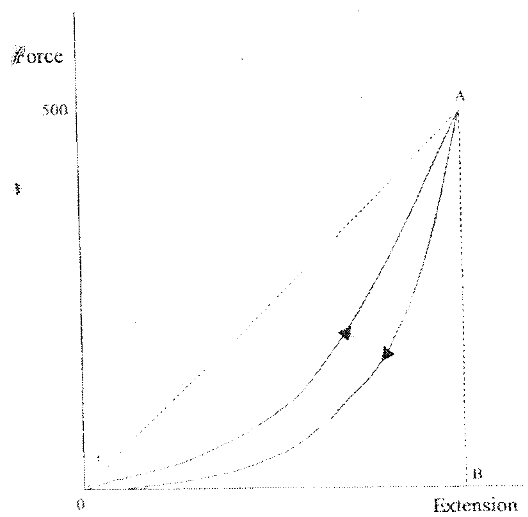
In order to measure the bending properties of the fabric the sample is bent between the curvatures - 2.5 and 2.5 cm^{-1} the radius of the bend being l/curvature as shown in Fig. 1.6. The bending moment required to give to curvature is continuously monitored to give the curve shown in Fig. 1.7. The following quantities are measured from this curve:

Bending rigidity B = slope of the bending moment - curvature curve

Moment of hysteresis 2HB = hysteresis width of the curve

The surface roughness is measured by pulling across the surface a steel wire 0.5mm in diameter which is bent into a U shape as shown in Fig. 1.8.

Physical testing of textiles



1.4 Load extension curves for KES-F

The contact force that the wire makes with the surface is 10gf (98.1 mN). A plot of the height variation against distance is shown in Fig. The value that is measured is SMD = mean deviation of surface roughness.

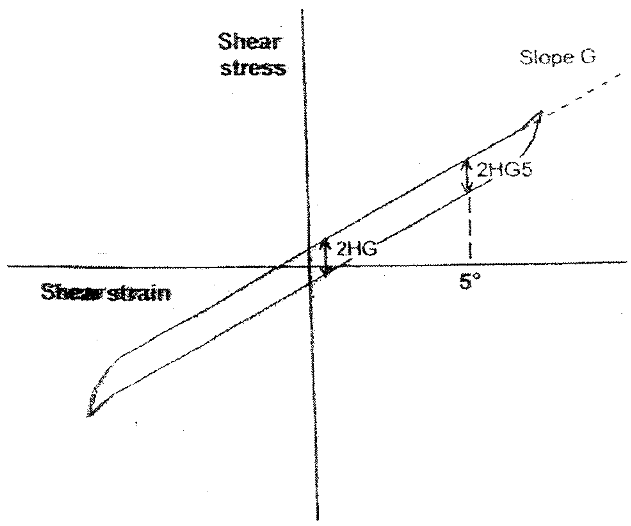
The surface friction is measured in a similar way by using a contactor which consists of ten pieces of the same wire as above as is shown in Fig. A contact force of 50 gf is used in this case and the force required to pull the fabric past the contactor is measured.

A plot of friction against distance traveled is shown in Fig. From which the following values are calculated:

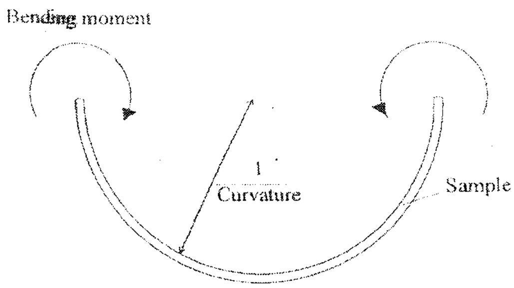
MIU = mean value of coefficient of friction

MMD = mean deviation of coefficient of friction

All these measurements are then converted into primary hand values by a set of translation equations and the total hand values are then calculated from these primary hand values by the use of a second translation equation. Typical results for a summer suiting fabric are shown in Table 10.6



1.5 Shear curve for KESF.



1.6 Forces involved in fabric bending.

The results can also be displayed in the from of a chart as shown diagrammatically in Fig. 10.31. Here the results have been normalized by the standard deviation of each of the corresponding characteristic values of hand values using the following relationship:

$$x = \frac{(X \ \overline{X})}{\sigma} \qquad \text{------- 1 .6}$$

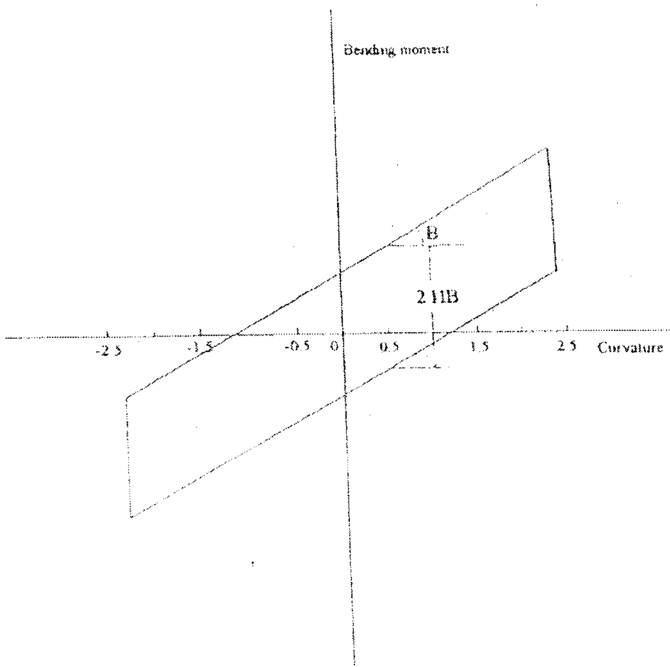
where: x = normalized mean.

X = measured parameter.

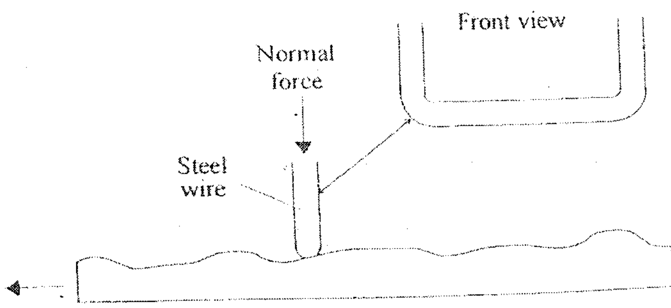
X = mean value of property for typical fabric.

σ = Standard deviation of property for typical fabric

By normalising the results they can all be plotted on the same scale. If the values n the chart are joined together a 'snake' chart is produced from which it can be readily seen which fabrics differ from the average. Guidelines can then be drawn on the chart as in showing the good zone into which the parameters of high-quality fabrics fall.



10.26 Plot of bending moment against curvature.



10.27 Surface roughness measurement.

1.3.7 Heat Setting and its Effects

R.Meredith (1971) states that the ability of spandex yarns to be heat-set is of considerable technological importance. As a result of heat treatment, the amount of available stretch and power may be adjusted to suit a given application. Temperatures of 180° C or more are required to produce substantial amounts of set.

Wet relaxation generally reduces the degree of set induced by heat treatment. The strength of the spandex yarns begins to fall after heatsetting at 150°C, and the breaking extension rises rapidly for heat-setting temperatures greater than 180°C.

American dyestuff reporter writes (1964) Heat setting is holding a fabric extended and heating it until it doesn't retract as much as previously. Physically, molecular slippage or break down has taken place in the spandex relieving the stress. Heat settability can be a help in over-coming the modulus disadvantage inherent in using bare spandex as compared to covered spandex.

A high set spandex has limitations but can have some advantages. If it is heat settable and has high modulus, when it is used bare in a fabric, these characteristics lead to:

a. Easy flat finishing and equalization of tension differentials.
b. Sheer fabrics from lighter yarns in constructions where hard fiber yarn must hold out the fabric.
c. High yield of fabric.
d. Fair power with bare spandex

M.Y.Gudiyawar (2003) subjected the synthetic fabrics to the process of heat setting before pulling them into the end use. The heat setting conditions like temperature, time and tension affect many mechanical properties of the fabric

CHAPTER 2

2. METHODOLOGY AND EXPERIMENTAL PLAN

2.1 Methodology

The following procedures and machineries are used to prepare the samples

Procurement of Birla *viscose* staple fiber: 1.2 Denier, 40mm cut length, and 30 Denier spandex yarn.

↓

Spinning of 30's NE Viscose yarn at TPI=18.8, TM=3.4

↓

Waxing, clearing and winding the viscose yarn into 54 Cones of each 1.5 kg using schlafhorst Auto coner

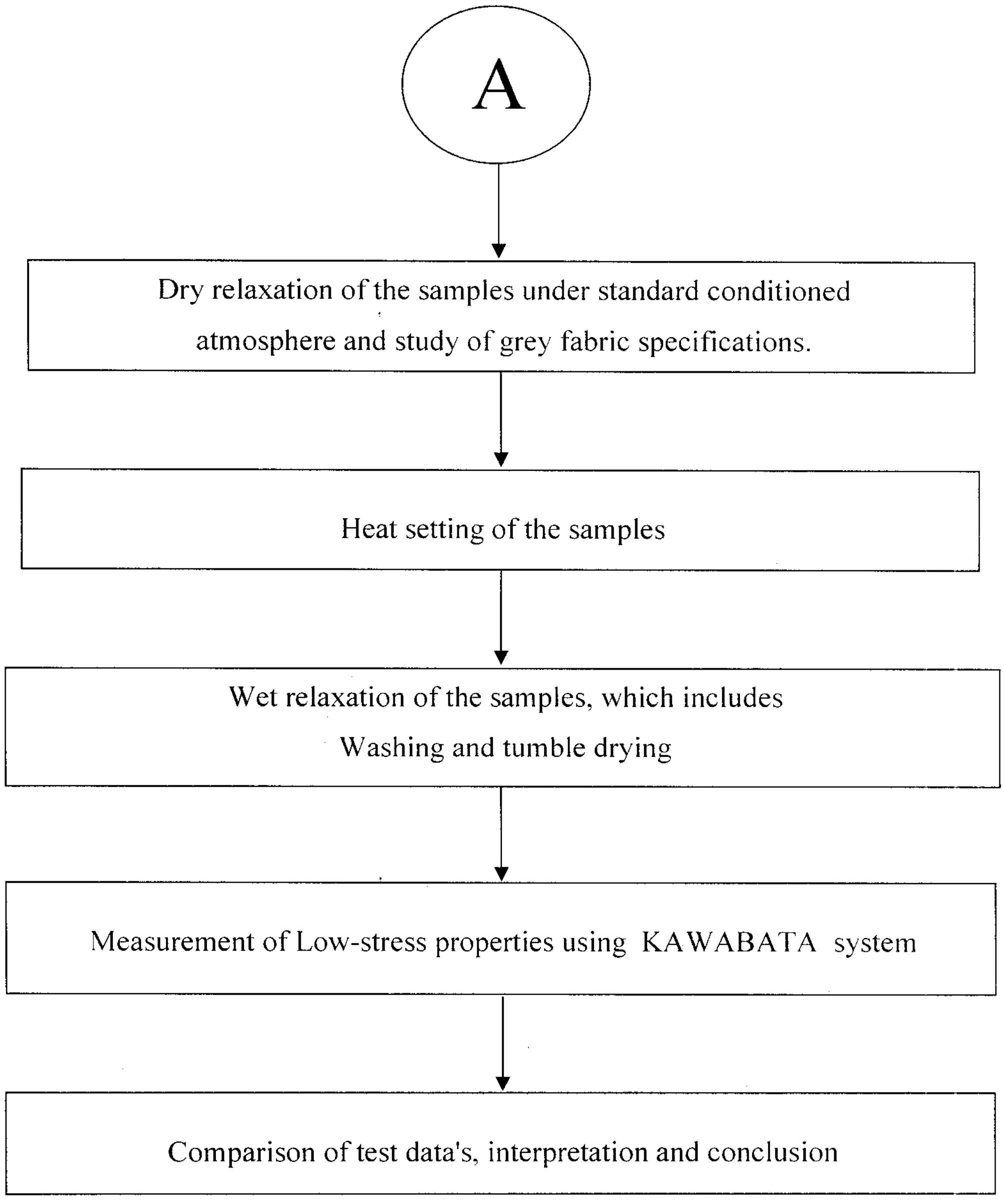
↓

Production of single jersey knitted fabrics at different loop lengths and at different constructions as

i. 100% viscose single jersey fabric
ii. viscose/spandex single jersey fabric with spandex in alternating courses
iii. viscose/spandex single jersey fabric with spandex in every course

↓

A


A
Dry relaxation of the samples under standard conditioned atmosphere and study of grey fabric specifications.
Heat setting of the samples
Wet relaxation of the samples, which includes Washing and tumble drying
Measurement of Low-stress properties using KAWABATA system
Comparison of test data's, interpretation and conclusion

2.2 EXPERIMENTAL PLAN

In order to study the dimensional and mechanical properties of viscose / spandex plated knitted fabrics the following tasks were performed

2.2.1 Fiber Details

Fiber	:	Birla Viscose Fiber
Denier	:	1.2
Cut Length	:	40 cm
Origin	:	Cellulose regenerated from Cellulose sodium Xanthate by wet spinning

2.2.2 Yarn Details

30/1 NE Viscose yarn

30 Denier Spandex yarn

Characteristics of Viscose Yarn

COUNT REPORT	
Actual Count [NE]	29.98
Count C.V%	0.90%
Actual Strength [lbs]	84.51
Lea Strength C.V%	2.85%
C.S.P	2533

USTER UT4 RESULTS	
U %	9.9
CVM %	12.5
Thin [-50%]	0.5
Thick [+50%]	4.9
Neps [200%]	37.9
Total IMP/ KMTR	43.3
Hairiness Index	6.41
SH	1.69
Actual TPI / TPM	18.71/ 736
TM	3.4
Direction of Twist	Z
TPI CV%	1.20%

USTER CLASIMATE 3 RESULTS	
Objectionable Faults [A4 +B4+C3+C4+D3+D4]	0.8
Long Thick Faults [E+F+G]	0.5
Long Thin Faults [H1+H2+I1+I2]	11
Total Faults [A1 to D4 +E+F+G+H1,2+I1,2]	185.3

STS RESULTS	
Breaking Strength in Gms	297.2 / 304.2
Elongation%	13.86 / 13.72
Elongation CV%	8.46% / 9.01%
RKM	15.09 / 15.45
RKM CV%	7.62 % / 7.70%

Characteristics of Spandex Yarn

Brand	Texlon
Grade	AA
Luster	Clear
Linear Density	30 Denier
Tenacity	8.0 CN /Tex
Elongation at Break %	608%
Elastic Recovery after 5 cycles 300% (%)	92.60%

2.2.3 Winding

It is the process of reversing yarn from the spin cops into cones of required amount and tension. The yarns from the spin cops are cleared for faults, waxed and wound on to 54 cones (baby cones) each weighing 300 grams using a schlafhorst auto caner winding machine.

2.2.4 Fabric Knitting

The fabric was knitted on a circular knitting machine.

Knitting Machine details

M/C Make	Fukahama Machinery co
M/C Type	SH-2XFA
M/C Year	Apr 2003
Diameter	20”
Gauge	24
Total Needle Count	1500
Number of Feeders Available	60
Number of Feeders Used	54
Knitting Speed	30 RPM
Yarn Feeding system	Fukahama DG / 24 V

Spandex Feeding

Tension	5 grams
Feed System	Memminger-IRO MER 2 SYSTEM

The yarn is knitted into a plain viscose single jersey fabric, a half plated viscose / spandex single jersey fabric, and a full plated viscose / spandex single jersey fabric with varying loop length values to represent different tightness levels.

The various samples knitted are as shown in the table

Sample No .	**Configuration**	**Loop length (mm)**
1	Plain viscose S.J fabric	2.7 mm
2	Plain viscose S.J fabric	2.9 r1)m
3	Plain viscose S.J fabric	3.1 mm
4	Half plated viscose / spandex S.J fabric	2.7 mm
5	Half plated viscose *I* spandex S.J fabric	2.9 mm
6	Half plated viscose *I* spandex S.J fabric	3.1 mm
7	Full plated *viscose I* spandex S.J fabric	2.7 mm
8	Full plated viscose *I* spandex S.J fabric	2.9 mm
9	Full plated viscose *I* spandex S.J fabric	3.1 mm

S.J Single jersey

2.2.5 Dry Relaxation

The knitted samples were relaxed in grey stage and conditioned in standard atmosphere. The standard atmosphere for testing textiles is, air maintained at a relative humidity of 65 ± 2% and at a temperature of 21 ± 1°C (70 ± 2 ° F) in a conditioning room for two days.

Reference

- ASTM: D 1776 90 (Re approved 1996)
- ISO 139

2.2.5.1 Study of Grey fabric specifications

2.2.5.1.1 Measurement of Wales and courses per inch

Fabric samples are taken and laid flat on a table. Creases and wrinkles are removed without distorting. On one side of the test specimen, with the help of pick glass or magnifying glass, the Wales per inch and courses per inch are counted. Five such readings are taken and the average is accounted.

Reference

- BS 5441 section Two: clause 8: 1988
- CAN CGSB 4.2: NO 7 M 88
- ASTM D 3887: 1996

2.2.5.1.2 Measurement of loop length

It is the length of yarn in mm for one loop

$$\text{Loop Length} = \frac{\text{Length of yarn in mm}}{\text{Known number of wale}} \rightarrow (2.1)$$

The loop value is measured by taking 50 Wales. 50 Wales are marked on the fabric surface and then the yarn for that particular place is unraveled, straightened (not stretched) and measured in mm. by substituting the measured values in the above formula, the loop length is measured.

2.2.6 Heat Setting

The fabric is stretched to the required level and set permanently by passing through the heating and curing chamber, by maintaining the required temperature. This is done to relieve the knitting stresses and to permanently set the fabric at required levels.

2.2.6.1 Heat Setting Conditions

i. Plain viscose single jersey fabric

Stretch = Fabric Ideal Diameter + 3%

Temperature = 160°C

Rpm = 6

Time = 4.8 sec

ii. Half plated fabric

Stretch = Fabric Ideal Diameter + 12%

Temperature = 190°C

Rpm = 5

Time = 4.2 sec

iii. Full plated

Stretch = Fabric Ideal Diameter +18%

Temperature = 210°C

Rpm = 3.3

Time = 3.3 see

2.2.7 Wet Relaxation

The wet relaxing includes washing, tumble drying and then relaxing the fabric at atmospheric condition.

Washing Process Parameters

Machine	:	Ramsons-Drum type washing machine
Temp	:	Cold Wash
Time	:	10 Min
Water Level	:	500 Lit
Wetting Agent:		35 % conc.,50ml wetting oil.

Tumble Drying Process Parameters

Machine : Ramsons Tumble dryer

Time taken : 1 hour 15 minutes

Temp : 95°C

Start Temp : 60°C

2.2.7.1 Fabric Specification after Wet Relaxation

The measurement of Wales per inch, Courses per inch and loop length of the fabric are done as before.

2.2.7.2 Measurement of Thickness

Thickness

Perpendicular distance between two reference plates exerting a pressure of 1 K Pa or less on textiles

Thickness is measured using a thickness meter. Thickness for the fabric is measured at five different places and the average value is noted.

Reference

- ISO 5084
- ASTM D 1777 96.

2.2.7.3 Measurement of Fabric Weight / Unit Area (GSM)

Using a cutting device (round, area 100 cm^2), the fabric is cut and weighed in a weighing balance. GSM for the fabric is measured at five different places and the average value is noted.

Calculation

100 x sample weight = weight / square meter (grams) [GSM] → (2.2)

Reference

- ASTM D 3776 96

CHAPTER 3

3. RESULTS , DISCUSSIONS AND CONCLUSION

3.1 RESULTS AND CONCLUSION

On each sample, the following test parameters are measured in dry relaxed conditions and after wet relaxation and the results are tabulated

1. Courses per inch
2. Wales per inch
3. loop length

Table 3.1 Effects of Loop Length and Plating on WPI at Dry Relaxation Stage

Loop Length MM (Inch)	1/LOOP Length 2	WPI (DRY RELAXED SAMPLE)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	8.2	30	40	43
2.9 (0.144)	8.8	30	40	43
2.7 (0.106)	9.4	30	40	43

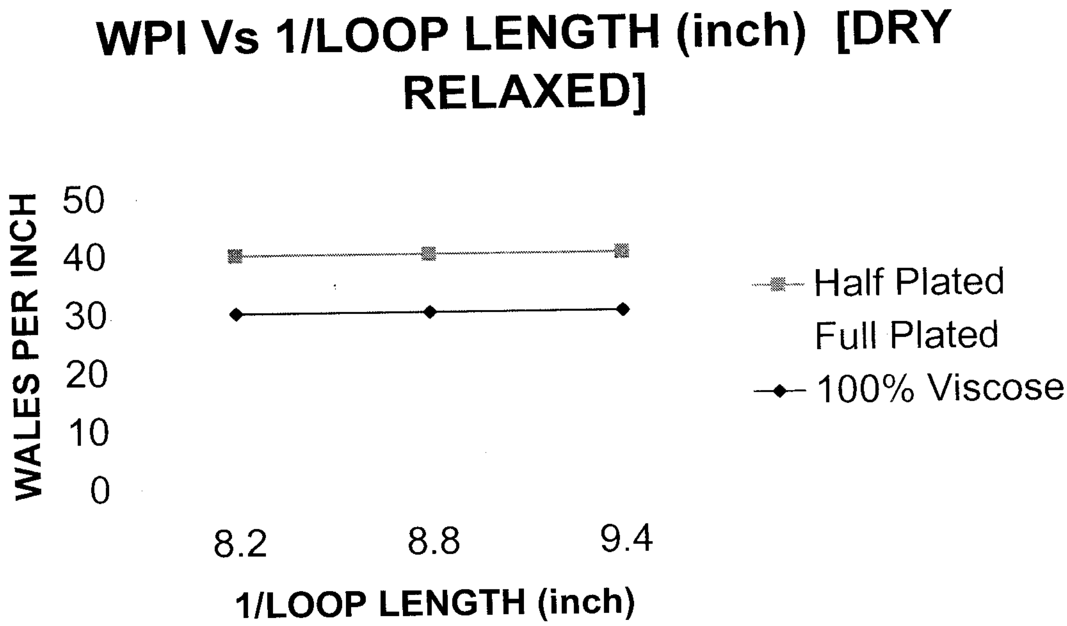


Figure 3.1 Effects of Loop Length and Plating on WPI at Dry Relaxation Stage

Table 3.1 and Figure 3.1 shows that WPI values remain unaltered with varying loop lengths but WPI increases due to plating effects. Regardless of loop length, for a particular plating level (amount of Spandex) the WPI values stand same as a constant but when the plating level is increased (100% viscose –half plated –full plated), the fabrics get tighter due to the elasticity of spandex and the WPI values increases gradually. This results in tighter fabrics

Table 3.2 Effect of Loop Length and Plating on WPI at Wet Relaxation Stage

1/LOOP Length 2	WPI (WET RELAXED SAMPLE)		
	100% Viscose	Half Plated	Full Plated
8.2	37	40	54
8.8	37	40	54
9.4	37	40	54

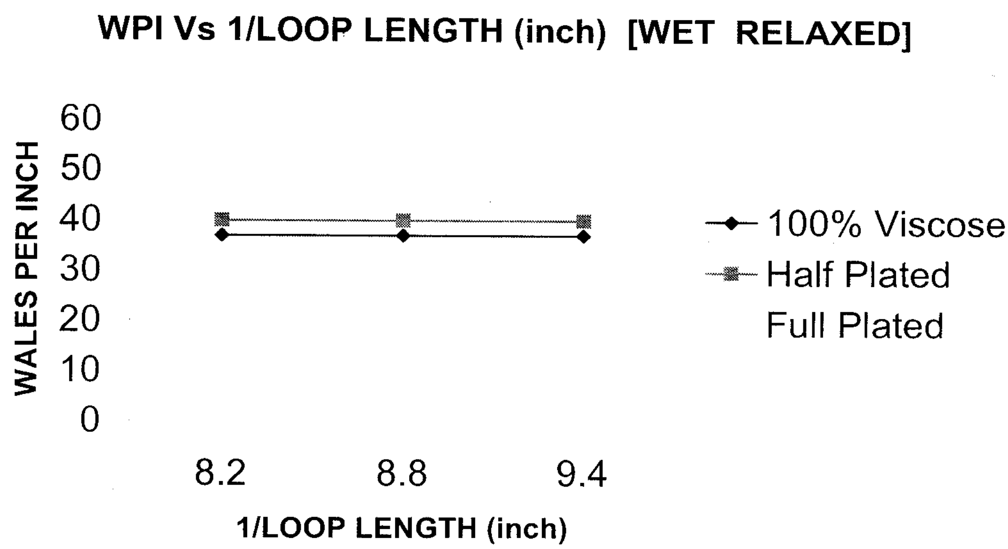


Figure 3.2 Effect of Loop Length and Plating on WPI at Wet Relaxation Stage

Table 3.2 and Figure 3.2 shows that the WPI values are fairly high after wet relaxation and an important factor to be considered is the different loop lengths have same WPI and increase in plating levels increases WPI, same as in the case of dry relaxed samples. Compared to dry relaxed results (Table 3.1 and Figure 3.1) the wet relaxed samples have higher WPI values inferring that wet further increases the fabric tightness wale spacing values of all samples decreases while relaxation progresses. The variation in WPI with loop length is nil and significant in different plating levels.

Table 3.3Effect of Loop Length and Plating on CPI at Dry Relaxation Stage

1/LOOP Length 2	CPI (DRY RELAXED SAMPLE)		
	100% Viscose	Half Plated	Full Plated
8.2	35	50.6	72
8.8	42	54.2	71
9.4	47.8	60	73.2

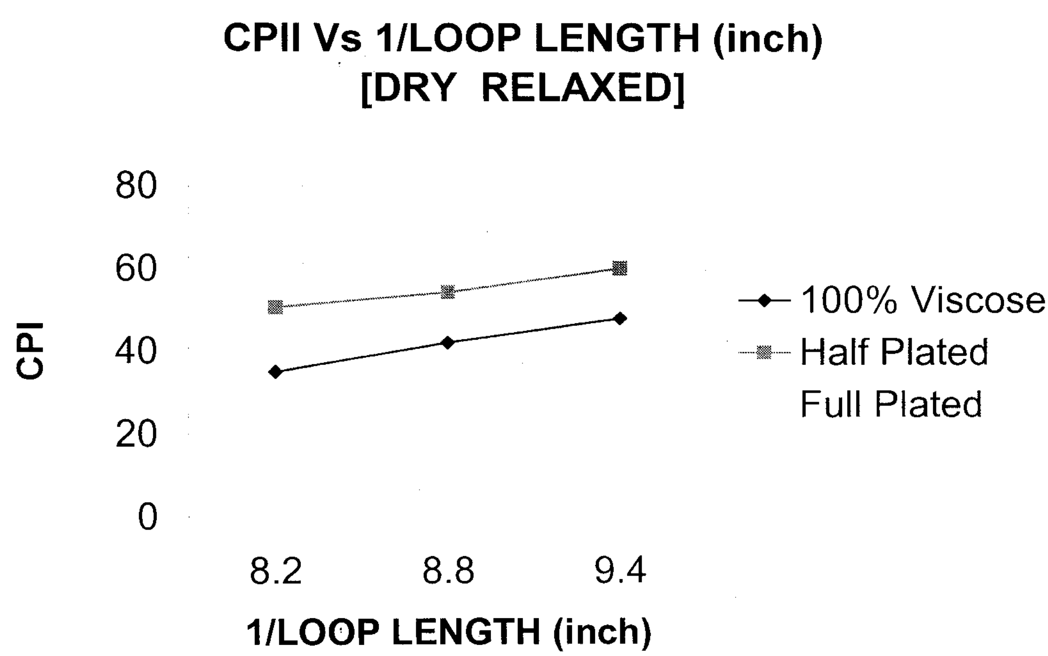


Figure 3.3Effect of Loop Length and Plating on CPI at Dry Relaxation Stage

Table 3.3 and figure 3.3 shows that CPI values for dry relaxation samples vary linearly with loop lengths. The CPI values decreases with increase in loop length. When the plating levels (amount of Spandex) are increased the CPI values gradually increases.

The regression equations for 100 % viscose, half plated and full plated samples are, y =6.4x + 28.8, y = 4.7x + 45.53, and y = 0.6x + 70.86 respectively and the regression coefficient for 100% viscose is r = 0.99, half plated is r = 0.98, and full plated is r = 0.29, stating that there is a strong correlation between loop length and CPI in 100% viscose and half plated samples, where as the correlation is poor in full plated

Table 3.4Effect of Loop Length and Plating on CPI at Wet Relaxation Stage

Loop Length MM (Inch)	1/LOOP Length 2	CPI (WET RELAXED SAMPLE)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	8.2	36	64	82
2.9 (0.144)	8.8	42	70	88
2.7 (0.106)	9.4	45	76	96

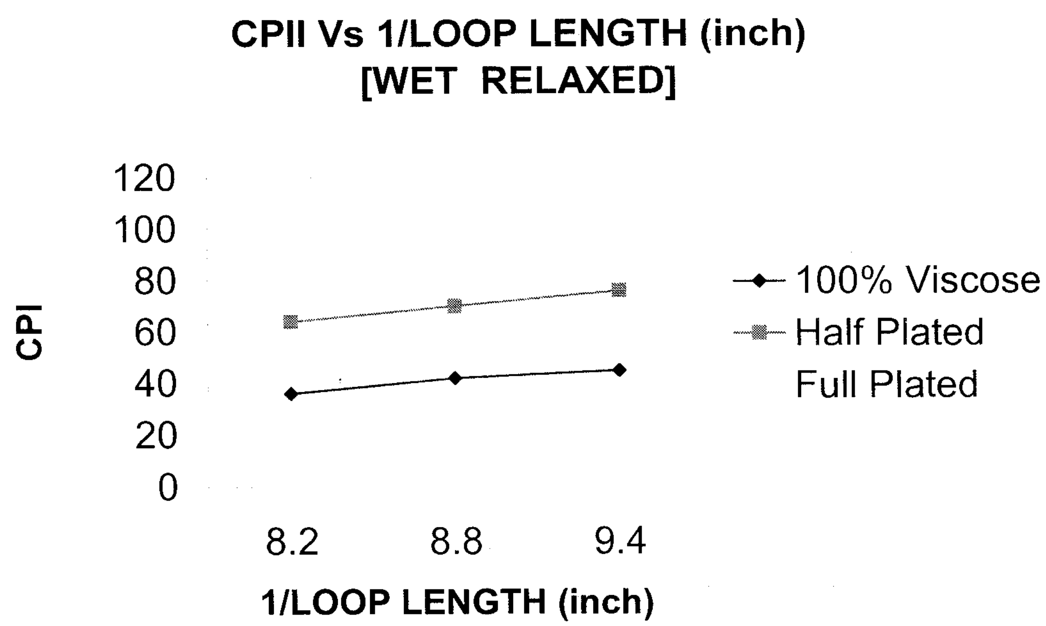


Figure 3.4Effect of Loop Length and Plating on CPI at Wet Relaxation Stage

Table 3.4 and figure 3.4 shows that CPI values for wet relaxation stage also vary linearly with loop lengths. The CPI values increases with decrease in loop length. Also when the plating levels increases the CPI values gradually increase.

The regression equations for 100 % viscose, half plated and full plated samples are, $y = 4.5x + 32$, $y = 6x + 52$, and $y = 7x + 74.66$ respectively and the regression coefficient for 100% viscose is $r = 0.96$, half plated is $r = 1$, and full plated is $r = 0.99$, stating that there is a strong correlation between loop length and CPI incase of configurations 100 % viscose and half plated samples, full plated

Table 3.5 Effect of loop Length and Plating on Tensile Properties using Tenstile Tester. Linearity LT

Loop Length MM (Inch)	1/100 P Length [2] (Inch)	Linearity LT (Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	0.818	1.029	1.296
2.9 (0.114)	76.71	0.884	0.978	1.328
2.7 (0.106)	88.49	0.797	0.922	1.272

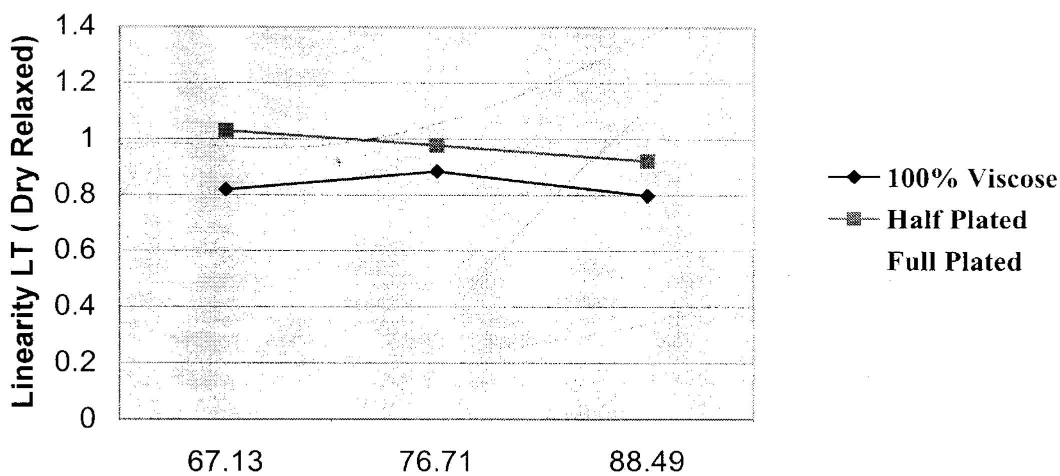


Fig. 3.5 Effect of loop Length and Plating on Tensile Properties using Tenstile Tester. Linearity LT

Table3.5 and Fig.3.5 shows that the linearity values Of wet relaxed samples vary non linearly with loop length. Since the increase in plating Level increase the fabric tightness and so the linearity increases.

For 100% Viscose the linearity is maximum for 2.9 inches Loop length fabric. For half plated fabric the linearity is maximum for 3.1 inches Loop length Fabric.Among the three types of fabric the linearity is maximum for full plated 2.9 inches Loop fabric.

Table 3.6 Effect of loop Length and Plating on Tensile Properties using Tenstile Tester. (Tensile Energy WT)

Loop Length MM (Inch)	1/100 P Length ² (Inch)	Tensile Energy WT(Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	2.64	14.80	8.85
2.9 (0.114)	76.71	2.68	11.50	7.90
2.7 (0.106)	88.49	3.00	10.40	7.05

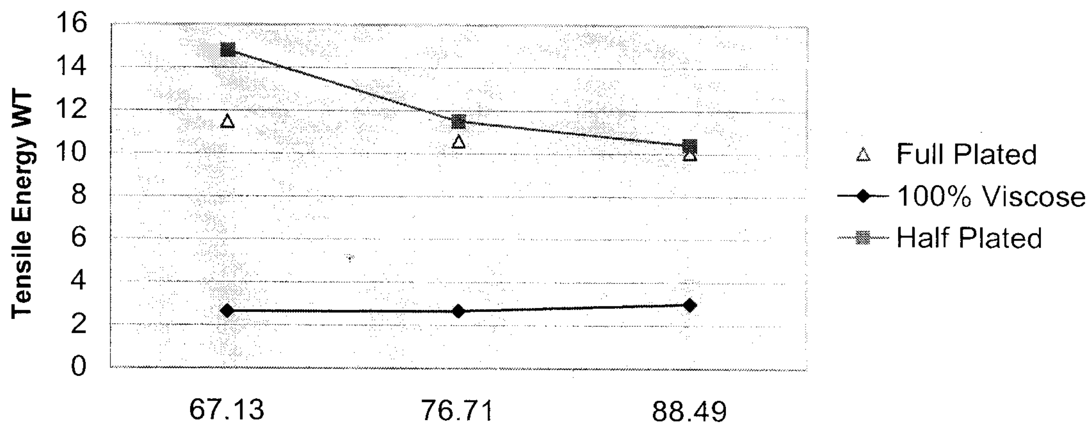


Fig.3.6 Effect of loop Length and Plating on Tensile Properties using Tensile Tester. (Tensile Energy WT)

Table 3.6 and Fig.3.6 shows that the tensile energy vary linearly with Loop length, Increase in loop length increases the tensile energy except in 100% viscose Fabric. Due to high amount of yarn present in higher Loop length, the fabric has high extensibility. The extensibility of Half plated fabric is very high in 3.1 inches Loop length fabric.

Table 3.7 Effect of loop Length and Plating on Tensile Properties using Tensile Tester. (Tensile Resilience RT)

Loop Length MM (Inch)	1/100 P Length [2] (Inch)	Tensile Resilience RT(Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	39.25	53.12	67.07
2.9 (0.114)	76.71	41.34	53.83	66.50
2.7 (0.106)	88.49	41.86	54.04	66.24

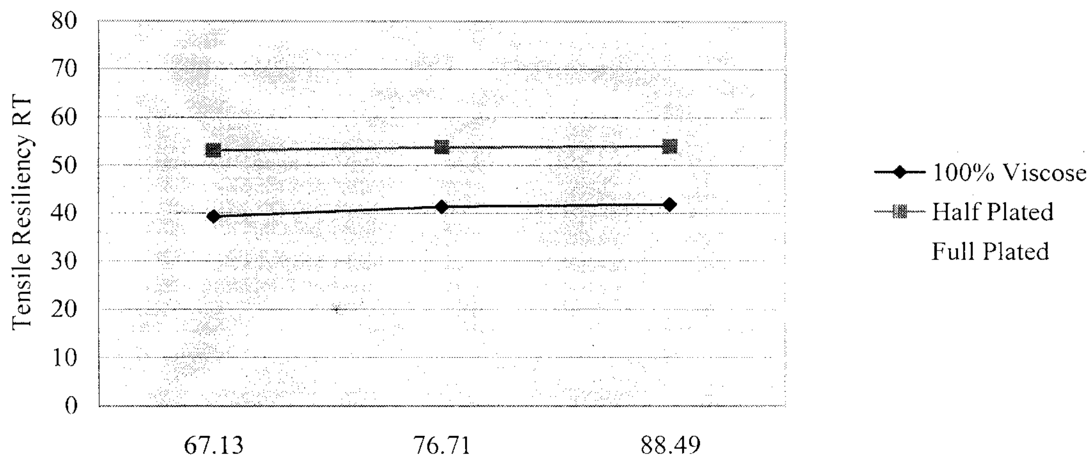


Fig. 3.7 Effect of loop Length and Plating on Tensile Properties using Tenstile Tester. (Tensile Resilience RT)

Table 3.7 and Fig 3.7. shows that the textile resilience vary linearly with Loop length. Due to the presence of high amount of spandex (elastic) Yarns the elastic Properties of full plated fabric is very high at the Loop length of 3.1inches fabric.

Table 3.8 Effect of loop Length and Plating on Shear Properties using Shear Tester.(Shear Rigidity gf.cm/deg)

Loop Length MM (Inch)	1/100 P Length ^{2} (Inch)	Shear Rigidity gf.cm/deg(Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	0.44	0.47	2.20
2.9 (0.114)	76.71	0.47	0.52	6.35
2.7 (0.106)	88.49	0.48	0.54	7.0

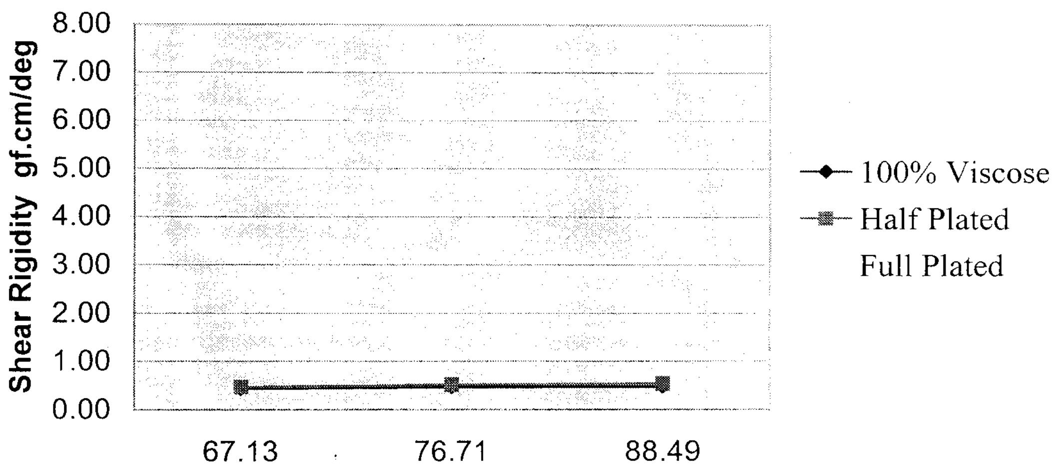


Fig. 3.8 Effect of loop Length and Plating on Shear Properties using Shear Tester.(Shear Rigidity gf.cm/deg)

Table 3.8 and Fig 3.8. shows that Shear rigidity vary linearly with Loop length. Due to the presence of high amount of spandex (elastic) Yarns the Shear rigidity of full plated fabric is very high at the Loop length of 2.7inches fabric. The shear rigidity decreases with the increase of loop length.

Table 3.9 Effect of loop Length and Plating on Shear Properties using Shear Tester. (Hysteresis of Shear force at 0.5°C (gm/cm))

Loop Length MM (Inch)	1/100 P Length ^{2} (Inch)	Hysteresis of Shear force at 0.5°C (gm/cm) (Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	2.17	1.36	6.01
2.9 (0.114)	76.71	2.36	1.52	6.35
2.7 (0.106)	88.49	2.50	1.74	6.48

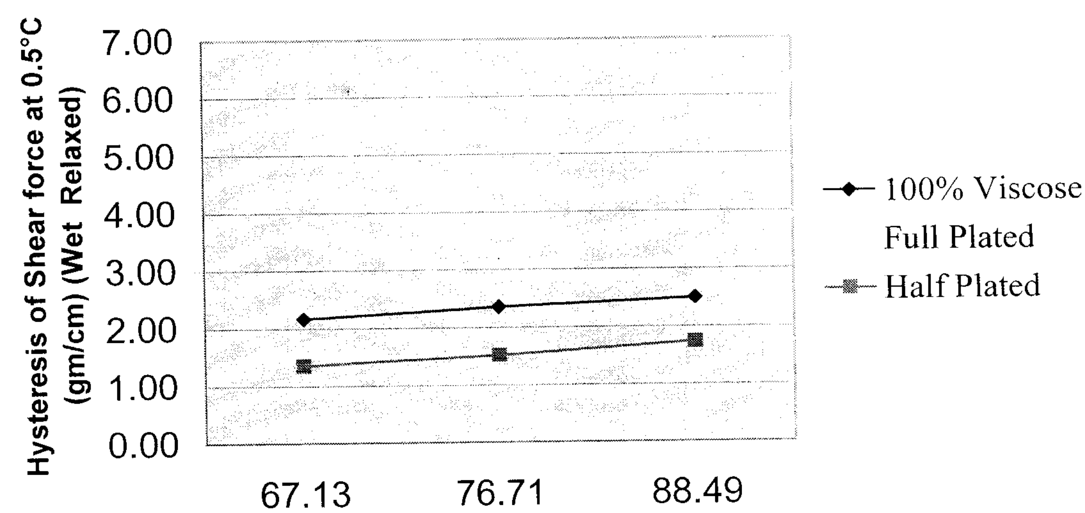


Fig. 3.9 Effect of loop Length and Plating on Shear Properties using Shear Tester. (Hysteresis of Shear force at 0.5°C (gm/cm))

Table 3.9and Fig 3.9. shows that hysteresis of Shear force at 0.5°c vary linearly with Loop length. Due to the presence of high amount of spandex (elastic) Yarns the hysteresis of Shear force at 0.5°c of full plated fabric is very high at the Loop length of 2.7 inches fabric. The hysteresis of Shear force at 0.5°c decreases with the increase of loop length.

Table 3.10 Effect of loop Length and Plating on Shear Properties using Shear Tester. (Hysteresis of Shear force at 5°C (gm/cm))

Loop Length MM (Inch)	1/100 P Length ^{2} (Inch)	Hysteresis of Shear force at 5°C (gm/cm) (Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	1.70	1.31	4.56
2.9 (0.114)	76.71	2.13	1.50	4.80
2.7 (0.106)	88.49	2.28	1.61	4.96

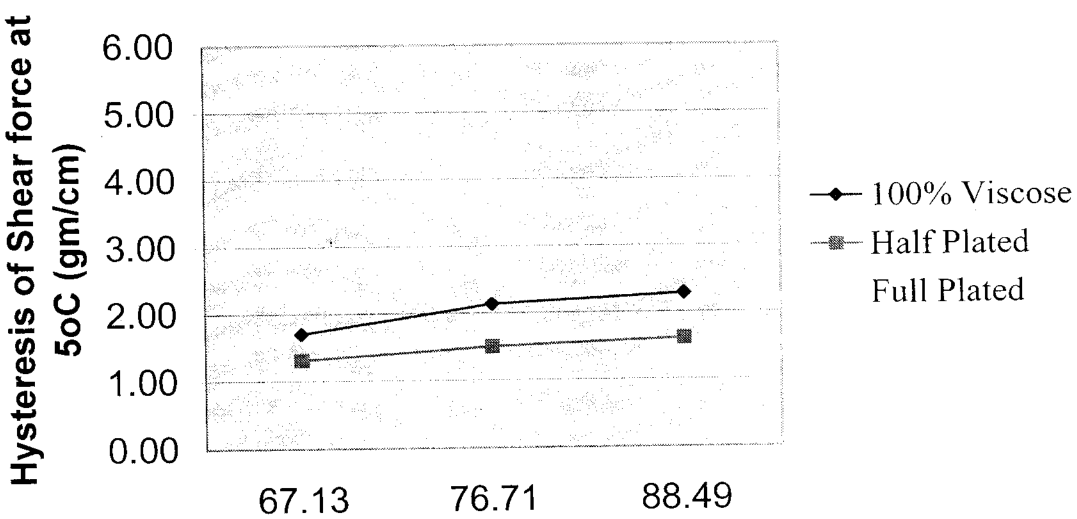


Fig. 3.10 Effect of loop Length and Plating on Shear Properties using Shear Tester. (Hysteresis of Shear force at 5°C (gm/cm))

Table 3.10.and Fig 3.10 shows that hysteresis of Shear force at 5°C vary linearly with Loop length. Due to the presence of high amount of spandex (elastic) Yarns the hysteresis of Shear force at 5°C of full plated fabric is very high at the Loop length of 2.7 inches fabric. The hysteresis of Shear force at 5°c decreases with the increase of loop length.

Table 3.11 Effect of loop Length and Plating on Bending Properties using Bending Tester. (Bending Rigidity ($gf.cm^2/cm$))

Loop Length MM (Inch)	1/100 P Length ^{2} (Inch)	Bending Rigidity ($gf.cm^2/cm$) (Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	0.0181	0.0300	0.2268
2.9 (0.114)	76.71	0.0109	0.0315	0.2056
2.7 (0.106)	88.49	0.0143	0.0318	0.2102

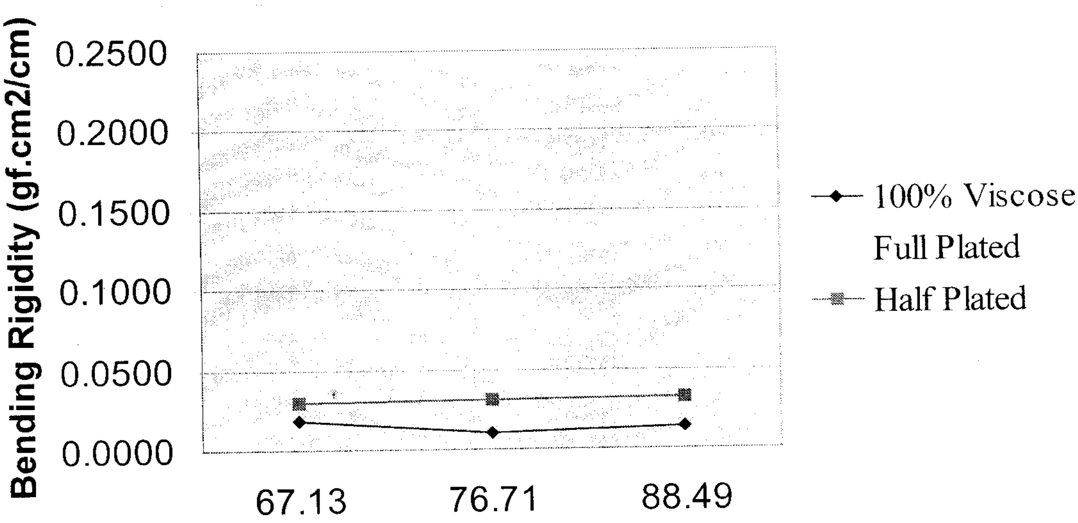


Fig. 3.11 Effect of loop Length and Plating on Bending Properties using Bending Tester. (Bending Rigidity ($gf.cm^2/cm$))

Table 3.11.and Fig 3.11 shows that Bending rigidity vary linearly with Loop length. Due to the presence of high amount of spandex (elastic) Yarns the Bending rigidity of full plated fabric is very high at the Loop length of 3.1 inches fabric. There is no correlation between Loop length and bending rigidity.

Table 3.12 Effect of loop Length and Plating on Bending Properties using Bending Tester. (Hysteresis of Bending Movement (gf.cm/cm))

Loop Length MM (Inch)	1/100 P Length ^{2} (Inch)	Hysteresis of Bending Movement (gf.cm/cm) (Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	0.0167	0.0398	0.2172
2.9 (0.144)	76.71	0.0109	0.0315	0.1901
2.7 (0.106)	88.49	0.0168	0.0399	0.2176

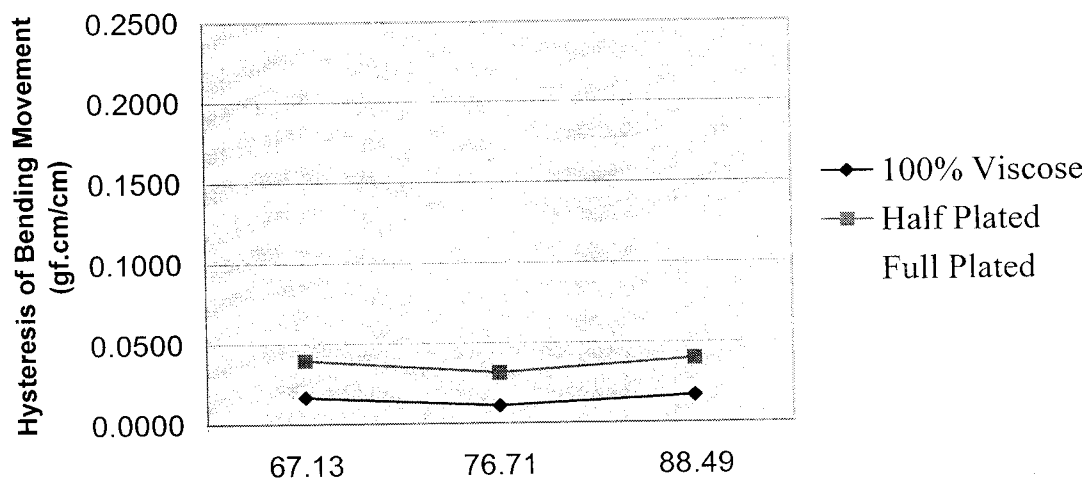


Fig. 3.12 Effect of loop Length and Plating on Bending Properties using Bending Tester. (Hysteresis of Bending Movement (gf.cm/cm))

Table 3.12.and Fig 3.12. shows that hysteresis of bending moment vary linearly with Loop length. Due to the presence of high amount of spandex (elastic) Yarns the hysteresis of bending moment of full plated fabric is very high at the Loop length of 2.9 inches fabric. There is no correlation between Loop length and hysteresis of bending moment .

Table 3.13 Effect of loop Length and Plating on Compression Properties using Compression Tester.(Linearity of compression thickness curve LC)

Loop Length MM (Inch)	1/100 P Length ^{2} (Inch)	Linearity of compression thickness curve LC(Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	0.364	0.348	0.386
2.9 (0.114)	76.71	0.150	0.342	0.421
2.7 (0.106)	88.49	0.354	0.354	0.392

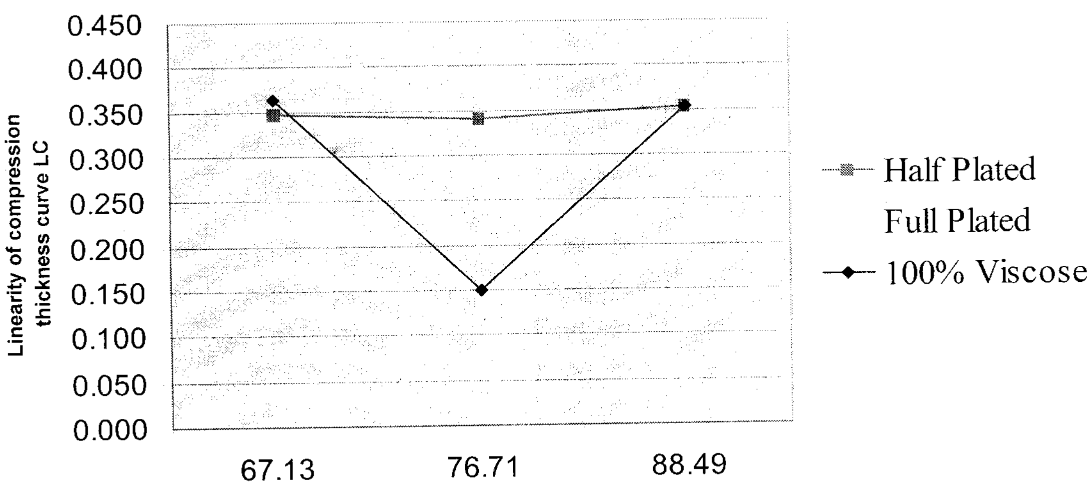


Fig. 3.13 Effect of loop Length and Plating on Compression Properties using Compression Tester.(Linearity of compression thickness curve LC)

Table 3.13.and Fig 3.13. shows that Linearity of compression thickness vary linearly with Loop length. Due to the presence of high amount of spandex (elastic) Yarns the Linearity of compression thickness of full plated fabric is very high at the Loop length of 2.9 inches fabric. There is no correlation between Loop length and Linearity of compression thickness.

Table 3.14 Effect of loop Length and Plating on Compression Properties using Compression Tester (Compression Energy WC).

Loop Length MM (Inch)	1/100 P Length ^{2} (Inch)	Compression Energy WC(Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	0.220	0.242	0.376
2.9 (0.114)	76.71	0.077	0.219	0.305
2.7 (0.106)	88.49	0.237	0.262	0.396

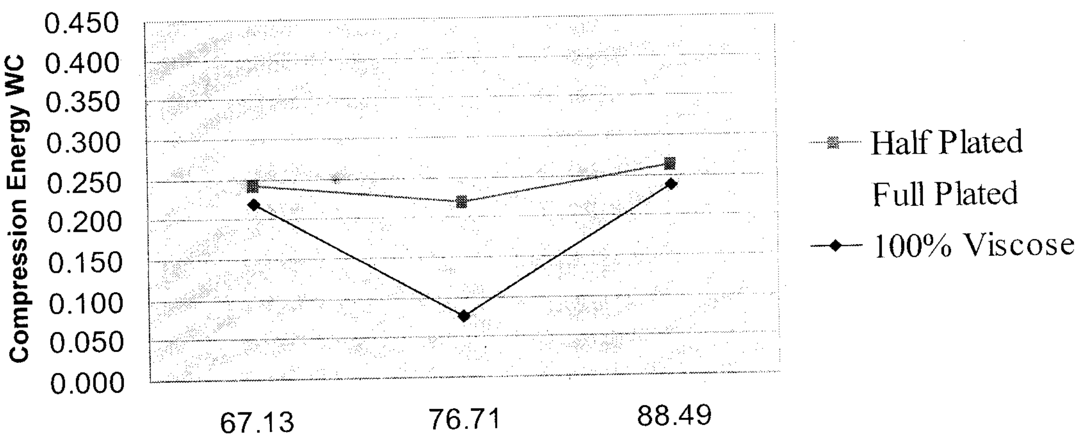


Fig. 3.14 Effect of loop Length and Plating on Compression Properties using Compression Tester (Compression Energy WC).

Table 3.14.and Fig 3.14. shows that Compression Energy vary linearly with Loop length. Due to the presence of high amount of spandex (elastic) Yarns the Compression Energy of full plated fabric is very high at the Loop length of 2.7.inches fabric. There is no correlation between Loop length and Compression Energy .

Table 3.15 Effect of loop Length and Plating on Compression Properties using Compression Tester. (Compressional Resilence RC)

Loop Length MM (Inch)	1/100 P Length ^{2} (Inch)	Compressional Resilence RC(Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	36.36	37.19	32.98
2.9 (0.114)	76.71	64.94	29.22	35.41
2.7 (0.106)	88.49	37.97	38.20	33.72

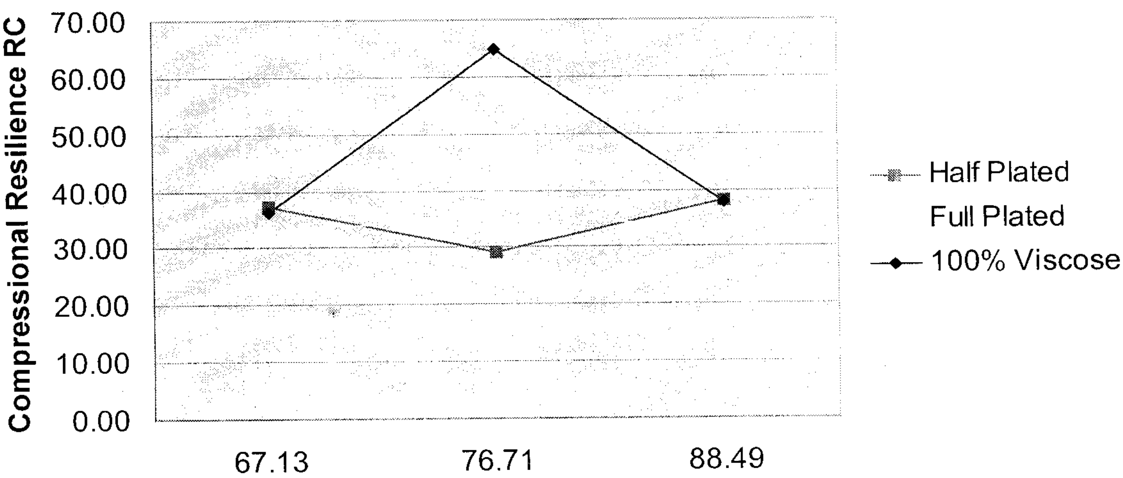


Fig. 3.15. Effect of loop Length and Plating on Compression Properties using Compression Tester.(Compressional Resilence RC)

Table 3.15.and Fig 3.15. shows that Compressional Resilence vary linearly with Loop length.The Compressional Resilence of 100% viscose fabric is very high at the Loop length of 2.9.inches fabric. There is no correlation between Loop length and Compressional Resilence.

Table 3.16 Effect of loop Length and Plating on Compression Properties using Compression Tester(Fabric Thickness To)

Loop Length MM (Inch)	1/100 P Length ^{2} (Inch)	Fabric Thickness To(Wet Relaxed)		
		100% Viscose	Half Plated	Full Plated
3.1 (0.122)	67.13	0.652	1.030	1.410
2.9 (0.114)	76.71	0.613	0.991	1.240
2.7 (0.106)	88.49	0.725	1.132	1.520

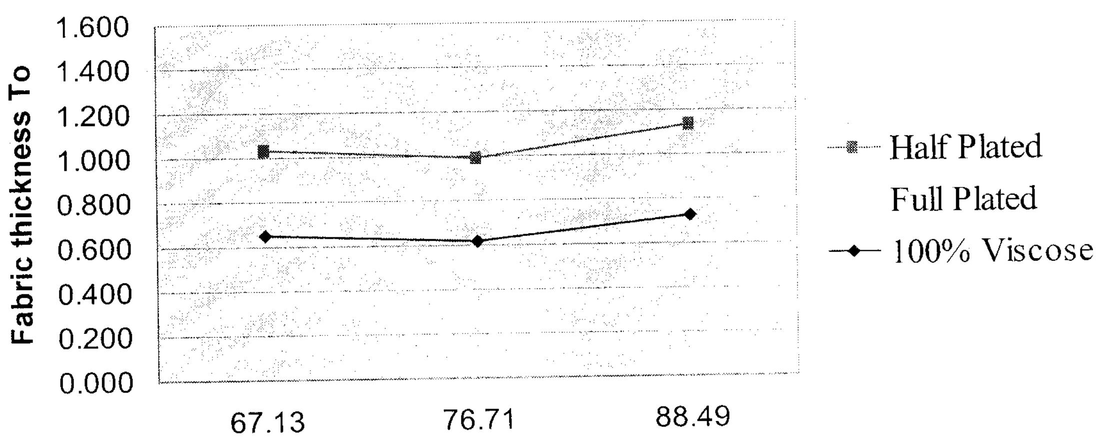


Fig. 3.16 Effect of loop Length and Plating on Compression Properties using Compression Tester(Fabric Thickness To)

Table 3.17.and Fig 3.17. shows that fabric Thickness To vary linearly with Loop length. Due to the presence of high amount of spandex (elastic) Yarns the Fabric Thickness To of full plated fabric is very high at the Loop length of 2.7.inches fabric. There is no correlation between Loop length and Fabric Thickness To .

3.2 RESULTS AND DISCUSSIONS -SUMMARY

1.100% VISCOSE

The following points are observed from the test results.

a. Wales per inch remains unchanged with loop length.

b. Courses per inch decreases with increase in loop length and it follows a linear equation as follows,

   CPI = 4.5(1/loop length(inch))+32[After wet relaxation]

c. Linearity is maximum at 2.9inch loop length. Linearity decreases with increase in Loop length.

d. Tensile energy is maximum at 2.9inch loop length. Tensile energy decreases with increase in Loop length.

e. Resilience is maximum at 2.7inch loop length. Resilience decreases with increase in Loop length.

f. Shear rigidity is maximum at 2.7inch loop length. Shear rigidity decreases with increase in Loop length.

g. Hysteresis of Shear force at 0.5°c is maximum at 2.7inch loop length. Hysteresis of Shear force at 0.5°c decreases with increase in Loop length.

h. Hysteresis of Shear force at.5°c is maximum at 2.7inch loop length. Hysteresis of Shear force at 5°c decreases with increase in Loop length.

i. Bending rigidity is maximum at 3.1inch loop length. Bending rigidity non -linearly varies with Loop length.

j. Hysteresis of Bending moment is maximum at 2.7inch loop length. Hysteresis of Bending moment non -linearly varies with Loop length

k. Linearity of compression thickness is maximum at 3.1inch loop length. Linearity of compression thickness non -linearly varies with Loop length

l. Compressional Energy is maximum at 2.7inch loop length. Compressional Energy non -linearly varies with Loop length.

m. Compressional Resilience is maximum at 2.9inch loop length. Compressional Resilience non -linearly varies with Loop length.

n. Fabric thickness is maximum at 2.7inch loop length Fabric thickness non -linearly varies with Loop length.

2.HALF PLATED FABRIC

The following points are observed from the test results.

a. Wales per inch remains unchanged with loop length.

b. Courses per inch decreases with increase in loop length and it follows a linear equation as follows,

CPI = 6(1/loop length(inch))+58[After wet relaxation]

c. Linearity is maximum at 3.1inch loop length. Linearity increases with increase in Loop length.

d. Tensile energy is maximum at 3.1inch loop length. Tensile energy increases with increase in Loop length.

e. Resilience is maximum at 2.7inch loop length. There is no linear relationship between resilience and loop length..

f. Shear rigidity is maximum at 2.7inch loop length. Shear rigidity decreases with increase in Loop length.

g. Hysteresis of Shear force at 0.5°c is maximum at 2.7inch loop length. There is no linear relationship between hysteresis of Shear force at 0.5°c and loop length.

h. Hysteresis of Shear force at.5°c is maximum at 2.7inch loop length. Hysteresis of Shear force at 5°c decreases with increase in Loop length.

i. Bending rigidity is maximum at 2.7inch loop length. Bending rigidity decreases with increase in Loop length .

j. Hysteresis of Bending moment is maximum at 2.7inch loop length. Hysteresis of Bending moment non -linearly varies with Loop length

k. Linearity of compression thickness is maximum at 2.7inch loop length. Linearity of compression thickness non -linearly varies with Loop length

l. Compressional Energy is maximum at 2.7inch loop length. Compressional Energy non -linearly varies with Loop length.

m. Compressional Resilience is maximum at2.7inch loop length. Compressional Resilience non -linearly varies with Loop length.

n. Fabric thickness is maximum at 2.7inch loop length Fabric thickness non -linearly varies with Loop length.

3.FULL PLATED FABRIC

The following points are observed from the test results.

a. Wales per inch remains unchanged with loop length.

b. Courses per inch decreases with increase in loop length and it follows a linear equation as follows,

   CPI = 7(1/loop length(inch))+74.66[After wet relaxation]

c. Linearity is maximum at 2.9inch loop length. Linearity decreases with increase in Loop length.

d. Tensile energy is maximum at 3.1inch loop length. Tensile energy increases with increase in Loop length.

e. Resilience is maximum at 3.1inch loop length. Resilience increases with increase in Loop length.

f. Shear rigidity is maximum at 2.9inch loop length. Shear rigidity non -linearly varies with Loop length.

g. Hysteresis of Shear force at 0.5°c is maximum at 2.7inch loop length. Hysteresis of Shear force at 0.5°c decreases with increase in Loop length.

h. Hysteresis of Shear force at.5°c is maximum at 2.7inch loop length. Hysteresis of Shear force at 5°c decreases with increase in Loop length.

i. Bending rigidity is maximum at 3.1inch loop length. Bending rigidity non -linearly varies with Loop length.

j. Hysteresis of Bending moment is maximum at 2.7inch loop length. Hysteresis of Bending moment non -linearly varies with Loop length

k. Linearity of compression thickness is maximum at 2.9inch loop length. Linearity of compression thickness non -linearly varies with Loop length

l. Compressional Energy is maximum at 2.7inch loop length. Compressional Energy non -linearly varies with Loop length.

m. Compressional Resilience is maximum at 2.9inch loop length. Compressional Resilience non -linearly varies with Loop length.

n. Fabric thickness is maximum at 2.7inch loop length Fabric thickness non -linearly varies with Loop length

3.3 CONCLUSION

From the work it is found that, as the amount of spandex increases, loop length values remain the same and the Wales per inch values also remains same, where as Courses per inch increases linearly. The lower Loop length full plated Viscose/Spandex knitted fabric is found to be better in many ways. The Full plating Of spandex on Viscose enhanced the properties and this fabric can be better used for active wears, casual wears etc. New applications can also be explored to use this fabric because of its Satisfactory results which will lead to increased use of viscose fibre as an alternative to cotton.

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