RELAXATION BEHAVIOUR OF 1X1 RIB CORE SPUN COTTON-SPANDEX AND 100% COTTON FABRICS UNDER WASHING TREATMENTS

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INTRODUCTION

Knitted fabrics change their dimensional characteristics during relaxation and washing treatments. This results in the lessening of certain important inherent qualities of knitwear such as better fit to the body, shape retention properties, stretchability, snugness, ideality for next-to-skin wear the variations of fabric GSM, thickness and physical properties [Herath (2009), Anand, *et.al.* (2002), Mikucioniene (2001)]. It was also highlighted that these structural changes in weft knitted fabrics significantly depend on the material type, relaxation & washing treatment level and fabric structure [Anand, *et.al.* (2002), Herath, (2009), Knopten, *et.al.(*1968)]. Structural changes occurred during relaxation and washing treatments are responsible for the dimensional changes in weft knitted fabrics.

In apparel industry, *100% cotton and cotton-spandex1x1 rib fabrics* are commonly used. Their structural behaviors are different to each other under various relaxation and washing treatments and can be determined using the changes of structural parameters. Variations of structural parameter during relaxation and washing treatments are largely due to the changes of the knitted stitch configuration [Anand, *et.al.* (2002), Knopten, *et.al.*(1968), Mikucioniene (2001)].

Knitted fabrics undergone stress resulting in stretching and various mechanical deformations during stitch formation and these stresses are released during relaxation and washing treatments. The behavior is directly responsible for dimensional stability of weft knitted fabrics. Therefore, in order to get a good quality and dimensionally stable fabric structure, a study on structural behavior is very important.This paper will be focused on the structural behavior of core spun cotton-spandex and 100% cotton 1x1 rib structures knitted with three tightness factors using circular knitting machines, during full-relaxation and repeated washing treatments (till 10^{th} washing cycle).

METHODOLOGY

Materials

100% Cotton (abbreviation: CO) and core spun cotton/spandex (abbreviation: CO-SP) with 93% cotton and 7% spandex were used to knit 1x1 rib structures in a circular knitting machine in high, medium and low tightness factors (TF). In order to achieve better fabric properties and uniformity, tension and feed rate of cotton/spandex yarns were controlled carefully. Table I gives the characteristics of cotton and cotton/spandex yarns used for 1x1 rib structures. Spandex filaments with 40dtex were used in producing core spun cotton-spandex yarns. Table 2 gives the knitting details of 1x1 rib structure manufacturing.

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Table 1.Knitted yarn characteristics

	Nominal Count [Ne]	Tensile Strength [gf]	Breaking elongation [%]	Yarn twist [tpi]
CO	30*	274.4	5.04	19.7
CO-SP	30*	305	8.94	27.4

*Measured count of pure cotton yarn is 20.14tex and that for cotton/spandex yarn is 20.40 tex

Table 2. Knitting details

	No. of feeders (positive)	No. of needles
CO	60	1680
CO-SP	60	1680

Note: Machine diameter=30 inches; gauge=24 and machine RPM=20

Table 3 gives the machine set stitch lengths and machine off stitch lengths, which are measured under 95% significant level and given in parenthesis. In determining machine off stitch lengths, the *SCSL(structural knit cell stitch length - i.e. yarn required to knit one structural knit cell [SKC])* concept was used and it was assumed that SCSL equals twice the stitch lengths required to knit face/reverse stitches.

Table 3. Machine set and machine off stitch lengths in cm.

Material	Low fabric tightness [L-TF]stitch length	Medium fabric tightness [M-TF]stitch length	High fabric tightness [H-TF]stitch length
CO-SP	0.290 (0.521 ± 0.053)	0.270 (0.489± 0.054)	0.250 (0.461 ± 0.066)
CO	0.290 (0.586± 0.083)	0.270 (0.541± 0.051)	0.250 (0.502± 0.054)

Procedure

Sample size of 30x30 cm^2 were cut from 100% CO and CO-SP 1x1 rib knitted fabrics. Six samples were cut from each TF of each CO and CO-SP rib fabrics. Samples were first subjected to dry- and wet- relaxation and then subjected to full relaxation (according to ASTM D 1284-76) followed by machine washing treatments (according to the ISO6330) up to 10 cycles. For *course density (CPC-courses/cm) and rib density(RPC-ribs/cm)* measurements, there were 5 places selected and measured in each tested fabric sample, after being subjected to the standard atmospheric conditions. In 1x1 rib fabrics, wale spacing calculations are based on the SCSL concept. Thus, linear dimensional measurements have been calculated according to the standard method and based on that the area shrinkages were calculated.

Dimensional constants

To calculate the dimensional constants, standard procedures were used for full relaxed and washed rib structures, till 10th cycle such as SCSL (cm), stitch density (cm^{-2}), tightness factor (tex$^{1/2}$ cm^{-1}), K- constants (Ks, Kc, Kw, and Kp). CPC and RPC were measured as the mean courses and ribs per cm per face. SCSL was measured by unraveling of yarn length of 25 ribs and taking its' uncrimp length with using 'Zweigle" tester by putting 0.5cN/tex weight on the underside. This weight was good enough to remove the crimp in the unraveled yarns. Five yarn lengths were measured from each sample and finally the average stitch length of 30 yarm samples was calculated with considering SCSL concept. Thus, TF was calculated using the formula ($\sqrt{tex}$ / [SCSL/n_t]), where n_t- number of needles in knitting operation in one SKC.

RESULTS AND DISCUSSION

COURSE AND WALE DENSTY CHANGES

Course (CPC) and ribs density (RPC) of 1x1 rib CO and core spun CO/SP fabrics have shown different behaviors during relaxation and washing treatments up to 10th cycle (W1-W10) in Figure 1 and 2, even though they were knitted under same machine set stitch lengths as given in Table 3. According to both these figures, RPC and CPC gradually increased with the progressing of treatments. Therefore, structural spacing reduces with progression of treatments and results in dimensional shrinkages. This would also affect the variations of structural behaviors and physical properties. Thus, based on the RPC values, wale density of CO-SP rib fabrics have lower values than their course densities (CPC). But, CO rib fabrics show the opposite behavior, where it is assumed that SCSL=2 x face or reverse loop stitch length. These variations may be due to the higher *robin back effect of* CO-SP structures and two planar construction of rib fabrics. Thus, RPC and CPC variations of CO-SP rib fabrics show steeper increases from full relaxations to W1 or some cases up to W3 compared to CO fabrics. After that, they show almost no variations till W10. It means that CO-SP rib fabrics became faster dimensional stable state than CO fabrics. Hence, CO-SP fabrics have given higher RPC and CPC values than CO fabrics, even though they were knitted using the same stitch lengths. This may be due to the higher robin back effect of the knitted structures and the excellent recovering properties of CO-SP core spun yarns. Thus, according to Figure 1 and 2, RPC and CPC values show positive correlation to *Fabric tightness factor* (TF) or stitch length^{-1}. Thus, the stitch densities of structures showed the same tendencies.

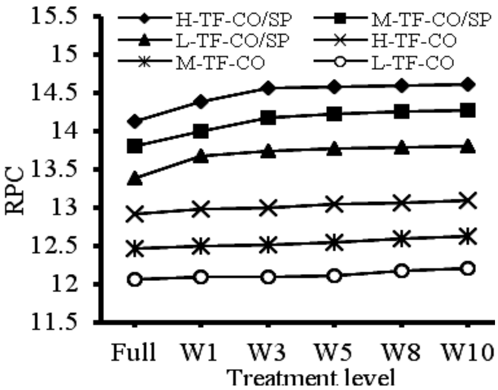

Figure 1. RPC variations of knitted fabrics

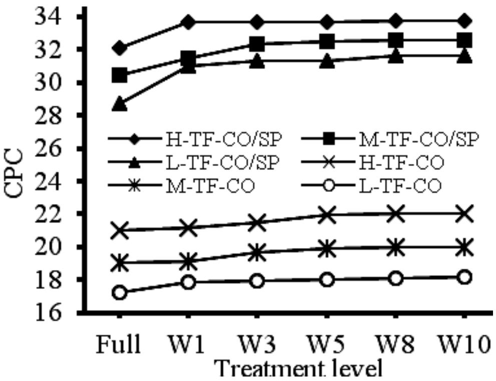

Figure 2. CPC aviations of knitted fabrics

DIMENSIONAL CONSTANTS (K-VALUES)

In order to Dimensional constant values for 1x1 rib structures, following relationships about structural knitted cell (SKC) concept [Knopten, *et.al.*(1968)]were used;

$$C_U = \frac{K_C}{l_U}; \quad W_U = \frac{K_W}{l_U}; \quad K_P = \frac{K_C}{K_W}; \quad K_S = C_U x W_U x l_U^2 = K_C x_W$$

Where C_U -Course units per fabric length(1cm), W_U -Ribs per fabric width(1cm), l_U - average total length of yarn in the SKC (SCSL). K_C, K_W, K_S *and* K_P are non dimensional parameters. Calculated K-values are given in Table 4 and Table 5.

CO-SP rib fabrics gave comparatively higher K-values than CO rib fabrics during full relaxation as well as in each stage of washing treatments. Almost all the K-values of CO and CO/SP rib structures are increased at 10th wash cycle. Thus, CO/SP rib fabrics show higher K-values than that of 100% CO rib fabrics, due to its higher CPC, RPC values and higher resiliency power of spandex component in the yarn core. Kp is generally taking as a guiding rule for relaxation of weft knitted structures. When Kp becomes constant, the whole structure has achieved the minimum energy state, where no further shrinkages/deformation will takes a place in the fabric. According to the obtained Kp values: CO/SP rib structures have *Coefficient of variation* (CV %)of 2.73 at full relaxation, but, after 3rd cycle, at 5th and 8th

cycles, CV% s are around 0.6 to 0.75. Then, at 10th cycle, CV% of K_p reduces up to 0.50. However CO rib structures have shown the CV% of 5.43 at full relaxation and it varies within the range of 5 to 5.42 values till 5th cycle. Then, it increases further and it reaches up to 6.29% after 10th washing cycle. Therefore, it can be understood that CO-SP structures become structurally very stable state after W10 rather than CO rib structures.

AREA DIMENSIONAL CHANGES

Linear dimensional shrinkages were calculated based on the measurements after each treatment level and then the fabric area shrinkages were determined. Those shrinkages have shown a good relation to the variations of the RPC and CPC as well stitch densities of the CO and CO-SP rib structures. Figure 3 and 4 those shrinkages. According to those figures, higher shrinkages and fabric deformations result by CO-SP fabrics than CO fabrics. In CO-SP fabrics, area shrinkages are positively correlated to the stitch length, but CO rib fabrics showed an opposite behavior. Area shrinkages are increasing with progressing of treatments. Hence, in the case of CO-SP fabrics, H-TF structures gave significantly lower area shrinkages than M-TF and L-TF structures. But, CO fabrics do not show such behaviour. Thus, after W3, most of the fabrics became dimensionally stable.

Table 4. K-values for CO/SP rib fabrics

TF	K_s	K_c	K_w	K_p	
L	100.53	14.68	6.84	2.14	Full relax
M	94.17	14.41	6.53	2.21	
H	88.72	14.19	6.25	2.26	
L	106.15	15.50	6.84	2.26	W1
M	98.67	14.89	6.62	2.24	
H	93.65	14.79	6.33	2.33	
L	107.63	15.7	6.87	2.28	W3
M	100.93	15.17	6.65	2.28	
H	93.36	14.69	6.35	2.31	
L	106.68	15.61	6.83	2.28	W5
M	99.76	15.10	6.61	2.28	
H	93.05	14.66	6.34	2.31	
L	107.03	15.67	6.82	2.29	W8
M	99.64	15.08	6.61	2.28	
H	90.40	14.46	6.25	2.31	
L	106.86	15.64	6.83	2.28	W10
M	99.43	15.06	6.60	2.28	
H	90.45	14.45	6.26	2.30	

Table5. K-values for 100% CO rib fabrics

TF	K_s	K_c	K_w	K_p	
L	59.76	9.23	6.47	1.42	Full relax
M	60.21	9.59	6.27	1.53	
H	57.86	9.57	6.04	1.58	
L	60.64	9.45	6.41	1.47	W1
M	59.60	9.56	6.24	1.53	
H	58.38	9.75	5.99	1.63	
L	60.52	9.47	6.38	1.48	W3
M	61.00	9.79	6.23	1.57	
H	58.79	9.84	5.97	1.65	
L	60.70	9.50	6.38	1.49	W5
M	61.81	9.90	6.24	1.58	
H	58.80	9.78	5.93	1.65	
L	60.96	9.53	6.39	1.49	W8
M	61.93	9.90	6.25	1.58	
H	58.79	9.96	5.90	1.68	
L	61.02	9.53	6.40	1.49	W10
M	61.97	9.92	6.24	1.59	
H	58.83	9.98	5.89	1.69	

Note: TF- tightness factor ($tex^{1/2}$ cm^{-1}); L-low TF; M-medium TF and H-high TF and all values are under 95% significant level.

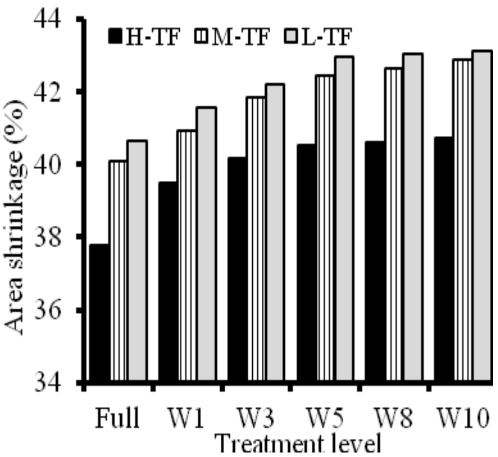

Figure 3. Area shrinkages of CO-SP fabrics

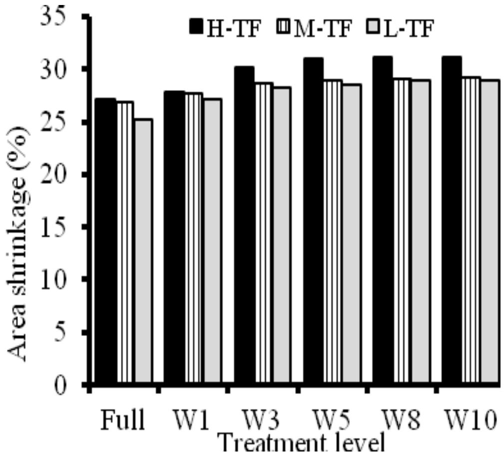

Figure 4. Area shrinkages of CO fabrics

CONCLUSION

CO-SP rib fabrics show higher RPC, CPC, stitch densities, area shrinkages and K-values than CO rib fabrics, even though they were knitted with same stitch lengths. Thus, RPC, CPC and stitch density of CO-SP and CO fabrics give positive correlation to stitch length^{-1}. CO-SP became faster dimensionally stable (minimum of 3 washing cycles) than CO fabrics. Thus, CO-SP fabrics result higher shrinkages and fabric deformations during treatments than CO fabrics. CO-SP and CO fabric area shrinkages show the opposite correlations to the stitch length. H-TF fabrics give significantly lower shrinkages than L-TF and M-TF CO-SP fabrics.

REFERENCES

Herath, C. N. (2007). Dimensional characteristics of Core Spun Cotton-Spandex 1x1 Rib knitted Fabrics in Laundering, International journal of clothing science & Technology, 19(1): 43-58.

Anand, S., C., *et.al.* (2002).Effect of laundering on the dimensional stability and distortion of knitted fabrics", AUTEX Research Journal, 2(2): 87-102.

Knopten, J.J.F., *et.al.* (1968).The dimensional properties of knitted wool fabrics, partII: 1x1 rib, 2x2 rib, and half cardigan structures", 38(10):1013-1026.

Mikucioniene, D., (2001). The reasons of shrinkage of cotton weft knitted fabrics, Material Science Journal, 7(4), 304-314.