Elastic Recovery Characteristics of Waist Band using High Stretch Polyester in Place of Lycra - a Technical Review

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Abstract— Lycra is one of the best yarn to use in different field. It is being used to manufacture in narrow width fabric. Like Wrist bandages, head bandages, innerwear etc. It has many advantages while it is used in elastic field. But Now a days there is a serve problem of presence of low elastane content of typical Lycra When it is used in garments have Jeans/pants, woven shirts, knit shirts, swimwear, innerwear. High stretch polyester (T400) has excellent properties which aid in elastic field. High stretch polyester has good desirable properties like its outstanding comfort stretch and recovery in all direction, better shape retention, High durability abrasion, fitness, moisture management as compared to Lycra, so I would like to compare the properties of waist band of High stretch polyester (T400) with Lycra (spandex).

Keywords: Lycra, T400, Stretch

I. INTRODUCTION

High Stretch Polyester fiber can be knitted woven in its bare state into garments. For certain applications where cotton is used, core-spun T400 yarns may be preferred. High Stretch Polyester is chlorine-resistant it can withstand bleaching and washing techniques not typically used on stretch Denim. The latest treatments, such as antique finishes, whisker washing and sandblasting, can be applied to garments with excellent results. High Stretch Polyester fiber helps to create jeans that hold a crease wash after wash. By adding T400 fiber to their fiber they have created a fibre that can be used in fabrics that are processed with abrasion and other aggressive finishing techniques. T400 stretch fiber is that of helping create better fit and comfort in wear without affecting performance and wash and wear endurance. T400 helps keep the denim still feeling like denim which means more designers will be willing to use it and more consumers will be happier to buy it. Then higher the stretch content in denim the poorer the elongation and other aggressive finishing techniques.

II. LITERATURE SURVEY

Kraemer (2002) studied the impact of Lycra power garments on the performance levels and this study was sponsored by DuPont from 1991 – 1995. A series of tests were administered in highly controlled laboratory conditions that represented the span of fatigue types experienced by an athlete when involved in sports or recreational activities. Before and after creating the fatigue, the athlete’s ability to produce power was examined. The study revealed that all types of fatigue (strength, endurance and power) can be significantly reduced by wearing Lycra power apparel.

Parmer M. (2002) has described the comfort in the fabric under high activity condition, and explained that absorption of the sweat followed by wicking and evaporation aids comfort. An unconventional way to create comfort has been tried by using a different type of yarn comprising two component fibers, defined as bi-component yarn. The fabric had been knitted and then subjected to washing so one of the soluble component in the yarn gets removed, thus making the yarn in the fabric lighter, bulkier and softer. After removal of water - soluble compound, from the fabric showed greater advantages over 100% cotton yarn knitted fabric in terms of absorbency, light weight and softer feeling. Since the fabric is costlier than 100% cotton fabric, the cost of water soluble material would also involve in this fabric.

A. Wet Processing and Effects on Properties

Gargi M. (1980) studied the effect of laundering on some physical properties of rib knitted fabrics and the study of surface change by scanning electron microscope. The dimensional stability and biaxial stress strain and growth, pilling and abrasion characteristics of knitted fabrics of pure cotton, Acrylic and polypropylene were used.

It was found that pure cotton fabrics had low shrinkage value than Acrylic and propylene fabrics. Repeated washing stabilizes them. Analysis of stress strain data revealed that irrespective of fibre content of the fabric, all the samples showed a decrease in stress required as the number of landering increased, both in wale and course direction. Recovery after 15% strain was 100 percent for all the fabrics. All the fabrics exhibited 4 to 8 percent of growth at 30 percent strain for 24 hours in wale and course directions. The fabrics were found to be abrasion resistant least damage was caused to polypropylene compared to cotton and acrylic. Pilling results showed that polypropylene showed maximum pills followed by Acrylic and cotton.

PavkoCudena, A., Srđjakband, M., & Pelkoč, H. (2000) mentioned in their study that the shrinkage of knitted fabrics significantly increases with the introduction of home
laundrying and tumble drying. The deformation caused by the mechanical forces can be reduced by appropriate relaxation. The quality requirement of knitted fabrics becomes highly demanding in terms of appearance and performance. In response to the demand, the fabric producers were inspired to develop a rich source of materials using a variety of yarn with Lycra for stretch and recovery.

Area density is a basic parameter defining knitted fabric offer. It is determined by both yarn and knitted fabric parameters. The performance properties like shrinking and laundring and elastic properties: breaking extension, maximum extension at cyclic loading up to defined load/extension and residual extension were assessed. The result of the study showed that area density of the knitted fabrics was reduced according to the optimization of knitting process parameters. Performance properties like shrinking at laundring and maximum extension were improved. It was suggested by the authors that objective elastic properties measurement of knitted fabrics should be developed for uniaxial cyclic loading.(5)

Mukhopadhyay et al (2003) studied the effect of Lycra filament and full relaxation on the extension at peak load, immediate recovery, delayed recovery, permanent set and resiliency of cotton – Lycra blended knitted fabric. The study revealed for Lycra blended fabric, the immediate recovery, extension and resiliency are higher but delayed recovery and permanent set are lower than those of 100% cotton fabric. Effect of full relaxation treatment is found to be useful in case of all cotton fabric. On the application of external load, both Lycra and non-Lycra fabrics show higher extension at peak load along course direction. However, the bias direction of 100% cotton fabric shows significantly higher immediately recovery and resiliency but lower delayed recovery and permanent set. Laundering reduces the extension at peak load, immediate recovery and permanent set become higher.(6)

Thangamani, K. (2002) studied shrinkage behaviour of knitted fabrics on repeated washing on seven different types of knitted fabrics – Single jersey, Interlock 1x1 Rib, 2x2 Derby Rib, Flat back rib, Locknit, Airtex. The fabric samples were subjected to 5 wash cycles, with benchmarks in the form of a square of dimension 25 x 25 cm. The samples were treated for 45 minutes at a temperature of 40°C in an IFB washing machine. Then they were dried in a hot air over until all the moisture was removed, allowed to cool and relax. After this the distance between the respective benchmarks was measured and tabulated. The process was repeated for another four times.

The results of shrinkage behaviour of different fabrics in repeated washings were as follows. The single jersey fabric shrinks for the first wash and the washing increases it tends to expand and again shrink. The interlock fabric shrinks for the first three washing and it expands in subsequent washing. The 1:1 Rib fabric for the first three washing elongates and shrinks in the fourth wash and again elongates in the fifth wash. The percentage of shrinkage gets reduced and moves towards a staple position in repeated washing for the 2x2 Derby Rib fabric. In repeated washings the Flat Back Rib Fabrics alternate between shrinkage and elongation. The shrinkage of the lock knit fabric for the first two washes remain near zero and start shrinking for the third and fourth wash. The Airtex fabric shrinks in the first four washes and for the fifth wash it expands.(8)

B. Blending Lycra with other Fibers for End Use and Their Properties

Hansen and Fletcher (1949) studied on evaluation properties of knitted fabrics and found that cotton and rayon materials decreased in recovery with an increase in strain, & for large strains had least recovery. It was found that time factor played an important role in elastic recovery for cotton, nylon, rayon and cool were 26, 19, 26 and 48 percent whereas the combined instantaneous and delayed recoveries were 58, 59, 55 and 80 percent respectively. Further the results indicated that delayed recovery of nylon materials was twice than that of the instantaneous recovery of the same material.(9)

Mundan (1962) studied the relationship of dimensional property of the geometry of plain knit fabrics various loops models were studied the found that there was a specific relationship between stitch density and stitch length which was independent of fabric openness. He further stated that the course and wale spacing are directly proportional to the stitch length. It was found that stitch density and dimensions of a fabric in the relaxed state are unaffected by the change in yarn count of the stitch length remains constant. Fabric dimension may be affected by change in yarn count owing to its effect on the extensional properties of the fabric. After relaxation the fabric will recover to similar dimensions if knitted to the same stitch length.

A study on the evaluation of elastic recovery of cotton knitted fabrics was conducted by Robert and Fletcher (1964). They found that elongation of these fabrics varied to a great extent. The elongation varied from 3-6 percent plain knit lengthwise, 3-45 percent double knit lengthwise, 3 – 235 percent plain knit widthwise and 6-156 percent double knit widthwise. The elastic recovery varied from plain knit lengthwise, 100-56 percent double knit lengthwise, 100-55 percent plain knit widthwise and 100-30 percent double knit widthwise. The growth recovery was found to be 0 to 106 percent plain knit and 0 to 111 percent double knit. Plain knit had more elongation and growth as compared to double knit. The growth after 30 seconds or relaxation was observed to be 36 percent and plain knit stretched more under load and after the load was released exhibited more growth than the double knit.(10)

PetterPoper (1966) has also studied the theoretical behavior of knitted fabrics subjected to biaxial stresses. His work has shown that biaxial deformation of textile material depends to a greater extent on fabric geometry as well as on the fiber properties. The “Structural” behavior is superimposed on the material properties of the fibers where an actual fabric is stressed and in many cases, the structural effect can predominate. It has shown that the plain knit fabric can deform considerably without any elongation of the component yarns. The fabric when extended, will reach a limiting extension in either direction due to yarn jamming.
The main conclusion was that knitted fabric develops a unique mechanical behavior from its geometry and ability to deform by inters yarn slipping. This structural behavior of the yarns gives the final behavior of the fabric.

Elder and Somashekar (1975) had made an attempt to study the bending and recovery properties of cotton plain knitted fabric by using Shirley Bending Hysteresis Tester. They had considered parameters like flexural rigidity and bending recovery i.e., the degree of flat set separately for wales and courses. It has shown that relaxation causes a tenfold reduction in inter yarn forces and couples. The effect was noted for fiber relaxation in yarn structure. (11)

Brain et al (1975) studied the biaxial deformation characteristics of plain knit fabrics.

They found when stretching proceeds, yarn strengthening occurs. During the straightening stages the knitted fabric deforms in such a way that the yarn in the cross over region start sliding past one another. Friction causes tension in the wide direction, which may be greater or less than the tension in the course direction, depending on which way sliding occurs. (7)

Mahirskaris (1978) studied the growth and elastic recovery properties of plain and rib knitted fabrics. The immediate elastic recovery and permanent growth were determined by modifying the ASTM method D 1775-60. One plain knit and three rib knit fabrics (cotton, nylon and polyester) were selected. The results revealed that among all the fabric plain knit cotton fabric showed 100% stretch ability with severe curling effect and having poor elastic recovery. The study also concluded that rib have a tendency to stretch more in course wise direction than in wale wise direction. Rib fabrics showed considerable loss in stress required with increase of frequency the nylon fabric showed delayed elastic recovery and plain cotton showed very low elastic recovery and growth.

Bains, M. (1979) studied the stress strain characteristics of woven and knitted fabrics subjected to uniaxial and biaxial stresses. Elastic recovery behavior of both woven fabrics of pure cotton, nylon and polyester blends and three knitted fabrics of cotton and polyester of plain and 1x1 rib knit were used for the study. For measurement of stress strain characteristics, an instrument was constructed with required modification.

The woven and knitted fabrics were subjected to uniaxial and biaxial stress. It was concluded that all fabrics subjected to uniaxial stress, showed extension in the variable load and contraction in the weft direction or vice versa. It was observed that higher the extension of the samples, greater was the contraction. In knits, warping was observed in both wale and course direction

Kunzru, V. (1982) studied hand knitting sample of different patterns and their applications in household articles. The study was undertaken to find out the ‘tension measurement’ the amount of yarn in length and weight required for different patterns when knitted on different needles. For the study eight commonly used knitted patterns were selected for the tension measurement, yarn length and weight calculations. Out of eight patterns six were selected for the measurement of elastic properties. An instrument was fabricated on the basis of instrument used by Mahiskar N. (22) to determine elongation of the knitted samples. The immediate and delayed elastic recovery was also determined. It was found that there was an increase in tension with an increase in the needle size for every knitted pattern. Results of elongation showed that elongation does not depend upon the individual ‘knit’ or ‘purl’ stitch, but upon the placement of these stitches in combination, in various patterns.

It was also observed that the pattern which elongates less recovery most. Curling was observed in patterns where the two sides comprise of different stitches.(5)

Srivastava (1983) studied the elastic characteristics of knitted fabrics, with and without seam on 100 percent polyester was taken. The extension and elastic recovery of fabrics with seam and without seam were determined with the help of bulging tester. The percent extension and percent elastic recovery after 5 minutes and 30 min. at various loads were calculated.

The analysis of the work was that elastic recovery was more or less same in the knitted fabrics due to the similarity in knitting structure. With the introduction of seam in sample at various loads, extension ranged from 58 – 94 percent and elastic recovery was 97 to 99 percent. In fabrics with seam and without seam it was found that extension was reduced due to the seam stitches hundred the extension of knitted fabrics.

Mehta I. (1990) studied the stretch and recovery characteristics in woven and knitted fabrics. The fabrics were cotton blended in plain twill weave and plain knit, interlock, honey comb and fleece fabrics. The stretch and recovery of woven and knitted fabrics were determined using the Scott tensile tester at 5, 10, 15 nos. load and the bulging tester using 1 kg load. The percent stretch and percent recovery were calculated. Aesthetic appeal for dress in combination of knitted and woven fabrics was judged by observers with help of snaps. It was concluded that knitted fabric had good stretch and recovery than woven.

Knitted and woven fabrics in combination fabric form also had a good recovery. It was found that the image of knitted being used for only as sportswear changed and they were much accepted as evening wear and casual wear.

Marmarali (2003) conducted a study on the dimensional and physical properties of cotton / spandex single jersey fabrics and the results were compared to 100% cotton knitted fabrics. The loop length and amount of spandex were used to determine the dimensions and properties of the knits. Cotton / spandex in every course or in alternating courses classified as full plating and half plating respectively. The study revealed that the dimensional and physical properties of cotton and cotton / spandex single jersey fabrics are affected by the amount of spandex in the fabric and the loop length. The course and wale spacing values of cotton / spandex samples are less because the fabrics tend to be tighter. The weight and thickness of full plating cotton / spandex fabrics are higher, but air permeability, pilling grades, and the degree of spirality are lower than half plating cotton / spandex and cotton fabric respectively.

Also the dimensional variations width wise for 100% cotton samples are higher, while the lengthwise variations for the same fabrics are less after relaxation.(1)

Sabria, G. et al (2006) studied influence of sewing parameters upon the tensile behavior of textile assembly. As
per them the stitch line is expected to play an important role in the tensile behavior of the assembly. In fact, the deformation of the assembly is a mixture of deformation of the fabric and that of the seam. In order to study the seam behavior, an extension load curve for the stitch line was established.

The results of the study were expressed through the description of load and extension curve followed by analysis of rupture of fabric or the seam. The visual analysis of seam slippage show that the displacement of yarns made it possible to bring out two major phenomena occurring before the rupture of assembly: Contracting of seam or Seam slippage. Contracting of seam has always induced the breaking of the sewing thread without any damage of the sample, whereas when seam slippage occurs, the seam is still intact but yarns in the fabric pull out of the seam from the edge, sewing thread ruptured leaving holes due to yarn slippage, damage of the fabric along the stitch line. Further comparison of warp, weft and bias direction of the seam that were introduced in terms of thread breakage or seam slippage was done. (10)

Baghai, M., et.al (2010) studied Effect of tensile fatigue cyclic loads on bagging deformation of elastic woven fabrics. Eight different kinds of core-spun yarn, which contain 44.4 dtex/4f spandex filament as the core and cotton fibres as the sheath to spin 19.7 tex elastic core-spun yarn, were produced. The yarns were used as weft and all the fabrics were produced with plain structure using the Rapier weaving machine.

The instrument for tensile fatigue cyclic loading was designed with two sensors control the initial and final position moveable clamps. The fabric samples were fatigued up to 1000 and 2000 cyclic loads with frequency of 9.8 Hz. According to this method, samples were extended up to 90% of their elongation at break and returned to initial position. These operations were repeated till the proposed number of cyclic loads. After applying cyclic loads on samples, bagging tests were carried out on samples. The results of the study were concerned in weft direction as the elastane yarn was used in the weft direction. The comparative evaluation of the results showed that the bagging fatigue of woven samples depends on the draw ratio of core part and twist factor of elastic core spun yarns. Number of cyclic loads was found to be effective 1000 cycles but no specific trend was observed in fatigue after 2000 tensile fatigue cyclic loads. The stretching properties of fabrics supported the fatigue behaviour of them under tensile fatigue cyclic loads.(6)

### Elastic recovery -93.5-96 at 50% extension
<table>
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<tr>
<th>Breaking extension(520-610)</th>
<th>Yarn crimp extension(%) - 275</th>
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<tr>
<td>Softening point(°C)-175</td>
<td>Breaking elongation(%) - 275</td>
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- Elastic recovery - As compared to Lycra yarn, High Stretch Polyester yarn is having a more elastic recovery and it shows excellent elasticity
- Strength - Lycra yarn is a weaker fibre than High Stretch Polyester yarn, so High Stretch Polyester is more durable due to good strength compare to Lycra yarn.
- Elastic content - Elastic content of the high stretch polyester yarn is high compare to Lycra yarn.
- Density(g/cm³)-Density of the high stretch polyester(1.36) yarn is high compare to Lycra yarn(1.0).

### Reference

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### III. Conclusion

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<tr>
<th>LYCRA(SPANDEX)</th>
<th>T400(HIGH STRETCH POLYESTER)</th>
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<tr>
<td>Density(g/cm³)-1.0</td>
<td>Density(g/cm³)-1.36</td>
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<tr>
<td>Melting point(°C)-250</td>
<td>Melting point(°C)-229</td>
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<tr>
<td>Moisture regain(%) - 0.3</td>
<td>Glass transition temp(°C)-65</td>
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<td>Tenacity(g/d) - 0.6-0.8</td>
<td>Modulus of elasticity (CN/dtex)-35.3</td>
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