The Consequences of Temperature on the Shrinkage Properties of Cotton Spandex Woven Fabric

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***Abstract*- The purpose of this research study was to establish the effect of heat-setting temperature on the shrinkage properties of cotton spandex woven fabric. Industrial settings, including machine speed, machine width and temperature had some direct effects on the shrinkage properties of cotton spandex fabric. Heat-setting did not allow to further compress the spandex fibers, so the cotton spandex could not shrink further when contacted with water. Heat-setting controlled and fixed the spandex portion, so that recovery forces seemed to be reduced. Basically, heat-setting also helped to condense the fiber size in core spun yarns. Quite a number of trials were carried out in textile mills with some adjusted industrial settings to control the shrinkage properties of cotton spandex woven fabric. Three cotton spandex fabrics with different constructions and compositions were used in this research. In the experiments, the temperature ranged from 180 °C to 200 °C and the machine speed varied from 24 to 28 meter per minute (MPM). Mercerized fabric was used to heat-set in a stenter machine. Heat was applied to the cotton spandex fabric very accurately, because overheat would spoil the spandex fabric. This study proved that temperature had a great effect on the shrinkage properties of cotton spandex fabric, and further research needs to be undertaken on this matter.**

***Keywords*: cotton spandex, heat treatment, fibers stabilization, industrial setting, shrinkage properties**

I. INTRODUCTION

There is a great importance of this work in textile and clothing engineering since the task of controlling the shrinkage of cotton spandex woven fabric is critical. Heat should be applied in cotton spandex woven fabric in stenter machine in such a way that, stabilization of spandex portions would be happened precisely with a view to controlling shrinkage appropriately. Fundamental experiments were performed in order to control the shrinkage properties. It was essential to check the consequences of heat treatment as it had a straight relationship with shrinkage of cotton spandex fabric.

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Liao *et al.* [1] showed that, the property of the fabric is changed when a parameter, such as machine speed, temperature, or width is changed during heat setting.

Another scholar [2] reported that the core structure of yarns was adjusted because of heat setting the spandex fabric. This incident increased the firmness in yarns.

It was reported that, heat setting resulted in a permanent structure to the spandex yarns manufactured using different polymer ingredients with haphazard molecular structures [3].

Another researcher [4] established that, heat setting influenced the elastic performances and recovery of fabrics.

Researcher also experimented that, heat setting changes the internal structure of spandex yarns. Crystalline interior can be changed due to temperature application [5].

It was also proved that, heat application stabilized the spandex portion in yarns and gave a permanent and rigid shape to the yarns [6].

Avcioglu Kalebek *et al.* [7] demonstrated that heat treatment developed the amorphous interior of spandex yarns, and therefore, some user-friendly elastic performances enhanced in fabrics [7].

As experienced by Gokarneshan *et al.* [8] proper heat setting could avoid creasing problem in fabrics and ensured dimensional stability of fabrics [8].

It was demonstrated that the temperature application could improve the dye take-up percentage and the crease resistance performances of fabrics [9].

Mansoor *et al.* [10] proved that the temperature application could enhance the mechanical abrasion and pilling properties in spandex fabrics.

It was also proved that a very little amount of elastane

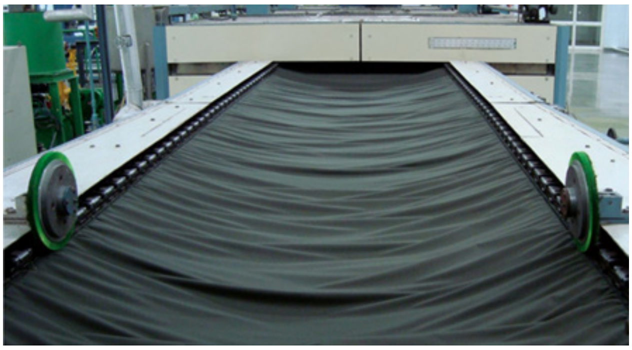

Fig. 1. Heat-Setting using Monforts stenter machine (Model: 16113040, Germany, 1992).

(2.3%) was sufficient enough to enhance the elastic performance of fabrics [11].

As shown by Herath *et al.* [12] the remaining energy in yarns gained after spinning or after twisting were removed if temperature was applied properly in spandex fabrics.

El-Dessouky *et al.* [13] showed that heat could reshape the flexible sections in spandex yarns and enhanced their elastic performance. It was revealed by the Sardag [14] experiments that temperature application stabilized the spandex portions of yarns and enhanced the strength of yarn.

Shariful *et al.* [15] experimented that, application of temperature enhanced the elastic performances of cotton spandex woven fabrics. The present research was conducted to improve the shrinkage performances of cotton spandex woven fabrics through adjusting industrial settings, including, machine speed, machine width and temperature.

Stenter machine was used to heat-set the cotton spandex fabrics. Heat-setting is a common industrial thermal procedure. This machine had two endless chain. The length of this machine was 120 feet and the width of the machine was 100 in. The machine could run with a speed of 20 MPM (meter per minute) to 80 MPM. The temperature range of 100 °C-280 °C could be applied with this machine. The temperature was selected based on the nature, composition and thickness of fabrics [16]. Stenter machine had a gas burner to increase the temperature. Fig. 1 shows the stenter machine used in this study.

II. EXPERIMENTAL

A. Ingredients

For conducting the required experiments, three types of cotton spandex fabrics with different weights, widths and weaves were used. Different temperatures were applied on different types of fabrics. Higher temperature was applied for the fabrics with heavier GSM (g/m^2) and lower temperature was applied for the fabrics with lighter GSM. All parameters, including temperature, machine speed, and width were taken into consideration, while the fabric was heat-set to achieve a desired shrinkage. Heat-setting was done before dyeing because heat could harm the dye shade of the fabrics. Shrinkage test was carried out in agreement with the ASTM D7983 standard.

Fabrics were taken from batcher that was kept in front of the stenter machine. The fabric was damped in the stenter bath with 8 g/L of acetic acid. Damping of fabric could stop any damage of fabric like burning, and acetic acid could stop the rise of pH level. The stenter chain pulled the fabric inside the machine. The gas burner supplied a temperature range between 160 °C and 220 °C. There was a circulating fan that could help the spread of temperature inside the machine. Three types of fabrics were used to complete this experiment as listed in Table I.

B. Experiment A

A specimen with a composition of 97% cotton and 3% spandex , a construction of 20x(16+70D)/140x70, a width of 51.5 in and a weave of 2/1 LHT was taken to perform the shrinkage tests at different temperature settings. Heat setting was performed at temperatures of 180 °C, 190 °C, and 200 °C. Shrinkage tests were done in both warp and weft directions at different temperatures, and the results are shown in Table II.

From Table II it can be seen that the fabric tested before heat exposure has the warp shrinkage of -6.22% and weft shrinkage of -12.34%. However, the fabric heated at 180 °C with a machine speed of 22 MPM shows a warp shrinkage of -5.44% and weft shrinkage of -10.12%. When the fabric was heated at 190 °C temperature with a machine speed of 24 MPM, warp shrinkage and weft shrinkage were found to be -4.00% and -8.00%, respectively. In addition, the fabric

TABLE I
DIFFERENT TYPES OF COTTON SPANDEX FABRIC

	Construction	Composition	Weave	Width	GSM
1	20x(16+70D)/140x70	97% Cotton 3% Spandex	2/1 Left hand twill	51.5”	301
2	24x(20+70D)/150x78	98% Cotton 2% Spandex	3/1 Right hand twill	53”	270
3	40x(32+40D)/160x86	99% Cotton 1% Spandex	4/1 Satin	54”	178

TABLE II
SHRINKAGE TEST RESULTS

Temperature (°C)	Machine speed (MPM)	Warp shrinkage (%)	Weft shrinkage (%)
Without heat setting	N/A	-6.22	-12.34
180	22	-5.44	-10.12
190	24	-4.00	-8.00
200	25	-3.38	-6.54

heated at 200 °C with a machine speed of 25 MPM has a warp shrinkage of -3.38% and a weft shrinkage of -6.54%. It is clear that, shrinkage can be controlled by increase in temperature.

C. Experiment B

A specimen with a composition of 98% cotton and 2% spandex , a construction of 24x(20+70D)/150x78, a width of 53 in and a weave of 3/1 LHT was taken to perform the shrinkage tests at different temperature settings. Heat setting was performed at temperatures of 170 °C, 180 °C, and 190 °C. Shrinkage tests were done in both warp and weft directions at different temperatures, and the results are shown in Table III.

From Table III it can be seen that the fabric tested before heat exposure has the warp shrinkage of -5.28% and weft shrinkage of -10.54%. However, the fabric heated at 170 °C with a machine speed of 21 MPM shows a warp shrinkage of -4.42% and weft shrinkage of -8.54%. When the fabric was heated at 180 °C temperature with a machine speed of 23 MPM, warp shrinkage and weft shrinkage were found to be -3.00% and -6.02%, respectively. In addition, the fabric heated at 190 °C with a machine speed of 25 MPM has a warp shrinkage of -2.24% and a weft shrinkage of -4.58%. It is clear that, shrinkage can be controlled by increase in temperature.

D. Experiment C

A specimen with a composition of 99% cotton and 1% spandex, a construction of 40x(32+40D)/160x86, a width of 54 in and a weave of 4/1 satin was taken to perform the shrinkage tests at different temperature settings. Heat setting was performed at temperatures of 160 °C, 170 °C, and 180 °C. Shrinkage tests were done in both warp and weft directions at different temperatures, and the results are shown in Table IV.

From Table IV it can be seen that the fabric tested before heat exposure has the warp shrinkage of -6.3% and weft shrinkage of -7.2%. However, the fabric heated at 160 °C with a machine speed of 20 MPM shows a warp shrinkage of -4.10% and weft shrinkage of -5.13%. When the fabric was heated at 170 °C temperature with a machine speed of

TABLE III
SHRINAKGE TEST RESULTS

Temperature (°C)	Machine speed (MPM)	Warp shrinkage (%)	Weft shrinkage (%)
Without heat setting	N/A	-5.28	-10.54
170	21	-4.42	-8.54
180	23	-3.00	-6.02
190	25	-2.24	-4.58

TABLE IV
SHRINKAGE TEST RESULTS

Temperature (°C)	Machine speed (MPM)	Warp shrinkage (%)	Weft shrinkage (%)
Without heat setting	N/A	-6.30	-7.20
160	20	-4.10	-5.13
170	22	-2.30	-2.90
180	24	-1.90	-2.02

22 MPM, warp shrinkage and weft shrinkage were found to be -2.30% and -2.90%, respectively. In addition, the fabric heated at 180 °C with a machine speed of 24 MPM has a warp shrinkage of -1.90% and a weft shrinkage of -2.02%. It is clear that, shrinkage can be controlled by increase in temperature.

III. RESULTS AND DISCUSSION

What actually happened, due to heat setting, is that the application of temperature increased the closeness of spandex portion with cotton fibers. Spandex fibers were strictly attached to the cotton fibers, and so the stability of yarns increased and the shrinkage properties of fabric were directly influenced. Heat treatment changed the structural rearrangement of yarns. Before heat-setting, the spandex yarns were bulky and thicker but after heat setting the yarns were seen to be thinner and harder due to the change in internal structure. The spandex portion closely attached to the cotton fibers and gave the yarns with improved high stability. As stability was obtained in yarns so the unwanted forces those were gained while spinning or twisting were seen to be relaxed or minimized due to heat treatment. Heat treatment caused thermal shrinkage and improved the dimensional stability or the shrinkage of the fabric.

In experiments A, B, and C, three trials were conducted for each nomenclature with a setting temperature ranged from 160 °C to 200 °C. In experiment A, the optimum shrinkage values of -3.38% and -6.54% were obtained at temperature 200 °C with the machine speed of 25 MPM. In experiment B, the optimum shrinkage values of –2.24% and -4.58% were obtained at temperature 190 °C with the machine speed of 25 MPM. In experiment C, the optimum shrinkage values of -1.90% and -2.02% were obtained at temperature 180 °C with the machine speed of 24 MPM. It should be kept in mind that heat at different temperatures should be applied to control shrinkage in such a way that other properties of cotton spandex fabrics, such as elasticity, recovery and strength were not affected. The thermal shrinkage was improved by attaching the cotton fibers to the spandex fibers.

IV. CONCLUSION

In this study, heat setting was conducted in adequately high temperatures with adjusting industrial settings to obtain desired shrinkage properties for the cotton spandex fabric within moderately rigid limits. Heat setting fixed the structural orientation exactly and also abolished the continuing energy that might lead to stop further distortion of cotton spandex. Trials were carried out in textile factories at various industrial settings on cotton spandex fabric to study the unpredictable shrinkage properties found in elastic fabrics. It was also seen that, the effect of heat on cotton spandex decreased the prospective distortion of fabrics and increased their stability. The heat applied on the cotton spandex fabrics stabilized the spandex portion with elastane that could contribute to improve the dimensional stability or shrinkage of fabrics.

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