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RESEARCH ARTICLE

EFFECT OF LYCRA ON PERFORMANCE OF WOVEN AND KNITTED FABRICS

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ABSTRACT

Fabrics for apparels, where comfort, durability and fit are the main criteria are manufactured with incorporation of Lycra. Stretch has fairly obvious impact on comfort, adding flexibility and freedom of movement. This research was carried out to test woven and knitted fabrics in combination of 97% cotton and 3% Lycra for their physical properties. These properties would be useful for construction of garments providing comfort, ease of body movement, and a good fit with shape retention. It was found from the study that strength and elongation values of compact woven fabrics were better with presence of Lycra. Knitted fabrics with looped structure exhibited highest elongation values. Growth and recovery property of fabrics showed better recovery value. Shrinkage behavior for all four fabrics was also within tolerable limit. The results of cyclic loading showed that even with Lycra woven fabrics could give recovery range within very lower limits of stress than knitted fabrics. The results of stretch and recovery on wearing would be useful for predictions of sizes to accommodate range of body sizes which could be used for construction of garments even with different styles. Woven Lycra blends would have additional advantage of allowing sewers to more closely fit a pattern and be very comfortable. For knits they would be comfortable as well as more of dimensionally stable fabrics.

INTRODUCTION

Today majority of the population is looking forward towards fashionable clothes but those which give them comfort, stretch and flexibility. The properties of cotton are limited due to its natural origins, and therefore elastomeric fiber-Lycra@ is increasingly used to impart a great level of stretch and more dimensional recovery. Lycra introduced in woven or knitted fabrics improves some of the performance properties. The comparative study on effect of Lycra@ filament on the extension at peak load, immediate recovery, delayed recovery, permanent set and resiliency of cotton/Lycra@ blended knitted fabric shows higher immediate recovery, extension and resiliency but delayed recovery and lower permanent set than those of 100% cotton fabric. Laundering reduces the extension at peak load, immediate recovery and permanent set become higher (Mukhopadhyay *et al*., 2003). The growth and growth recovery characteristics with Lycra@ in 4% and 6% both woven and knitted samples show permanent set. The cyclic snap test do not show formation of surface bulges up to 1000 cycles, further up to 2000 cycles only the folds appeared showing good recovery of fabrics with Lycra (Nair, 2004)@.

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The area density of cotton /Lycra@ knitted fabrics reduces according to the optimization of knitting process parameters. Performance properties like shrinkage at laundering and maximum extension also improve (PavkoCudena *et al*., 2000). The objective of this research was to test the performance of Lycra in woven and knitted fabrics of different geometry that would be useful to study growth and recovery properties which would establish relations between the fiber content, method of construction and other related physical properties necessary for garments to give comfort, shape retention and better fit.

MATERIALS AND METHODS

Two fabrics under the category of each woven and knitted fabric in cotton/Lycra (93/3%) combination were selected to study performance of Elastane with different fabric construction patterns. Woven fabrics with 2 x 2 basket weave (A) and 2 x 2 twill weave (B) construction; and knitted fabrics with single jersey (C) and rib knit (D) construction were mill finished and ready to use. The preliminary data of fabrics has been given in Table 1. The series of tests were carried out for performance and serviceability of fabrics like pilling resistance (ASTM D 4970), abrasion resistance (ASTM D 1175-61), growth and elastic recovery property (Marmali, 2003), shrinkage behavior (ASTM D 2724), strength and elongation properties (ASTM D 5034), air permeability and stress-strain behavior under cyclic loading (ASTM D 1174-94) according to standard test methods.

RESULTS AND DISCUSSION

Pilling and abrasion resistance properties of fabrics

All four fabrics under study did not show any protruding fibers or effect of pilling on the surface. The effect of fussiness, fading or change in color was also not observed. As all the fabrics were made of cotton, pilling was not expected on the fabric surface. The impact of Lycra was the only concern for pill formation. The results of woven fabrics showed very good resistance because of compact weave structure. As number of abrasion cycles progressed yarn breakage was observed in the fabric. The thickness of the fabrics reduced up to 0.02 mm. Knitted fabrics showed loss of luster and dull surface due to abrasive effect. Reduction of fabric thickness up to 0.03 mm. was noticed. Rib knit fabric was quite resistant due to double jersey knit construction. (Table 2)

Effect of growth and elastic recovery properties of fabrics

Results of fabrics for growth and recovery property have been presented in Table 3. Perfectly elastic materials will have an elastic recovery of 1.0, while materials without any power of recovery will have recovery of zero (Booth, 1996). Fabrics A and B did not show recovery in warp direction presenting elastic recovery value 0. Weft direction exhibited better recovery for fabric A (0.8) and fabric B (0.9). Knitted fabrics C and D both had very good extension and recovery. Though Lycra was present only in course direction, wale direction also exhibited good recovery due to knit structure. Fabric C and D both had recovery value of 0.9 in wale as well in course direction indicated that these fabrics recovered better (Kunzru, 1982).

Load and elongation characteristics of fabrics

Lycra alone exhibits about 600% elongation, and when incorporated in fabrics even in small amount of 2 to 5% gives

Table 1. Preliminary data of fabrics

Fabric Code	A 2 x 2 Basket weave	B 2 x 2 Twill weave	C Single jersey	D Rib knit
Fabric count / 2.5 cm^2	168 x 96	168 x 92	46 x 64	33 x 60
Cloth cover	26.2	26.6	-	-
Tightness factor	-	-	0.67	0.85
Thickness (mm)	0.26	0.26	0.69	0.78
Weight per unit area (gm/m^2)	141.31	140.92	202.49	299.39

Table 2. Abrasion resistance of fabrics under study

Fabric Code	No. of Cycles	Observation	Loss in Thickness (in mm)
A	680	Single yarn breakage	0.02
B	685	Single yarn breakage	0.02
C	850	Single yarn breakage	0.03
D	1000	No yarn breakage	0.03

Table 3. Growth and elastic recovery value of fabrics in warp and weft directions

Fabric Code	Original length (cm)	Extended length (cm)	Immediate Recovery(cm)	Recovery after 24 hrs (cm)	Elastic recovery value
A warp	20.0	20.4	20.1	20.0	0.0
A weft	20.0	20.7	20.2	20.1	0.8
B warp	20.0	20.4	20.1	20.0	0.0
B weft	20.0	21.1	20.3	20.1	0.9
C wale	20.0	28.6	21.2	20.3	0.9
C coarse	20.0	28.4	20.8	20.3	0.9
D wale	20.0	22.3	20.5	20.2	0.9
D coarse	20.0	26.2	20.5	20.3	0.9

Key: A-2 x 2 Basket weave, B-2 x 2 Twill weave, C-Single jersey, D-Rib knit

Table 4. Load and elongation properties of woven fabrics

Direction of Sample	Fabric A		Fabric B	
	Load (kgf)	Elongation (mm)	Load (kgf)	Elongation (mm)
Warp wise	61.98	10.16	65.12	9.64
Weft wise	43.28	26.33	39.96	24.38
Bias	37.66	46.34	28.46	36.78

Table 5. Load and elongation properties of knitted fabrics

Direction of Sample	Fabric C		Fabric D	
	Load (kgf)	Elongation (mm)	Load (kgf)	Elongation (mm)
Wale wise	26.16	149.30	48.16	83.93
Course wise	18.24	185.80	24.66	206.22
Bias	26.72	105.67	33.30	96.69

Table 6. Shrinkage behavior of fabrics

Fabrics	A		B		C		D	
Laundry washes	Warp wise % shrinkage	Weft wise % shrinkage	Warp wise % shrinkage	Weft wise % shrinkage	Wale wise % shrinkage	Course wise % shrinkage	Wale wise % shrinkage	Course wise % shrinkage
Control sample	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L1W	-1.5	1.0	-1.0	2.5	3.5	4.5	5.5	-0.5
L2W	-1.5	1.0	-1.0	2.5	4.5	5.5	7.0	-0.5
L3W	-1.0	1.0	-0.5	3.0	5.5	6.5	8.0	-1.5
L1T	-1.5	1.0	-1.0	2.5	4.0	4.5	7.0	0.5
L2T	-1.5	1.0	-1.0	2.5	5.5	5.5	8.5	-0.5
L3T	-1.5	1.0	-0.5	2.5	5.5	5.5	8.5	-0.5

Key: L1W – Wash cycle I – treatment with only water, L2W – Wash cycle II- treatment with only water, L3W - Wash cycle III -treatment with only water, L1T –Wash cycle I- treatment with 5% detergent solution, L2T–Wash cycle II- treatment with 5% detergent solution, L3T –Wash cycle III- treatment with 5% detergent solution

Table 7. Air Permeability Of Treated And Untreated Fabrics

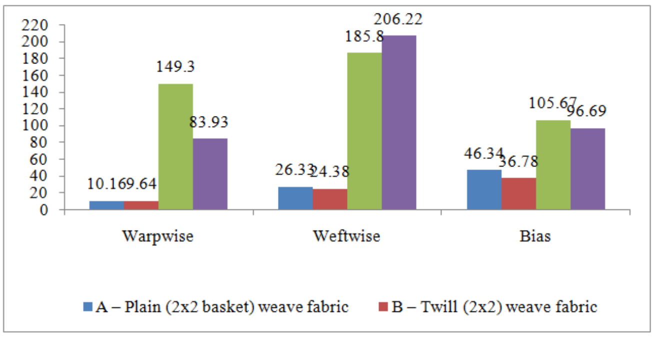
Treatments	Fabrics			
	A Air permeability $m^3/m^2/hr$	B Air permeability $m^3/m^2/hr$	C Air permeability $m^3/m^2/hr$	D Air permeability $m^3/m^2/hr$
Control	700	515	710	655
LW	505	410	485	600
LT	585	500	475	580

Key: LW-Laundry with water only, LT- Laundry with Teepol solution

Table 8. Elastic recovery property of fabrics

Fabrics	Warp wise (cm)	Weft wise (cm)	Bias (cm)
A	0.241	0.89	0.81
B	0.29	1.12	0.85
C	4.78	7.20	3.12
D	2.4	7.79	2.73

As the warp yarns being pure cotton and also under stress while manufacture, the elongation value obtained was low. The weft wise direction had decreased load value with increased elongation due to presence of Lycra in the weft direction and also the relaxed, corrugated path that weft yarn followed while weaving. Bias exhibited maximum elongation with lowest load value as the direction was not supported by warp or weft yarns. Fabric B exhibited slightly lower load elongation value than fabric A for weft wise and bias direction due to compact twill weave pattern (Hearle *et al*., 1969).



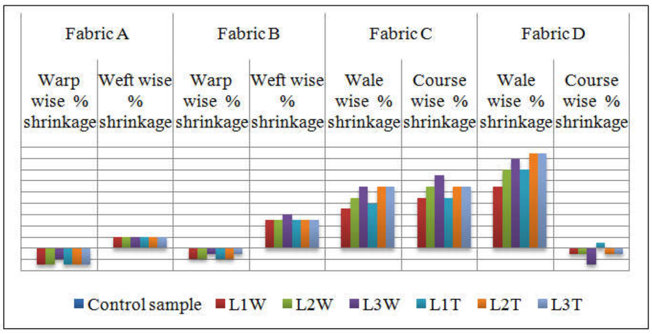
Graph 1. Comparison of elongation property of fabrics

Knitted fabric C exhibited maximum elongation value in course wise direction with Lycra allowing the fabric to extend so high. Unlike woven fabrics bias direction showed lower elongation value than wale wise or course wise direction due to slippage of knitted loops under applied load. Fabric D showed highest elongation value in course wise direction with presence of Lycra in double jersey knit construction.

Bias direction showed slightly higher elongation than wale wise direction but quite lower than course wise direction value (Table 5, Graph 1).

Shrinkage behavior of fabrics

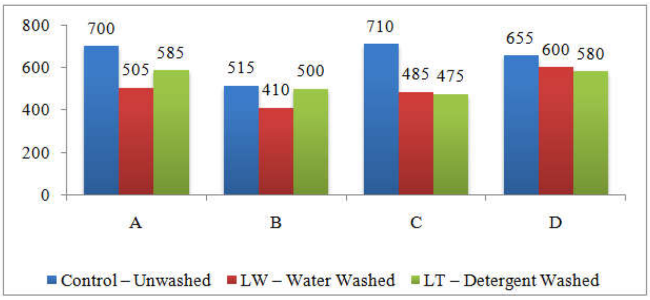
Shrinkage values for woven and knitted fabrics indicated that all fabrics behaved differently as per their geometry (Table 6). Fabric A exhibited extension of -1.0 to -1.5 percent in warp direction while weft direction showed shrinkage of 1.0 percent due to presence of Lycra in the weft. Fabric B exhibited extension of -0.5 to -1.0 percent in warp direction while weft direction exhibited shrinkage of 2.5 percent. Only third wash cycle with water resulted in shrinkage of 3 percent in weft direction. Compact twill weave pattern in fabric B was responsible for less shrinkage values in warp direction than basket weave fabric A. Similarly weft shrinkage values were more for fabric B than fabric A. Fabric C exhibited progressive shrinkage when washed with water in wale as well as in course direction ranging from 3.5 to 5.5 percent and 4.5 to 6.5 percent respectively. Wale direction showed progressive shrinkage in the first two wash cycles with detergent ranging from 4.0 to 5.5 percent and then it became steady at the third wash cycle. The course direction shrinkage was also progressive from 4.5 to 5.5 percent and became steady. The contraction of loop structure and presence of Lycra resulted in such changes. The sample edges also curled after washing. This showed the dimensional set of fabric with detergent solution (Marmali, 2003). Fabric D being double jersey knit, showed progressive shrinkage in wale direction from 5.5 to 8.0 percent with water and 7.0 to 8.5 percent with detergent solution. Unlike the behavior of single jersey fabric in course direction, fabric D showed extension from -0.5 to -0.5 to -1.5 percent in course direction. The third wash with detergent showed steady shrinkage value. Compact double knit construction might not have allowed the fabric to contract in this direction (Graph 2).



Graph 2. Shrinkage behavior of fabrics treated with and without detergent solution

Air permeability of fabrics

The fabrics in their control state and after each laundry cycle of water and detergent wash were subjected to air permeability test. The results obtained have been presented in Table 7. permeability. Detergent wash removed the surface finish from the fabrics and hence the permeability of fabrics A and B increased than the samples washed with water. Knitted fabrics C and D with their looped structure showed more air permeability. Fabric D with double jersey knit construction showed lesser permeability to air than fabric C. The treatment with water made the fabric structure swollen, compact and more resistant to air showing decreased value. Further the treatment with detergent showed lower readings indicating closeness of the fabric structure supported by progressive shrinkage in the wale and course direction of with presence of Lycra (Graph 3).



Graph 3. Air permeability of treated and untreated fabrics under study

Elastic recovery property of fabrics under cyclic loading

The fabrics were first tested for their tensile strength in lengthwise, widthwise and bias direction (Latzke, 1983; Mehta, 1990). From the tensile strength graphs, yield points for maximum recovery at stress found had been represented in Table 8. The values showed that the warp direction of fabric A without Lycra could be worked within limitation of 0.24 cm which is very low recovery and fabric does not behave like a stretch fabric. The weft direction with Lycra showed slight better recovery of 0.89 cm which could give very good result when used for garment construction to get better fit. Maximum stretch ability in bias direction was found to be 0.81 cm (Table 8). Like plain basket weave fabric, twill weave fabric B also showed lower recovery 0.29 cm in the warp wise direction. The weft wise direction with compact twill weave structure and Lycra showed recovery of 1.12 cm which is expected to give better result for garment fit and comfort. However, bias direction did not show the expected value of high elongation as seen in the plain woven fabric A. The single jersey knit fabric C showed recovery of 4.78 cm in wale direction and 7.20 cm in course direction which could be considered very high. Weft knitted structure with Lycra was responsible for such an excellent property. The bias direction showed minimum elastic recovery of 3.12 cm. Inter looped structure of knitted fabric when undergoes stretching, slippage of looped stitches caused this result. The wale direction of rib knit fabric D did not show much elasticity as double knit compact structure did not loosen so easily, showing 2.4cm recovery at yield point. The course wise direction due to Lycra and opening of double knitted loops exhibited very good elastic property of 7.79 cm. Bias direction showed slightly higher recovery of 2.73 cm. Though the fabric was double jersey knit, the loops did not support the behavior of wale or course direction getting better recovery.

Conclusion

Overall it could be viewed that Lycra had its impact on improving performance of woven and knitted fabrics. The strength and elongation properties of woven fabrics showed lower elongation values as compared to knitted fabrics. The results of the elastic recovery showed that woven fabrics even with three percent Lycra exhibited poor recovery where as knitted fabrics gave better results. Laundry washes initially showed progressive shrinkage and then the fabrics stabilized. Air permeability was low for woven fabrics. Looped structure of knitted fabrics was more permeable to air. Elastic recovery under cyclic loading showed that woven fabrics recover less within the limit of smaller extension with rigid structure. Knitted fabrics recover maximum exhibiting elastic property with higher extension. The results of the study could be useful for designing of woven and knitted fabrics with Lycra to get better, comfortable and dimensionally stable garments.

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