Effect of Lycra Extension Percent on Single Jersey Knitted Fabric Properties

R. Sadek, A. M. El-Hossini, A. S. Eldeeb, A.A. Yassen

Mansoura University, Textile Engineering Department, Mansoura, EGYPT

Correspondence to:
Roqaya Sadek email: r_sadek@mans.edu.eg

ABSTRACT

This research studies the effect of extension increase percent of bare Lycra yarns during loop formation on the geometrical, physical and mechanical properties of plain jersey fabrics. Samples with 100% cotton yarns, Lycra yarns in alternating courses (half plating) and Lycra yarns in every course (full plating) were produced on a circular knitting machine. The two latter cases were produced at five different levels of Lycra extension. Thermal setting was carried out without any traverse tension during finishing, thus evaluating the full effect of Lycra extension. Results show a sharp increase in the courses density rather than the wales density. Fabric thickness and weight per unit area also increased, and air permeability in the case of the half and full plating fabrics decreased considerably. The breaking load and extension also increased, while the initial elasticity modulus decreased with an increase in abrasion resistance in the case of full plating. A comparison between half and full plating methods contributes to improving fabric quality by determining optimal Lycra percentage.

Keywords: Fabric geometrical properties, Lycra extension percent, half and full plating.

INTRODUCTION

Single jersey fabrics are generally used to make underwear and outerwear such as T-shirts. Compared to woven structures, knit fabric can more easily deform or stretch by compressing or elongating the individual stitches that from the fabric. This ability to stretch by stitch rearrangement adds to wearing comfort that, among other factors, is affected by Properties such as extensibility, air permeability, and heat insulation of garments made from knit fabrics. Even when knit fabrics are constructed of 100% cotton, there is some recovery of the knit stitches to original dimensions after imposed forces are removed. However, this recovery by knit stitch rearrangement generally is not complete because cotton yarns, which are not elastomeric, do not a have a recovery force to rearrange the stitches. As a consequence, single-knit fabrics may experience permanent deformation. To improve the recovery performance of circular single-knit fabrics, it is now common practice to co-knit a small amount of spandex fiber or yarn with companion cotton yarn. As used herein, Lycra means a manufactured fiber in which the fiber forming substance is a long–chain synthetic polymer comprised of at least 85% of segmented polyurethane [1]. The polyurethane is prepared from a polyether glycol and chain extender and then melt-spun, dry-spun or wet-spun to form the spandex fibers. There are many different counts and types of spandex on the market. The main ones are yarns that are used on circular knitting machines together with other yarns. For jersey knit constructions in circular knitting machines, the process of co-knitting spandex is called "plating." When the cotton yarn and the spandex yarn are knitted parallel or side-by-side in every course, with the spandex yarn always kept on one side of the cotton yarn, the method is classified as “full plating.” When the Lycra is placed in alternating courses, the method is classified as “half plating.” Feeding of the Lycra yarn to knitting machine with a rate less than the required stitch length of cotton yarn results in yarn extension which in turn generates tension, and as the knitted loops leave the needles the spacing of courses and wales decrease and the fabric shrinks in both directions thus affecting the properties of knitted fabric.. The aim of this research was to study the effect of Lycra extension percent on the properties of the plain jersey fabrics by quantitative assessment in order to predict the optimal lycra extension percent with respect to fabric required quality.

LITERATURE SURVEY

Bayazit [2] investigated the dimensional and physical properties of cotton/spandex single jersey fabrics and compared the results with fabrics knitted from cotton alone. It was apparent that as the amount of spandex increased the loop length value remained nearly the same and the course and wale spacing decreased. Furthermore, because spandex-containing fabrics

tend to be tighten. The weight per unit area and thickness of the fabrics are higher but the air permeability, the pilling grade, and the spirality are lower. Herath [3] Studied the dimensional characteristics of a core spun cotton /spandex interlock structure. The results were compared with those for similar fabrics knitted from 100% cotton. Dimensional characteristics for both types of samples were measured by considering the change of the courses and the wale and the stitch densities under dry, wet and full relaxation conditions. It was found that, the wale and the course densities were lower for 100% cotton structures during relaxation. Also, the stitch density variations of cotton/spandex interlock structures were significantly higher than the ones of 100% cotton during relaxation. Chathura [4] studied the dimensional stability of core spun cotton/spandex single jersey structures with high, medium and low tightness factors under dry, wet and full relaxation conditions. Results were compared with those for similar fabrics knitted from 100% cotton fabrics. The courses, the wales and the stitch density were increased with of the relaxation and higher values were reported with cotton/spandex 1x1 Rib knitted structures. Serkan Tezel [5] investigated the effects of spandex brand, the tightness factor of the base and spandex yarn on the dimensional and physical properties of cotton/spandex single jersey fabrics. This was done in order to produce tight, medium and loose. Four different spandex yarns were used. Shown that the largest tension values under a constant draw ratio give the highest the weight per unit area, the number of courses/cm, the number of stitches/cm^2, the thickness and but lowest the air permeability values.

Most of the researches [2-9] studied the dimensional and physical properties of the knitted fabric produced from core spun yarn and few of these researches investigated the properties of the knitted fabric produced from cotton and Lycra yarns. As Lycra yarns are often used in alternating courses (half plating) instead of every the course (full plating) either for economical reasons or for better fabric quality, there is a necessity to compare these two cases under different levels of the lycra extension percent. Such a comparison is the aim of this research.

EXPERIMENTAL

Fabric Production

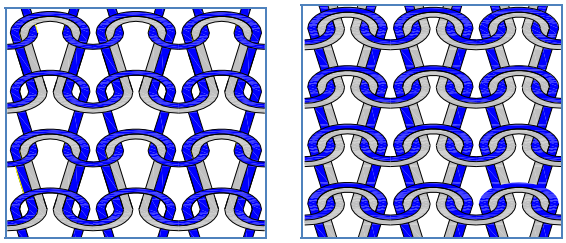
A circular knitting machine with the specifications shown in *Table I* was used to produce 11 samples from cotton spun yarn 30/1 Ne and 40 dTex lycra yarn. *Table II* shows the specifications of the produced samples and *Figure 1* shows the structure of half and full plating samples.

TABLE I: Knitting machine specifications.

Machine Type	Model	Gauge Needle/inch	Diameter (inch)	No. of Feeders
Single Jersey (circular)	Mayer&Cie	24	30	96

TABLE II. Fabrics production plan.

Fabric Structure				
	Single Jersey (without lycra)			✓
	Single Jersey(Half plating)	Lycra Extension %	232%	✓
			170%	✓
			129%	✓
			103%	✓
			82%	✓
	Single Jersey(Full plating)	Lycra Extension %	230%	✓
			173%	✓
			134%	✓
			99%	✓
			82%	✓



(a) *(b)*

FIGURE 1. Loop diagram of the cotton/spandex single jersey fabrics (a) the lycra in alternating courses (half platting), (b) the lycra in every courses (full plating).

Definitions

Lycra Extension Percent

The Lycra extension percent was calculated from the loop length of (cotton and lycra yarns), from the following Eq. (1).

$$\text{Lycra extension \%} = ((A-B)/B)*100 \quad (1)$$

Where:
A = loop length of cotton yarn.
B = loop length of lycra yarn.

The mean value of loop length for cotton and lycra yarns as shown in *Table III* were obtained from **Lycra* Multifunction tester LMT-6** which was connected to the knitting machine during the production of the fabric as shown in *Figure 2*.

FIGURE 2. **Lycra* Multifunction tester LMT-6**

TABLE III. The mean value of loop length for 100% cotton, half and full plating single jersey fabric.

Loop Length (mm)	100% Cotton	Half Plating				
	3	1.65	1.5	1.3	1.11	
	Full Plating					
	0.9	1.65	1.5	1.22	1.1	0.91

***Percent change**

The measured property of half and full plating cotton/spandex fabrics was calculated as a percent from the measured property of the 100% cotton fabrics as follows.

$$\text{Percent change} = ((C-D)/D)*100 \quad (2)$$

Where:
C=value of the property for (cotton/ spandex) sample.
D = value of the property for 100% cotton sample.

Fabric Preparation and Dyeing

The fabrics were prepared and dyed in a finishing mill according to the plan shown in *Figure 3*.

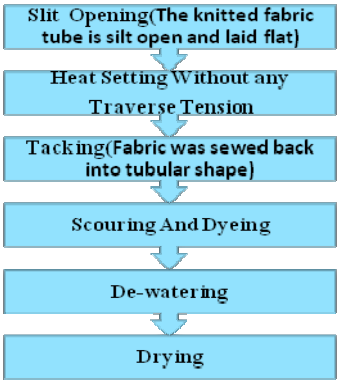


FIGURE 3. Fabric finishing plan.

Testing Methods

The following properties were measured for dyed samples, in accordance to standard methods as follows: The fabric weight was tested by using the ASTM D 3776 - 96 standard test methods. The fabric thickness was tested by (K094) SDL Atlas digital thickness gauge by using ISO 1765 test method. The air permeability was tested using (M021A) SDL Atlas air permeability device according to the ASTM D 737 test method. The abrasion resistance was tested which are abrasion resistance tester using AATCC 93 test method. The bursting strength was tested using ASTM D3787 test method.

RESULTS AND DISCUSSION

Effect of the Lycra Extension Percent on the Geometrical Properties of Dyed Single Jersey Knitted Fabrics

Half Plating Fabrics

Figure 4 Shows that, as the lycra extension percent increased, the wale density increased from 2% to 6%, the course density increased from (17% to 40%), the stitch density increased from 20% to 48%, the thickness increased from 12% to 25% and the weight per unit area increased from 30% to 47%. Also results showed the increase in the courses density to be nearly seven times the increase in the wale density. This may be due to the nature of the knitted fabric structure in which each stitch is interloping vertically with the previous stitch by a number of yarns twice the number of yarns with the adjacent horizontal stitch. Density may be also increased to a level more than the theoretical jamming condition by stitch overlapping as shown in *Figure 5* which results in increase in the fabric thickness, where the average increase percent is 18 %.

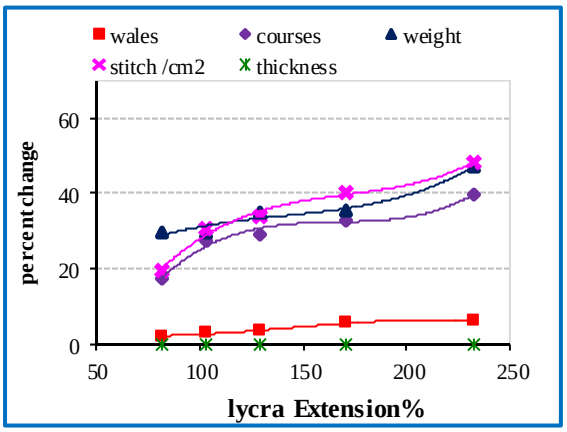
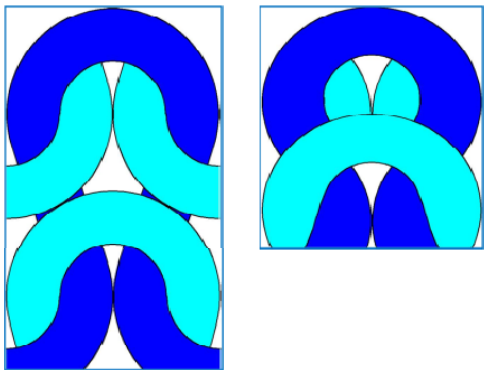


FIGURE 4. Effect of the lycra extension % on the geometrical Properties for half plating dyed fabrics.



(a) *(b)*

FIGURE 5. Loop structure diagram of the 100% cotton single jersey fabric: (a) theoretical jamming, (b) stitch overlapping.

Full Plating Fabrics

Figure 6 Shows that, as the Lycra extension percent increased, the wale density increased from 5% to 14%, the course density increased from 42% to 77), the stitch density increased from 48% to 103%, the thickness increased from 19% to 46%, and the weight per unit area increased from 58% to 104%. The increases percentage of these properties in the case of full plating is about twice the increase percentage as in the case of half plating. Also, the increase percentage in the course density is nearly six times the increase percentage in the wale density as found in half plating. This can be interpreted by the same reasons mentioned in half plating and is confirmed by the increase percent fabric thickness, which reaches 33% as an average value. This confirms that the Lycra yarn tension leads to stitch overlapping which increase the fabric thickness.

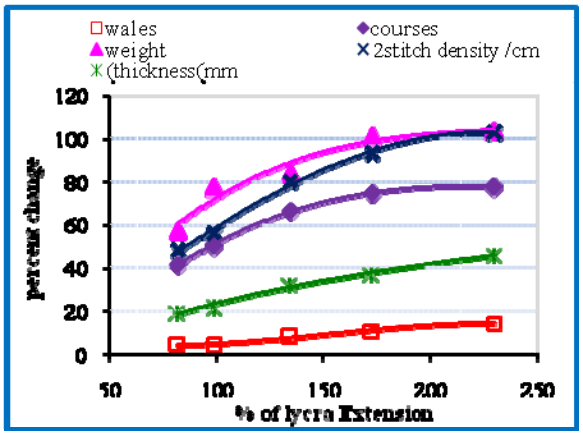


FIGURE 6. Effect of the Lycra extension % on the geometrical Properties for full plating dyed fabrics.

Effect of the Lycra Extension Percent on the Air Permeability of Dyed Single Jersey Knitted Fabrics

Figure 7 Shows that, as the Lycra extension percent increased, the air permeability decreased from 64% to 78% for the half plating fabrics and decreased from 84% to 92% for the full plating fabrics. The decrease in the air permeability is due to the increase in the stitch density which means more fabric tightness and fine pore diameter in addition to the increase in the fabric thickness.

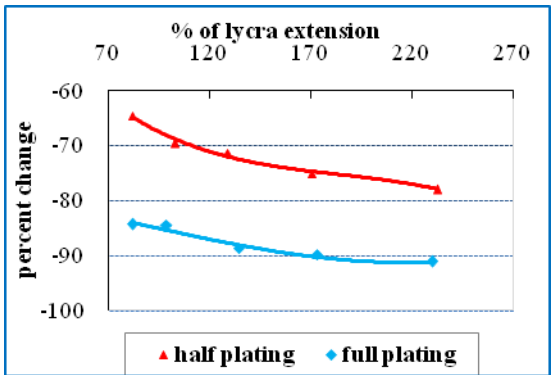


FIGURE 7. Effect of the lycra extension % on the air permeability for dyed fabrics in half and full plating.

Effect of the Lycra Extension Percent on the Mechanical Properties of Dyed Single Jersey Knitted Fabrics

Bursting Strength

Figure 8 Shows the load–Extension curves obtained from the bursting–strength tester for the cotton, half, and full plating fabrics at very high Lycra extension. As shown the cotton fabric has the lowest breaking extension. Also at the same extension the load in the case of half and full plating fabrics is less than the load in the cotton by about 80 % as shown in equation (3), which makes the fabric produced from both cotton and spandex yarns more comfortable. The breaking load in the case of the full plating fabric is higher than for both the cotton fabric and the half plating fabric, which means that adding the spandex yarn in every course increases the fabric strength while the strength decreases by adding the spandex yarn in alternating courses.

$$Y = ((y1-y2)/y2)*100 \quad (3)$$

Where Y is the decrease percent in the load at the same extension, y1 is the load at extension (15mm) for the half and full plating fabrics at very high lycra extension, and y2 is the load at extension (15mm) for 100% cotton fabric.

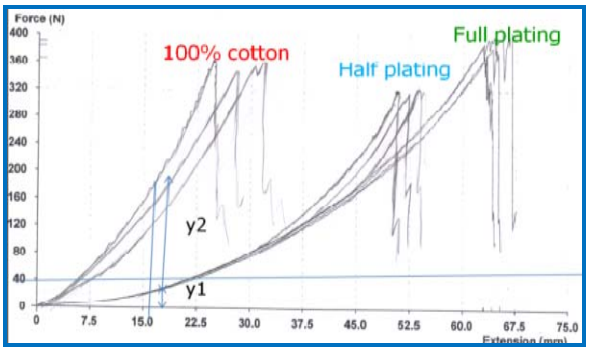


FIGURE 8. Relation between the force and extension result from the bursting strength tester for 100% cotton, half and full plating fabrics.

Breaking Load

Figure 9 Shows the effect of the increase in Lycra extension percent on the breaking load of the cotton fabric and the half and full plating fabrics. The breaking load increased in the case of the full plating fabrics by an average of 10 % and in the case of the half plating by an average of 5% compared to 100% cotton fabric. The breaking load of half and full plating fabric depends essentially on the cotton yarn which has higher initial elasticity modulus of the Lycra yarn. The increase of the breaking load may be interpreted by the variation in the stitch density.

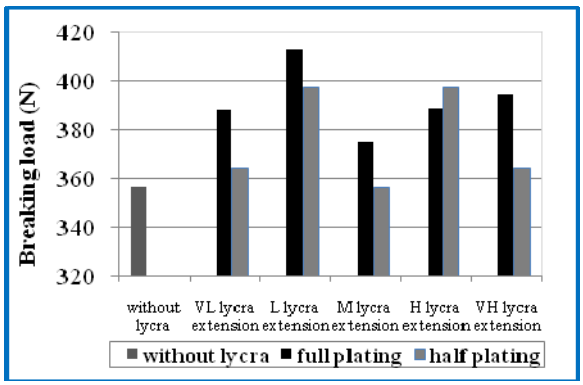


FIGURE 9. Effect of the Lycra extension % on the breaking load for half and full plating and without lycra fabrics.

The Breaking Extension

Figure 10 shows results of the breaking extension for 100% cotton fabric and the half and full plating fabrics where the breaking extension in the case of the full plating increased by an average value of 150 % and in the case of the half plating by an average value of 73 % compared to fabric without Lycra. It is obvious that the breaking extension of the full and half plating fabrics is only dependant on the lycra extension percent.

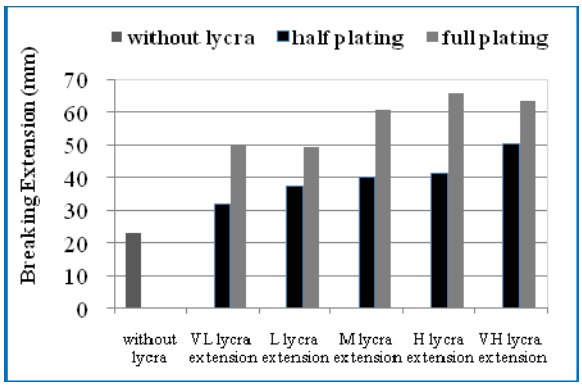


FIGURE 10. Effect of the Lycra extension % on the breaking extension for half, full plating and without Lycra fabrics.

Initial Elasticity Modulus

Figure 11 Shows the effect of the increase in the Lycra extension percent on the initial elasticity modulus. The decrease percent in the initial elasticity modulus reaches 55 % in the case of the half plating fabric with the very high Lycra extension percent and 69 % in the case of the full plating fabric with very high Lycra extension percent. The lower initial elasticity modulus is a very important parameter with respect to comfort ability.

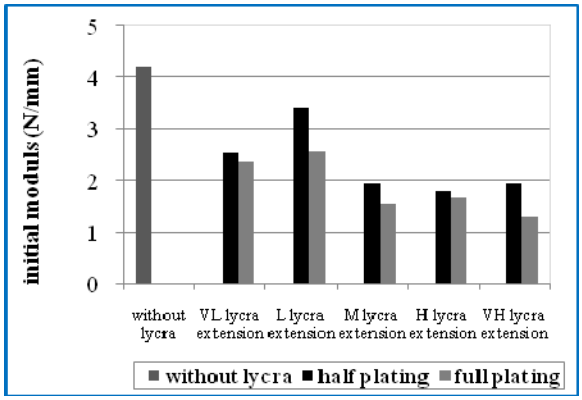


FIGURE 11. Effect of the Lycra extension % on the initial elasticity modulus for half and full plating and without Lycra fabrics.

Abrasion Resistance

Figure 12 shows that the fabric weight loss % in the case of half plating is greater than that of the 100% cotton fabric by an average of 7.5 %. The fabric weight loss% in the case of the full plating is less than 100 % cotton fabric by an average decrease of -15 %. The increase in weight loss% in the case of the half plating may be interpreted by the ridges formed on the fabric surface due to the absence of Lycra in half of the courses. These ridges are not formed on the fabric surface in the case of the full plating and the surface is more regular.

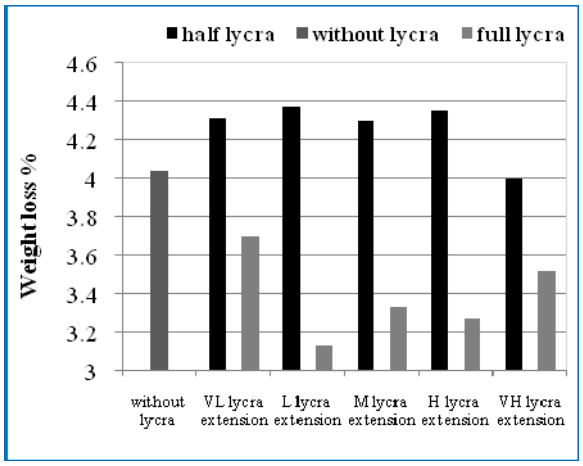


FIGURE 12. Effect of the lycra extension % on the fabric abrasion resistance for dyed samples in half, full plating and without Lycra.

CONCLUSION

This research studies the effect of the extension increase% of the bare Lycra yarns on the geometrical, physical and mechanical properties of plain jersey fabrics produced from cotton and Lycra yarns. As the Lycra extension percent reached 232% in the case of the half plating fabrics, the course density increased by 40%, the wale density increased by 6%, the thickness increased by 25%, the air permeability increased by 78%, and the initial elasticity modulus decreased by 55%. The abrasion resistance of the half plating fabric decreased by an average value of 7.5%. Also, as the Lycra extension percent reached 232% in the case of the full plating fabrics, the course density increased by 77%, the wale density increased by 14%, the thickness increased by 46%, the air permeability increased by 92%, and the initial elasticity modulus decreased by 69%. The abrasion resistance of the full plating fabric increased by an average value of 15%. Thus, the half plating fabrics showed better results for the course and wale density. The air permeability and the optimum Lycra extension was 82% while the full plating fabric showed better results for the initial elasticity modulus and the abrasion resistance. The optimum Lycra extension percent was 232% and 103% respectively. According to the required property of the knitted fabrics, the Lycra percent (either half or full) and the extension percent in each case can be chosen.

REFERENCES

[1] Meredith, R. Elastomeric Fibres. Woodhead Publishing Limited, 2004.

[2] Bayazit, A. Dimensional and Physical Properties of Cotton/Spandex Single Jersey Fabrics. Textile Research Journal 2003; 73: 11-14.

[3] Herath, C. N. Bok C K. Han-Yong J Dimensional Stability Of Cotton – Spandex

[4] Interlock Structures under Relaxation, Fibers and Polymers J 2006; 8,105-110.

[5] Herath, C. N. Bok C K. Han-Yong J Dimensional Characteristics Of Core Spun Cotton – Spandex 1x1 Rib Knitted Fabrics In Laundering. International Journal of Clothing Science and Technology 2007; 19:43-58.

[6] Chathura N. Bok C. Dimensional Stability Of Core Spun Cotton/Spandex Single Jersey Fabrics Under Relaxation. Textile Research Journal 2008; 78: 209–216.

[7] Serkan, T. Yasemin, K. Experimental Investigation of Effects of Spandex Brand and Tightness Factor on Dimensional and Physical Properties of Cotton/Spandex Single Jersey Fabrics. Textile Research Journal 2008; 78: 966–976.

[8] Arzu, M. Lubos, H. The Effect Of Moisture On Friction Coefficient Of Elastic Knitted Fabrics, Tekstil Ve Konfeksiyon 2008; 18: 206- 210.

[9] Saber B. Abdes S. Influence Of Elastane Consumption On Plated Plain Knitted Fabric Characteristics. Journal of Engineered Fibers And Fabrics 2009; 4: 30-35.

[10] Prakash C. Established The Effect Of Loop Length On Dimensional Stability Of Single Jersey Knitted Fabric Made From Cotton/Lycra Core Spun Yarn. Indian Journal of Science and Technology 2010; 3:287-289.

AUTHORS' ADDRESSES

R. Sadek
A. M. El-Hossini
A. S. Eldeeb
A.A. Yassen
Mansoura University
Textile Engineering Department
Mansoura, 35516
EGYPT