Annual Academic Sessions 2011
ISSN 2012-9912; ©2011 Open University of Sri Lanka

DIMENSIONAL VARIATIONS OF CORE SPUN COTTON/SPANDEX SINGLE JERSEY FABRICS WITH RELAXATION AND WASHING TREATMENTS

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INTRODUCTION

When *knitted* fabrics are subjected to the *relaxation and washing treatments*, various *structural changes* may occur and therefore their dimensions can vary accordingly [Herath (2008), Sharma *et. al.* (1985), Mikucioniene (2004), Marmarali (2003)]. This behavior depends on number of factors and the material is basically an important factor out of those [Herath (2008), Mikucioniene (2004), Marmarali (2003)]. Due to the dimensional variations of knitted fabrics, garments may have serious quality problems during manufacturing as well as during washing and wearing. Thus, this results in changing fit the garments and customer complaints are very often. Consequently, study on the dimensional variations of knitted fabrics made out of different textile materials is extremely important.

During *relaxation and washing treatments*, *structural parameters* progressively increase in *single jersey knitted structures* and it causes to reduce the course and wale spacing in the structure [Sharma *et. al.* (1985), Marmarali (2003)]. Hence, the *dimensional shrinkages* in lengthwise and widthwise directions and in area in the single jersey fabrics are observed [Sharma *et. al.* (1985), Mikucioniene (2004)]. These shrinkages are significantly higher during tumble drying and further in washing treatments in the single jersey fabrics [Mikucioniene (2004)]. In the previous research works done, dimensional variations have been studied for single jersey fabrics made from *cotton, wool and cotton/man-made fibers* mixed in various proportions. In this research work, dimensional variations in lengthwise, widthwise as well as in area of single jersey knitted fabrics made from *cotton/spandex* were studied and results have been compared with the similar fabrics made from 100% cotton.

METHODOLOGY

Core spun cotton/spandex-*CO/SP*- (93%:7%) and 100% cotton-*CO*- structures were knitted according to the machine set *stitch lengths* as 2.90, 2.70 and 2.50mm(for both CO/SP and CO fabrics) in a circular knitting machine with machine diameter of 30 inches and 72 positive feeders. Based on that the fabrics were categorized into three *tightness factors* (*TF*) such as *L-TF* (for 2.90 stitch length), *M-TF* (for 2.70mm stitch length) and *H-TF* (for 2.50mm stitch length). Six samples of 30 x 30 cm^2 were cut from each tightness factor of CO/SP and CO fabrics. Samples were then subjected to standard *dry-, wet- and full- relaxation* treatments (according to ASTM D 1284-76) and standard *washing treatments* up to 10^{th} washing cycles (according to ISO 6330). There were 5 measurements taken from each length- and widthwise direction of a sample and all together 30 data were collected for each direction. After each treatment level, course and wale densities, stitch densities and linear dimensional changes were measured and then, area dimensional changes of samples were determined using the formulae (1) and (2).

$$\text{Linear dimensional change (\%)} = \frac{[L_O - L_1]}{L_O} \times 100 \quad \text{- (1);}$$

where, L0:average distance between pair of marks, before relaxation treatment
L1:average distance between pair of marks, after relaxation treatment.

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$$\text{Area dimensional change (\%)} = \frac{[L_{LO} \times L_{WO} - L_{L1} \times L_{W1}]}{L_{LO} \times L_{WO}} \times 100 \quad \text{- (2);}$$

where, LL0 : distance between pair of marks in lengthwise, before relaxation treatment
LW0: distance between pair of marks in widthwise, before relaxation treatment
LL1 : distance between pair of marks in lengthwise, after relaxation treatment
LW1 : distance between pair of marks in widthwise, after relaxation treatment

RESULTS AND DISCUSSION

Structural spacing variations

For the dimensional variations of weft knitted structures, structural spacing (i.e: wale spacing and course spacing) is the most responsible factor. Based on the course and wale density values at each treatment stage, variations of structural spacing changes were calculated. Table 1 shows the structural spacing reduction (in %) from dry relaxation to full relaxation treatment. In this table wale and course density increases (in %) are also given. All values are in average. Table 2 shows the same variations for the treatment from full relaxation to 10th washing cycle.

		H-TF		M-TF		L-TF	
		Wale	Course	Wale	Course	Wale	Course
CO/SP	Spacing reduction (%)	21.1	16.2	17.4	23.8	14.9	24.4
	Density increase (%)	26.9	19.3	21.1	31.2	17.5	32.2
CO	Spacing reduction (%)	19.2	5.80	13.9	6.30	8.60	6.80
	Density increase (%)	23.8	5.10	16.2	6.70	9.44	10.6

Table 1: Structural changes from dry relaxation to full relaxation

		H-TF		M-TF		L-TF	
		Wale	Course	Wale	Course	Wale	Course
CO/SP	Spacing reduction (%)	6.16	3.44	5.74	3.80	5.62	4.29
	Density increase (%)	6.57	3.56	6.09	3.95	5.95	6.48
CO	Spacing reduction (%)	7.38	5.21	6.90	5.53	6.48	6.52
	Density increase (%)	7.97	5.50	7.41	5.86	6.98	6.93

Table 2: Structural changes from full relaxation to 10th washing cycle

According to Table 1 and 2, from H-TF to L-TF structures, wale spacing reduction percentage decreased where as course spacing reduction percentage gradually increased during progressing the relaxation and washing treatments. Same changing pattern can be observed in wale densities and course densities also. Thus, it shows the significantly lower values of spacing reduction percentages in wale and course directions of CO/SP structures from full relaxation to 10th washing cycle (Table 2) compared to dry relaxation to full relaxation (Table 1). Reason would be that full relaxation treatment gave the better stable state to the CO/SP structures than dry- and wet- relaxation treatments and therefore during washing treatments, structures have not subjected to higher deformations compared to dry- to full-relaxation treatments. Hence, same pattern of spacing reduction percentage can be observed with CO samples. Thus, full relaxation with tumble drying gave the higher structural changes [Herath (2008)], which gave the higher structural spacing reduction compared to dry- and wet- relaxation. During washing, there was not such a vast changes happened. Thus, higher wale spacing reductions can be observed than course spacing reductions for all tested fabrics.

Linear and area dimensional variations

Using formulae (1) and (2), linear dimensional variations in lengthwise and widthwise were calculated. Table 1 shows the linear dimensional changes from dry- to full- relaxation treatments. Figure 1 and 2 show the length and width direction shrinkages of CO and CO/SP single jersey fabrics in full relaxation treatments up to 10^{th} washing cycle. Thus, Figures 3 and 4 shows the variations in for the treatments from full relaxation to 10^{th} washing cycle.

It is clearly shown that dimensional shrinkages in lengthwise and widthwise in samples have increased with progression of treatments as given in Table 3 and Figures 1 & 2. This is due to the decrease of wale and course spacing in the structures as the increase of stitch densities [Herath (2008)], while relaxation of CO/SP and CO single jersey structures during treatments. Thus, specially in CO/SP single jersey structures, they had the inclination/bending of plain stitches into 3^{rd} dimension during relaxation through treatments, which results to a higher dimensional shrinkages than CO structures. This is more prone to happen in CO/SP structures as they compose of very high stitch densities at machine off state (after removing the knitted fabric from the machine) as well as further increasing them during treatments [Herath (2008)].

TF category	CO/SP shrinkages (in %)		CO shrinkages (in %)		Treatment
	Lengthwise	widthwise	Lengthwise	widthwise	
L-TF	5.60±0.05	2.40±0.04	2.70±0.06	4.16±0.11	Dry Relax
M-TF	4.90±0.08	4.46±0.07	1.71±0.03	5.21±0.08	
H-TF	1.64±0.07	8.88±0.03	1.16±0.02	6.57±0.07	
L-TF	16.52±0.10	9.92±0.14	2.84±0.09	8.52±0.09	Wet Relax
M-TF	13.72±0.06	11.48±0.06	1.88±0.08	9.84±0.12	
H-TF	8.24±0.06	14.20±0.07	1.24±0.05	11.40±0.07	
L-TF	25.16±0.03	17.20±0.13	5.52±0.07	12.64±0.09	Full Relax
M-TF	23.28±0.08	17.92±0.28	2.04±0.07	14.64±0.05	
H-TF	13.8±0.06	18.52±0.07	1.92±0.04	15.28±0.13	

Table 3: Dimensional shrinkages in lengthwise and widthwise from to dry- to full-relaxation

Note: All values calculated under 95% significant level

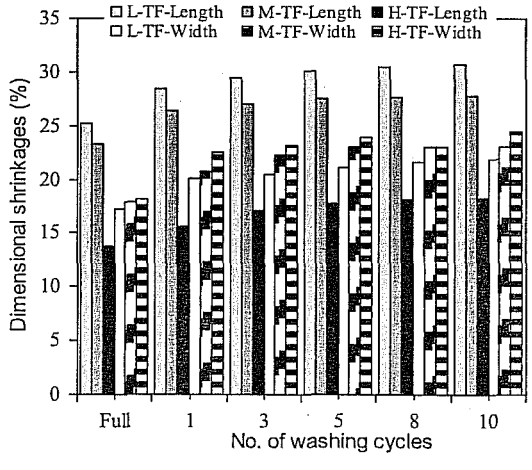

Figure 1:Dimensional shrinkages of CO/SP fabrics from full relaxation to 10^{th} cycle

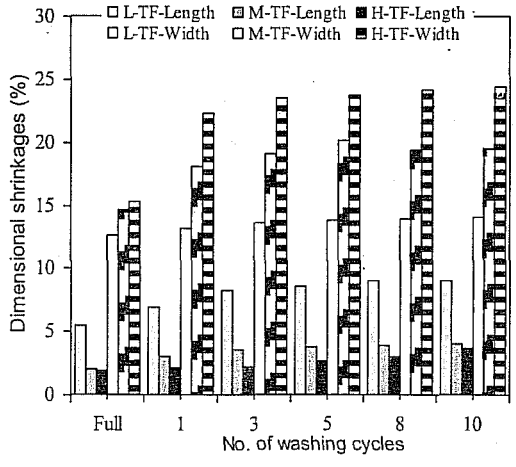

Figure 2: Dimensional shrinkages of CO fabrics from full relaxation to 10^{th} cycle

According to the Table 3 and Figures 1 & 2, significantly higher shrinkages in lengthwise and widthwise (except Dry-CO/SP) dimensions can be observed in CO/SP single jersey samples

compared to CO fabric samples. Reason would be its significantly higher structural spacing reductions than in CO structures (as given in Table 1 and 2), which is resulted by increasing of course and wale densities (i.e: increasing stitch densities).

Thus, another remarkable feature is that the length shrinkages of L-TF and M-TF CO/SP structures are higher than their width shrinkages as given in Table 3 and Figures 1 & 2. However, H-TF CO/SP fabrics showed an opposite behavior to this. It can be proved by Table 1 and 2 such as the higher course spacing reduction %, which is responsible for lengthwise dimensional shrinkages, than their wale spacing reduction %. But, in H-TF CO/SP structures, higher wale spacing reduction % has given than course spacing reductions (as given in Table 1 and 2), which results higher width shrinkages as given in Table 3 and Figure 1 & 2 . But, all CO samples gave the higher width shrinkages after each treatment stage and it can be proved by Tables 1 and 2, where higher wale spacing reduction %s (responsible for widthwise dimensional shrinkages) have reported. Therefore, in the CO/SP structures, it was observed the longitudinal deformation and lateral deformation in shape of L-TF/ M-TF and H-TF fabric samples respectively. However, CO samples gave only the lateral deformation in sample shape. Thus, Lengthwise shrinkages of H-TF CO/SP structures had approximately 50% reduction compared to their L-TF and M-TF structures but, in the same structures, widthwise shrinkages do not show such a variation among L-TF to H-TF structures.

Hence, at each treatment level, it can be observed gradually decreasing of length shrinkages and increasing of width shrinkages from the CO/SP and CO samples with increasing of tightness factor of structures such as L-TF to H-TF as given in Table 3 and Figures 1 & 2. This is called as "*Anisotropic* " behavior of knitted structures during relaxation. Further, calculated area shrinkages are shown in Figures 3 and 4. According to Figures 3 and 4, higher area shrinkage reductions have given by H-TF structures. In CO/SP samples this reduction is more prominent as shown in linear dimensional shrinkages. But, CO fabrics do not show such a clear difference between H-TF and L-TF & M-TF structures. Thus, full relaxation and further washing treatments gave much higher area shrinkages specially in CO/SP fabrics.

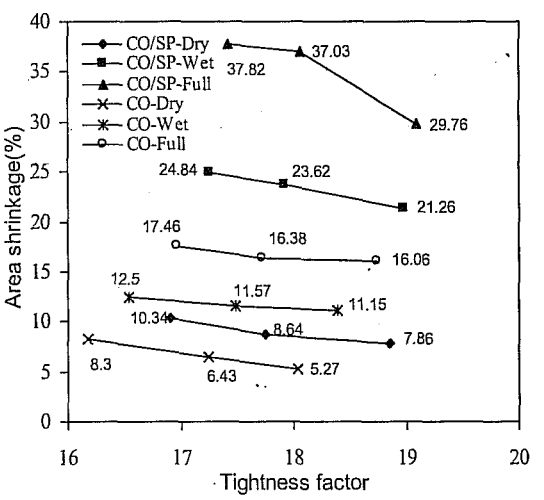

Figure 3: Area shrinkages during dry- to full- relaxation treatments

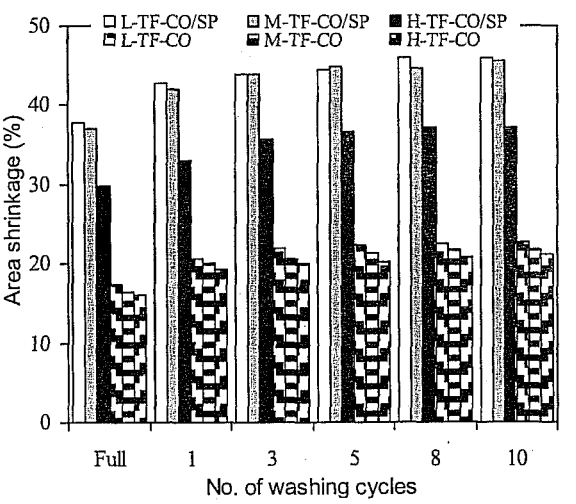

Figure 4: Area shrinkages during full relax to 10th washing cycle.

CONCLUSIONS

Fabric shrinkages in lengthwise and widthwise progressively increase during relaxation and washing treatments and causes shape deformation in fabrics. This shrinkage behavior is different for CO/SP and CO single jersey fabrics. CO/SP fabrics gave the higher linear shrinkages than that of CO fabrics. L-TF and M-TF CO/SP showed higher length shrinkages compared to width shrinkages, but H-TF showed and opposite behavior. However, all CO samples gave the higher length shrinkages during treatments than their width shrinkages. In the CO/SP structures, it was observed the longitudinal deformation and lateral deformation in shape of L-TF/ M-TF and H-TF fabric samples respectively. However, CO samples gave only the lateral deformation in sample shape. Thus, anisotropic behavior in lengthwise and widthwise shrinkages of CO/SP and CO fabric samples with increasing tightness factor. Thus, CO/SP fabric showed much higher area shrinkages compared to that of CO fabrics. H-TF structures of CO/SP had a greater reduction of area shrinkages than L-TF and H-TF. Fabrics with higher tightness factors (lower in stitch lengths) may have lower linear dimensional variations and area dimensional variations. Thus, further to the full relaxation treatments, fabrics deform in lower amounts during washing treatments and mostly, after 5th washing cycle, CO/SP and CO fabrics will not vary their linear and area dimensions in significantly.

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