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Achieving Optimal Shrinkage of Cotton Spandex Woven Fabrics by Apposite Heat Setting Temperature

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Abstract

The aim of the paper was to achieve the optimal shrinkage values of cotton spandex woven fabrics through heat setting with a stenter machine. Three types of cotton spandex woven fabrics of different fiber content were used in this research. Heat setting was conducted with the facilities of a stenter machine with adjusted industrial setting. Required shrinkage tests were carried out as standard specified by AATCC as stated in this paper. Temperature ranges from 160°C to 200°C were applied in this research based on the thickness of the cloths. The findings of this paper established that, application of precious temperature disallowed the elastic fibers to further compression, due to this; the spandex portion couldn't shrink further when it came in contact of water. Heat setting stabilized the elastic portions so that the spandex recovery forces seemed to be reduced. Heat setting reorganized the polymer chain of spandex fibers with thermal shrinkage. The core spandex size was condensed caused by heat setting therefore the elastic power upon elongating beyond this point was reduced. Condensation was materialized due to the physical redisposition of internal molecules. The geometrical shape in the yarn was seemed to be rearranged. This research opened possible ways for the scholars to further study in this field.

Keywords: Stabilization; Restructuring; Amorphous region; Crystalline region; Thermal shrinkage; Dimensional stabilities

Introduction

There is a great significance of this research in the field of textile and clothing engineering, since the task of controlling of the shrinkage properties of cotton spandex woven fabric is always challenging. Different scholars worked related to this experiment at different times where literature review exposed different results. If any parameters were changed while heat setting or while testing, then other characteristics of the fabrics were also changed [1]. The word Heat setting is used in the textile industry to define a thermal procedure typically taking place in either one of a vapor thermosphere or of a warm heated environment [2].

The consequence of the procedure gives fibers, yarns or fabric dimensional constancy and habitually, other required qualities like higher volume, crease resistance or high temperature resistance etc. Sometimes, heat setting is also undertaken to progress qualities for consequent procedures [3]. Heat setting can remove the propensity of unwanted torqueing. At the stage of winding and twisting procedures, the enlarged propensity to torqueing can create problems in dispensing the yarn [4]. When applying heat setting for flooring yarns, wanted results contain not only the lessening of torqueing but also the steadying of the fiber yarn. Both twist equilibrium and equilibrium of decoration effect are consequences of the heat setting procedure [5].

Heat setting aids staple yarns and bulked incessant filament yarns. Heat setting frequently reasons synthetic fibers to increase volume as well. This volume progress is usually labeled as "bulk development" [6]. All procedures using temperature and dampness to give textiles one of the overhead stated characteristics are termed as heat setting. The term "thermal fixation" is used less commonly [7]. In the mat industry, the procedure is wholly called "heat setting". The crinkle propensity is because of the technical circumstances of the spun yarn manufacture and the physical fiber possessions [8]. Especially, the "technical circumstances of the spun yarn invention" describes the rotating minute of the yarn [9].

A warped yarn will continually attempt to screw when it suspends spontaneously amid two secure ideas in the form of a loop. In liability this, it stretches up a part of its unique twist that develops helixes those winding way is conflicting to the unique rotation track [10]. This growth of rotation in the contradictory way happens as the perverse yarn tries to spread symmetry [11]. Meandering in the conflicting way is because of the strains resultant from the yarn winding that Mueller designated in the drawing of tension and compression [12]. The entire stiffness substitute in contradiction of the winding is augmented in relative to amplified winding due to the cumulative tightness and weight of the package of fibers in the yarn [13].

It might become so stout that the yarn core clasps when it can no lengthier endure the compressive stresses. The yarn coils, meaning that the yarn stabs to spread a position of symmetry in which rotations in the conflicting route from the unique twist course equilibrium the yarn's turning [14]. These rotations are also called undesirable rotations. In this state of stability, the internal torsional strains abandon each other out. The yarn always clasps at a point where the cross section is minor due to the roughness of the strand [15]. While in the spinning procedure this spot removed up more screws and is consequently exposed to higher inner strains, which eventually break

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the yarn core [16].

Though, denser yarns are less warped than fine ones, the internal tension increases conflicting to the yarn size. Reduced yarn is more debilitated by scorching. Additional optimistic features of sweltering are the lessening of coiling and, at the same time, the scenery of the physical assets of closeness and postponement informed to the yarn by twisting [17]. As soon as vapor arrives, the yarns amount of dampness increases at once, instigated by the space heating of the yarn and by vapor compression. Ionization can be perceived at the bonds that were created from salt deliverance [18]. Because of the upsurge of heat in the fibers during baking a fluctuation of the particles is created those clues to the overflowing of the hydrogen bonds, now remaining valences are set unrestricted those are capable to marinate with the dipole water [19].

The water then performances as lubrication among the separate molecules. Thus the connections of the chief chains among each other are softened by the adjacent chains, the discrete polypeptide chains can swing in contradiction of each other and the strains find their symmetry [20]. When the sweltering of the yarn is sustained, new side chains are created among the separate substitutes of the main chains. When lastly the yarn is dehydrated, that means the dampness balance happening inside the yarn, salt is open-minded again and hydrogen bonds are created [21]. Now the discrete polypeptide chains can no longer be lifted counter to each other and the fibers recovered their previous intimacy, however deprived of having extraordinary tensions privileged [22].

The morphological arrangement of the fibers must be measured when balancing the tensions by scorching. As the woolen fiber very rapidly grows the heat for contravention up the hydrogen bonds and the vapor for hydrolyzing the cysteine bonds, a comparatively rapid twist alteration is conceivable that unevenly agrees to the values of an autoclave moderated yarn [23]. The hot quality of the blistering process is much enhanced with reference to the consistency of moisture fascination [24]. Synthetic fibers can be alienated up into two fiber areas, the crystal-like domain and the amorphous domain. In crystalline domains physical marines of magnetism are acting among the strictly equivalent lines of polymers [25].

These militaries acts diagonally to the fiber axis create up the intimacy of a fiber. If tension is practical to the fiber, these armies hinder the fiber from contravention. In distinction, the nebulous fiber areas act like links of the fibers [26]. They are accountable for the flexional power of the fibers. Moreover, the amorphous fiber areas brand it conceivable for water or dye to arrive. During sweltering, the boiler of the fiber sources its molecules to flinch hesitating [27]. The upsurge of oscillation that can be prejudiced by the amount and the time of heating melt the electronic bond armies in the fiber; at first in the shapeless domains, future in the crystalline ones and finally in the polymers [28].

As with wool, the strains transported in by spinning are set free. In drying or cooling of the yarn, the compulsory militaries are reconstructed without having strains in the internal part [29]. The problematic of synthetic fibers is that the decrease of the obligatory forces only happens among the distortion point and the crystalline fiber domains that in a comparatively high infection range [30]. The springiness of elastomer has been combined into an extensive range of cloths, particularly in body fit cloths [31]. An advantage of spandex is its important strength and elasticity and its capability to arrival to the unique shape after extending and earlier dehydrating than normal fabrics. Figure 1 shows the Physical and chemical forces among two polypeptide chains [32].

For dress, spandex is typically assorted with cotton or polyester, and explanations for a minor fraction of the final fabric those recall most of the appearance and texture of the other fibers [33]. Nowadays most garments covering spandex end up as biodegradable leftover once they have been damaged out, as fabric mixtures containing spandex are problematic to reprocess [34]. This gives to the contamination of the atmosphere. When garments are washed away, thousands of microfibers are unconfined into the wastewater, ending up in the waters, and if dresses comprise plastic then they will origin micro plastic contamination [35].

Shrinkage is a property of testing cloths to quantity variations in length and width after laundry. Shrinkage deteriorating resources are dimensionally unbalanced and they can origin distorting of the cloths or goods made out of those resources [36]. Shrinkage is verified at numerous phases, but most prominently before cutting the cloths into further sewn goods and after cutting and stitching prior to providing the products to purchasers [37]. It is an obligatory parameter of excellence regulator to assure the sizes of the goods to evade any protests concerning distortion or change in dimensions after internal washing [38].

The experiments are carried out with provided stipulations of buyers copying the same circumstances like washing cycle time, heat and water ratio and fabric load and occasionally top loading and obverse loading laundry machines are selected to validate the test and pledge of the results [39]. This process delivers standard and alternative home laundering circumstances using an involuntary washing machine [40]. While the process includes several selections, it is not conceivable to comprise every current mixture of washing parameters. The test is appropriate to all fabrics and end products appropriate for washing [41].

Composition regulates the type and fraction of fibers. Natural fibers shrink more than manmade fibers. Manmade fibers are steadier due to their crystal-like and amorphous nature [42]. They do not shrink, while natural fibers are more disposed to shrink owing to more nebulous area in their fiber construction which permits more preoccupation of water, bulge of fibers and augmented lubricity upsurges the shrinking propensity [43]. Mixed fabrics usually artificial and natural are also measured steadier. Structure of fabric also acts an important role in the shrinking of the garments [44].

The products those are insecurely woven or knitted are disposed to shrink more and firmly knitted and woven products are steadier [45]. The main cause is that knitted fabrics shrinkage is since they are made by interloping the yarn which is moderately a moveable and springy structure while woven are measured more steady and less subtle to shrinkage [46]. Fibers to fabric change suggests lots of mechanical strains and forces through manufacturing, which comprises following steps for fiber to yarn adaptation with spinning then fabric with weaving [47]. When the cloths are engrossed in water, the water acts as a calming medium and all pressures and strains get tranquil and try to come back to its unique relaxed state [48].

Even after finishing with urbane finishing machines some remaining shrinkage, which is conveyed to the cloths stage [49]. This remaining shrinkage may reason irregularity or de-shaping of the cloths after home washing [50]. There are certain receipt limits of shrinkage levels for every cloth. Irregular shrinkage levels are measured a non-conformity to excellence standards [51].

Materials and Method

Fabric used

For conducting the experiments and the required shrinkage tests, three different cotton spandex woven fabrics of different composition and weigh were used in this research as mentioned in Table 1. Three different spandex deniers were used in this research for making the cloths such as 70D, 40D and 20D. Higher spandex denier increases the spandex content in the cloths and *vice versa*.

Cotton spandex fabrics with higher denier like 70D exposed the highest weight of the fabric and vice versa. All the fabrics were manufactured in same weave structure that is 3/1 Left Hand Twill (LHT). All the fabrics have same width of 57 inch. In table 1, the construction of the fabric is 16×(10+70D)/122×80 that means, warp yarn count is 16Ne, weft yarn count is 10Ne. spandex of 70D was inserted in weft way with cloths. The other two cloths in serial number 2 and 3 were manufactured in same technique. Ends per inch and picks per inch count were 122 and 80.

Method used

The shrinkage testing of the cloths were carried out in agreement with the test method provided by AATCC 135 (American Association of Textile Chemists and Colorists) [52]. This test method is applicable for the purpose of dimensional (length and width) changes of fabrics when exposed to home laundering processes. Four types of home washing temperatures in the washing machine with three distress cycles along with four drying actions arrange for these standard parameters to exemplify general home washing preferences. This test is appropriate to all types of fabrics in home laundering process. Shrinkage tests were done by using shrinkage testing formula as shown in equation 1.

$$\text{Shrinkage\%} = \left\{\frac{\text{After Wash Length} - \text{Before Wash Length}}{\text{Before Wash Length}}\right\} \times 100$$

Equation 1: Shrinkage Testing Formula

Instruments used

Shrinkage testing of the fabrics was conducted with the facilities of the "DynaWash" of James Heal, UK. This machine is suitable for evaluating the influence of repeated washing, as it considerably speed up the effect of washing on fabrics. This instrument provides important investments in water, energy and CO_2 discharges in contrast to outdated washing methods. It also permits people to establish the longevity of fabrics. Figure 2 shows the Shrinkage Testing Instrument DYNAWASH of James Heal manufactured in United Kingdom [53].

Machine used

Heat setting of the fabrics was carried out with the facilities of MontexStenter Frame 6500. This machine was manufactured in Germany, 1992 [54]. Heavier to lighter all types of woven fabrics could be heated with this machine. This machine has 8-12 heated chambers circulating with hot air flow. This machine has stenter chain to grip the fabrics at the edges to pass to the heating chamber.

The Experiment

Three different types of fabrics as mentioned in table 1 were used in this research for conducting the experiments and the required shrinkage tests. Varied temperature ranges from 160°C to 200°C were applied with the help of stenter machine to heat set the fabric. High temperature was applied to heat set the fabrics of heavier weight and comparatively lower temperature was applied to heat set the fabrics of lower weight. Several industrial techniques were applied to apply temperature on the fabrics to achieve required shrinkage values. Industrial setting includes temperature, speed of the machine, width of the fabrics, water content in the bath, batcher and the tension in between the batcher and the cloths roller all of which were taken into consideration while applying heat on the fabrics before heat setting. Mercerized or dyed fabrics were used to heat set the fabrics instead of grey fabrics. Figure 3 shows heat setting was carried out in stenter machine.

Fabrics were slowly passed to the machine heating area from the batcher. Fabrics were dampening down in water bath of stenter machine with 5g/l of acetic acid to control the pH level. If fabric is dampen down properly prior to heat setting it reduces the probability to unwanted burning of the fabrics by gas burner. Stenter chain of both sides pulled the fabrics inside the machine and gas burner regulated temperature from 160°C to 200°C. There were circulating fans inside the chamber to spread the heated air properly to fabrics.

Experiment A

Heat setting was carried out on the fabrics of construction 16×(10+20D)/122×80 that contains 99% Cotton and 1% Spandex with the spandex content of 20D Denier. This fabric had the width of 57" with the weight of 396g/m^2. Due to having lower denier count of 20D and lower percentage of spandex content in this fabric, lower temperature was applied in this fabric while heat setting. Temperatures of like 160°C, 170°C and 180°C were applied to control the shrinkage properties of the fabrics while heat setting and found the consequences shown in Table 2. Mercerized and heat set fabrics were collected for measuring the shrinkage values.

Using a plastic measurement tape or shrinkage cutting template, sample of size "40 inch×40 inch" was cut but "36 inch×36 inch" was marked with permanent marker to prepare the sample for shrinkage testing. Interlock stitching was arranged at the selvedge of the fabric prior to washing, due to this stitching, yarns from the fabrics were not be removed while heavy washing. This test method was followed to experiment the dimensional changes of fabrics while exposed to laundering. In the beginning soap washing was done for 90 minutes at 60°C temperatures. Then, the samples were rinsed washed that means, the samples were simply washed with clean water in 30°C temperature for 45 minute. Then again, squeezing of water for 10 minutes and lastly drying for 5 minutes. After this process was conducted, values of shrinkages were evaluated with equation 1 in accordance with the test method provided by AATCC Test Method 135.

It is seen from the table 2 that, for the sample of

16×(10+20D)/122×80, before wash warp length and before wash weft length were the same that is 36”. When, 160°C temperature was applied on fabric while heat setting, after washing warp length becomes 33.38” and after washing weft length becomes 31.12”. When, 170°C temperature was applied on fabric while heat setting, after washing warp length becomes 33.50” and after washing weft length becomes 32.11”. When, 180°C temperature was applied on fabric while heat setting, after washing warp length becomes 34.42” and after washing weft length becomes 33.02”. When, no heat was applied in the fabrics, after washing warp length becomes 33.00” and after washing weft length becomes 30.12”.

Experiment B

Heat setting was carried out on the fabrics of construction 16×(10+40D)/122×80 that contains 98% Cotton and 2% Spandex with the spandex content of 40D Denier. This fabric had the width of 57” with the weight of 401g/m^2. Due to having medium denier count of 40D and average percentage of spandex content in this fabric, average level of temperature was applied in this fabric while heat setting. Temperatures of like 170°C, 180°C and 190°C were applied to control the shrinkage properties of the fabrics while heat setting and found the consequences shown in Table 3. Mercerized and heat set fabrics were collected for measuring the shrinkage values.

Using a plastic measurement tape or shrinkage cutting template, sample of size “40 inch×40 inch” was cut but “36 inch×36 inch” was marked with permanent marker to prepare the sample for shrinkage testing. Interlock stitching was arranged at the selvedge of the fabric prior to washing, due to this stitching, yarns from the fabrics were not be removed while heavy washing. This test method was followed to experiment the dimensional changes of fabrics while exposed to laundering. In the beginning soap washing was done for 90 minutes at 60°C temperatures. Then, the samples were rinsed washed that means, the samples were simply washed with clean water in 30°C temperature for 45 minute. Then again, squeezing of water for 10 minutes and lastly drying for 5 minutes. After this process was conducted, values of shrinkages were evaluated with equation 1 in accordance with the test method provided by AATCC Test Method 135.

It is seen from the table 3 that, for the sample of 16×(10+40D)/122×80, before wash warp length and before wash weft length were the same that is 36”. When, 170°C temperature was applied on fabric while heat setting, after washing warp length becomes 33.81” and after washing weft length becomes 32”. When, 180°C temperature was applied on fabric while heat setting, after washing warp length becomes 34.08” and after washing weft length becomes 32.66”. When, 190°C temperature was applied on fabric while heat setting, after washing warp length becomes 34.52” and after washing weft length becomes 33.12”. When, no heat was applied in the fabrics, after washing warp length becomes 33.46” and after washing weft length becomes 30.88”.

Experiment C

Heat setting was carried out on the fabrics of construction 16×(10+70D)/122×80 that contains 97% Cotton and 3% Spandex with the spandex content of 70D Denier. This fabric had the width of 57” with the weight of 405g/m^2. Due to having higher denier count of 70D and higher percentage of spandex content in this fabric, higher temperature was applied in this fabric while heat setting. Temperatures of like 180°C, 190°C and 200°C were applied to control the shrinkage properties of the fabrics while heat setting and found the consequences shown in Table 4. Mercerized and heat set fabrics were collected for measuring the shrinkage values.

Using a plastic measurement tape or shrinkage cutting template, sample of size “40 inch×40 inch” was cut but “36 inch×36 inch” was marked with permanent marker to prepare the sample for shrinkage testing. Interlock stitching was arranged at the selvedge of the fabric prior to washing, due to this stitching, yarns from the fabrics were not be removed while heavy washing. This test method was followed to experiment the dimensional changes of fabrics while exposed to laundering. In the beginning soap washing was done for 90 minutes at 60°C temperatures. Then, the samples were rinsed washed that means, the samples were simply washed with clean water in 30°C temperature for 45 minute. Then again, squeezing of water for 10 minutes and lastly drying for 5 minutes. After this process was conducted, values of shrinkages were evaluated with equation 1 in accordance with the test method provided by AATCC Test Method 135.

It is seen from the table 4 that, for the sample of 16×(10+70D)/122×80, before wash warp length and before wash weft length were the same that is 36”. When, 180°C temperature was applied on fabric while heat setting, after washing warp length becomes 33.86” and after washing weft length becomes 32.44”. When, 190°C temperature was applied on fabric while heat setting, after washing warp length becomes 34.30” and after washing weft length becomes 32.98”. When, 200°C temperature was applied on fabric while heat setting, after washing warp length becomes 34.69” and after washing weft length becomes 34.15”. When, no heat was applied in the fabrics, after washing warp length becomes 33.84” and after washing weft length becomes 31.96”.

Results and Discussion

Shrinkage values depend on the extent of heat setting on cotton spandex woven fabrics. Higher heat setting temperatures exposed less shrinkage values, conversely, lower heat setting temperature exposed higher shrinkage values. Based on the data obtained in experimental parts, shrinkage values are shown in results and discussions part with tables and figures.

Shrinkage Values of Experiment A

Figure 4 shows the shrinkage values of fabric construction 16×(10+20D)/122×80 in different heat setting temperature (99% cotton 1% spandex). When the fabric was heated with 160°C Temperature, warp shrinkage was found -7.28% and weft shrinkage was found -13.56%. When the fabric was heated with 170°C Temperature, warp shrinkage was found -6.94% and weft

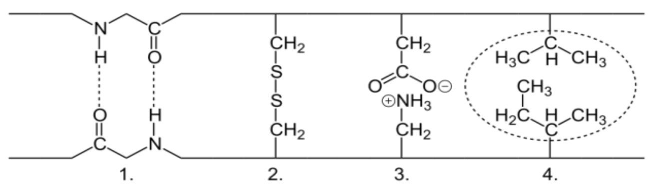

Figure 1: Physical and chemical forces among two polypeptide chains.

Figure 2: Shrinkage Testing Instrument DYNAWASH, James Heal, UK.

Figure 3: Heat Setting Conducting Stenter Machine (Heat Setting Going On).

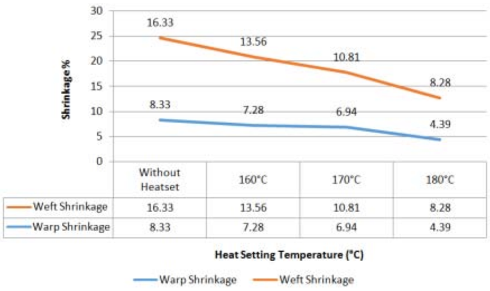

Figure 4: Shrinkage Values of Fabric's Construction 16×(10+20D)/122×80 in Different Heat Setting Temperature (99% Cotton 1% Spandex).

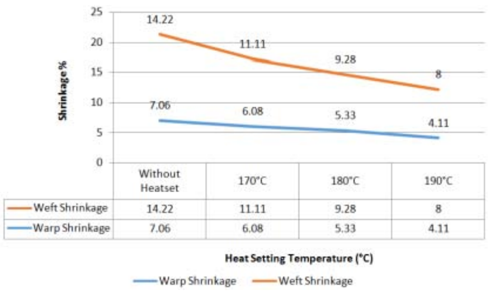

Figure 5: Shrinkage Values of Fabric's Construction 16×(10+40D)/122×80 in Different Heat Setting Temperature (98% Cotton 2% Spandex).

shrinkage was found -10.81%. When the fabric was heated with 180°C Temperature, warp shrinkage was found -4.39% and weft shrinkage was found -8.28%. When the fabric was not heated with any temperature, it exposed the warp shrinkage values of -8.33% and weft shrinkage values of -16.33%. Optimal shrinkage values were achieved in both warp and weft way when the fabrics were heated with 180°C Temperature. It was seen that, shrinkage values were decreased with the increase of temperature. Overheat in cotton spandex woven fabircs could damage the other desireable properties of fabircs like elasticity, strethc, growth and strenght. Therefore heat should be applied in fabrics in such a way that, other properties of the

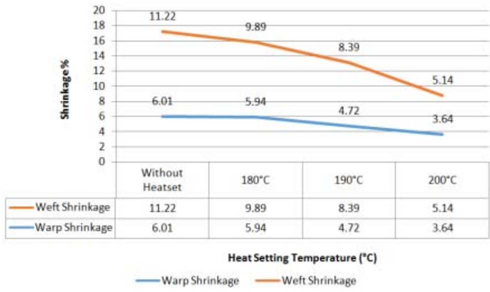

Figure 6: Shrinkage Values of Fabric's Construction 16×(10+70D)/122×80 in Different Heat Setting Temperature (97% Cotton 3% Spandex).

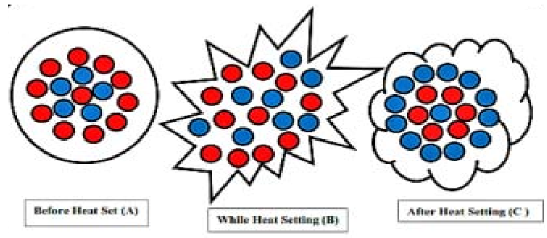

Figure 7: Inner Structural Rearrangement of Yarns of Before, After and During Heat Setting.

fabircs would not be hampered.

Shrinkage values of experiment B

Figure 5 shows the shrinkage values of fabric construction 16×(10+40D)/122×80 in different heat setting temperature (98% cotton 2% spandex). When the fabric was heated with 170°C Temperature, warp shrinkage was found -6.08% and weft shrinkage was found -11.11%. When the fabric was heated with 180°C Temperature, warp shrinkage was found -5.33% and weft shrinkage was found -9.28%. When the fabric was heated with 190°C Temperature, warp shrinkage was found -4.11% and weft shrinkage was found -8.00%. When the fabric was not heated with any temperature, it exposed the warp shrinkage values of -7.06% and weft shrinkage values of -14.22%. Optimal shrinkage values were achieved in both warp and weft way when the fabrics were heated with 190°C Temperature. It was seen that, shrinkage values were decreased with the increase of temperature. Overheat in cotton spandex woven fabircs could damage the other desireable properties of fabircs like elasticity, strethc, growth and strenght. Therefore heat should be applied in fabrics in such a way that, other properties of the fabircs would not be hampered.

Shrinkage Values of experiment C

Figure 6 shows the shrinkage values of fabric construction 16×(10+70D)/122×80 in different heat setting temperature (97% cotton 3% spandex). When the fabric was heated with 180°C Temperature, warp shrinkage was found -5.94% and weft shrinkage was found -9.89%. When the fabric was heated with 190°C Temperature, warp shrinkage was found -4.72% and weft shrinkage was found -8.39%. When the fabric was heated with 200°C Temperature, warp shrinkage was found -3.64% and weft shrinkage was found -5.14%. When the fabric was not heated with any temperature, it exposed the warp shrinkage values of -6.00% and weft

Table 1: Cotton Spandex Woven Fabrics used in this Experiments.

	Construction	Composition	Weight (g/m²)	Weave	Width
1	16×(10+70D)/122×80	97% Cotton 3% Spandex	405	3/1 LHT	57"
2	16×(10+40D)/122×80	98% Cotton 2% Spandex	401	3/1 LHT	57"
3	16×(10+20D)/122×80	99% Cotton 1% Spandex	396	3/1 LHT	57"

Table 2: Heat Setting Temperature, Before Wash and After Wash Sample Measurement.

Temp	Before Wash Warp Length (")	After Wash Warp Length (")	Before Wash Weft Length (")	After Wash Weft Length (")
Without heat set	36	33	36	30.12
160°C	36	33.38	36	31.12
170°C	36	33.50	36	32.11
180°C	36	34.42	36	33.02

Table 3: Heat Setting Temperature, Before Wash and After Wash Sample Measurement.

Temp	Before Wash Warp Length (")	After Wash Warp Length (")	Before Wash Weft Length (")	After Wash Weft Length (")
Without heat set	36	33.46	36	30.88
170°C	36	33.81	36	32
180°C	36	34.08	36	32.66
190°C	36	34.52	36	33.12

Table 4: Heat Setting Temperature, Before Wash and After Wash Sample Measurement.

Temp	Before Wash Warp Length (")	After Wash Warp Length (")	Before Wash Weft Length (")	After Wash Weft Length (")
Without heat set	36	33.84	36	31.96
180°C	36	33.86	36	32.44
190°C	36	34.30	36	32.98
200°C	36	34.69	36	34.15

shrinkage values of -11.22%. Optimal shrinkage values were achieved in both warp and weft way when the fabrics were heated with 200°C Temperature. It was seen that, shrinkage values were decreased with the increase of temperature. Overheat in cotton spandex woven fabircs could damage the other desirable properties of fabircs like elasticity, strethc, growth and strenght. Therefore heat should be applied in fabrics in such a way that, other properties of the fabircs would not be hampered.

Discussion

Application of high temperature was closely compacted the spandex portion with cotton fibers [55]. The elastic portions were firmly attaching with the cotton fibers due to temperature treatment and this incidence developed stability to yarns, which had a direct consequence on the shrinkage properties of fabrics [56]. Reorganization happened in the internal structure of yarns with increased stability [57]. Heat treatment readjusted both the amorphous section and the crystalline section of yarns [58]. Molecular structures of the yarns were also seen to be repositioned because of temperature application [59]. Heat treatment also changed the internal orientation of yarns [60].

The internal geometrical shapes of yarns were also changing due to heat application. Before heat setting, the cotton spandex yarns had bulky and thicker shapes but, after heat setting, the yarns had thinner and harder shapes [61]. The elastic portions were meticulously attached with the cotton fibers, which provided with increased stability and this incidence reduced the dimensional stability of yarns and controlled the shrinkage values [62]. Figure 7 shows the inner structural rearrangement of yarns of before heat setting, after heat setting and while heat setting."A" showed the state of yarns of before heat setting, where the structural orientation was noticed to be well-defined. During heat setting "B" showed a haphazard structure. The attachments amongst the molecules were weak and moveable with a modified structure. Internal gaps were found in between molecules. In "C" after the temperature application, the molecules were reformed and the structural arrangements were enhanced, which improved the dimensional stabilities of yarns.

Conclusion

It was seen from the research that, heat setting was carried out in sufficiently high temperatures with adjusted industrial setting so that the preferred shrinkage values were achieved of the cotton spandex fabrics. Temperature treatment prohibited the spandex recovering forces to a rigid limit and also stabilized the elastic parts with cotton fibers so that the geometrical positioning of the cotton spandex yarns were restructured, which could resist the fabric shrinkage. The elasticity in between the crystalline and amorphous region was seen to be destroyed due to the heat treatment in stenter which could successfully reduce the spandex recovery forces for further compression and it significantly impacted the dimensional stabilities of fabrics. It was seen from the research that, shrinkage values were decreasing with the increase of temperature. It was because; heat setting fixed the structural orientation at exact magnitudes and also eliminated the remaining energy that might lead to end additional alteration of cotton spandex. During heat setting, the spandex polymer chain got transposed and was reallocated due to that the elastic forces in core spun yarns were condensed. Condensation was a mechanical process that physically reorganized the geometrical relationship of yarns in a fabric that could contribute to develop the dimensional stability or shrinkage of fabrics.

References

1. Siddiqa F, Haque M, Smriti SA, Farzana N, Haque A, Abu NM. Effect of Elastane and Thread Density on Mechanical Attributes of Stretch Woven Fabric. AATCC Journal of Research. 2020; 7: 21-30.

2. Sitotaw DB, Gedion RK. Performance Characteristics of Knitted Fabrics Made from 100% Cotton and Cotton/Elastane Blended Yarns. Journal of Textile and Apparel, Technology and Management. 2020; 11.

3. Berenguer JL, M Martínez P, Díaz-García P. Modelling loop length in weft-knitted fabrics with an interlock structure after the dyeing process with a stitch density, Wales and courses per centimetre analysis. The Journal of the Textile Institute. 1-7.

4. Islam S, Haque MD, Arifuzzaman MD, Ahmed S, Sarker B, Hossain Md. Identifying the Causes of the Spandex Breakage of Woven Garments and its Solutions. Advance Research in Textile Engineering. 2020; 1: 1-24.

5. Islam S, Parvin F, Urmy Z, Ahmed S, Arifuzzaman M, Yasmin J, Islam F. A Study on the Human Health Benefits, Human Comfort Properties and Ecological Influences OF Natural Sustainable Textile Fibers. European Journal of Physiotherapy and Rehabilitation Studies. 2020; 1: 1-24.

6. Üstüntağ S, Şenyiğit E, Mezarcıöz S, Türksoy HG. Optimization of Coating Process Conditions for Denim Fabrics by Taguchi Method and Grey Relational Analysis. Journal of Natural Fibers. 2020; 1-15.

7. Parvin F, Islam S, Urmy Z, Ahmed S. A Study on the Textile Materials Applied In Human Medical Treatment. European Journal of Physiotherapy and Rehabilitation Studies. 2020; 1: 26-51.

8. Nasir S, Humayoun UB, Khan AA, Kuma M, Ali N, Yoo JH, et al. Engineering of sustainable clothing with improved comfort and thermal properties-A step towards reducing chemical footprint. Journal of Cleaner Production. 121189.

9. Bedez UT. Analysis of mechanical and dimensional properties of the denim fabrics produced with double-core and core-spun weft yarns with different weft densities. The journal of the Textile Institute. 2019; 110: 179-185.

10. Islam S, Alam SMM, Akter S. Identifying the values of whiteness index, strength and weight of cotton spandex woven fabric in peroxide bleaching of different concentration. Fibers and Textiles. 2019; 26: 96-109.

11. Islam S. Attaining Optimum Strength of Cotton-Spandex Woven Fabric by Apposite Heat-Setting Temperature. Journal of the Institution of Engineers (India): Series C, Springer. 2019; 601-606.

12. Zulifqar A, Hu H. Development of bi-stretch auxetic woven fabrics based on re-entrant hexagonal geometry. physica status solidi. 2019; 256: 1800172.

13. Islam S, Mominul Alam SM, Akter S. The Consequences of Temperature on the Shrinkage Properties of Cotton Spandex Woven Fabric. Journal of Textiles and Polymers. 2019; 7: 25-29.

14. Islam S, Ahmed S. Investigation of the Mechanical Properties of Thermal Bonded Nonwoven Composite Produced of Blends with Sustainable Fibers. Advance Research in Textile Engineering. 2019; 4: 1039.

15. Islam S, Chowdhury N, Arifuzzaman JY, Hasan FIM, Khatun M. Detecting the Physical Properties of Thermal Bonded Nonwoven Fabrics. Trends in Textile Engineering and Fashion Technology. 2019; 5: 1-18.

16. Islam S, Tasnim N, Islam T. Investigation of the change of the shrinkage properties in contradiction to the change of the composition of cotton polyester spandex denim fabrics. Journal of Textile Engineering and Fashion Technology. 2019; 5: 163-168.

17. Islam S, Yasmin J, Kanon R. Detecting the spandex injuries and therapies of stretched garments. Journal of Textile Engineering and Fashion Technology. 2019; 5: 170-175.

18. Islam S, Ahmed S, Arifuzzaman Md, Islam AKMS, ktAezr S. Relationship in between Strength and Polyester Content Percentage of Cotton Polyester Blended Woven Fabrics. International Journal of Clothing Science. 2019; 6: 1-6.

19. Shariful I, Jarin Y, Toufiqul AS, Faridul I, Rowshanuzzaman K. Identifying the strength properties of cotton polyester blended woven fabrics of different fiber content. Research Journal of Material Sciences. 2019; 7: 1-6.

20. Varan Y. The effects of chitosan antimicrobial treatments on the physical and mechanical properties and wear performances of highly elastic fabrics used for burn scar management. The Journal of the Textile Institute. 2018; 109: 39-45.

21. Islam S, Chowdhury S, Akter S. The experiential analysis of woven fabric for reproduction. Journal of Textile Science and Technology. 2018; 4: 18.

22. Islam S, Alam SMM, Akter S. Identifying a suitable heat setting temperature to optimize the elastic performances of cotton spandex woven fabric. Research Journal of Textile and Apparel. 2018; 28: 1-28.

23. Islam S, Alam SMM. Investigation of the acoustic properties of needle punched nonwoven produced of blend with sustainable fibers. International Journal of Clothing Science and Technology. 2018; 52: 34.

24. Ali M, Zeeshan M, Qadir MB, Riaz R, Ahmad S, Nawab Y, et al. Development and mechanical characterization of weave design based 2d woven auxetic fabrics for protective textiles. Fibers and Polymers. 2018; 19: 2431-2438.

25. Sarwar N, Mohsin M, Bhatti AA, Ahmma SW, Husaain A. Development of water and energy efficient environment friendly easy care finishing by foam coating on stretch denim fabric. Journal of Cleaner Production. 2017; 154: 159-166.

26. Chen Q, Ma P, Mao H, Miao X, Jiang G. The effect of knitting parameter and finishing on elastic property of PET/PBT warp knitted fabric. Autex Research Journal. 2017; 17: 350-360.

27. Sarioğlu E, Babaarslan O. A comparative strength analysis of denim fabrics made from core-spun yarns containing textured microfilaments. Journal of Engineered Fibers and Fabrics. 2017; 12.

28. Ertaş OG, Zervent Ünal B, Çelik N. Analyzing the effect of the elastane-containing dual-core weft yarn density on the denim fabric performance properties. The Journal of the Textile Institute. 2016; 107: 116-126.

29. Kizildag N, Ucar N, Gorgun B. Analysis of some comfort and structural properties of cotton/spandex plain and 1× 1 rib knitted fabrics. The Journal of the Textile Institute. 2016; 107: 606-613.

30. Umar J, Hussain T, Maqsood M. Modeling the mechanical and compression properties of polyamide/elastane knitted fabrics used in compression sportswear. The Journal of the Textile Institute. 2016; 107: 1240-1252.

31. Nazir A, Hussain T, Rehman A, Abid A. Modelling Heat-Setting of Cotton/ Elastane Knitted Fabrics for Optimum Dimensional Stability. Journal of Textile and Apparel, Technology and Management. 2015; 9.

32. Heat setting. From Wikipedia, the free encyclopedia. Physical and chemical forces between two polypeptide chains.

33. Varghese N, Thilagavathi G. Development of woven stretch fabrics and analysis on handle, stretch, and pressure comfort. The Journal of the Textile Institute. 2015; 106: 242-252.

34. Kalkanci M, Kurumer G. Investigation of dimensional changes during garment production and suggestions for solutions. Fibres& Textiles in Eastern Europe. 2015.

35. Varghese N, Thilagavathi G. Handle and comfort characteristics of cotton core spun lycra and polyester/lycra fabrics for application as blouse. Journal of Textile and Apparel, Technology and Management. 2014; 8.

36. Akankwasa NT, Jun W, Yuze Z, Mushtaq M. Properties of cotton/T-400 and 100% cotton plain knitted fabric made from ring spun yarn: Eigenschaften von Baumwolle/T-400 und 100% Baumwolle glattgestrickten Fasern aus Ringspinngarn. Material wissenschaft und Werk stofftechnik. 2014; 45: 1039-1044.

37. Gun AD, Akturk HN, Macit AS, Alan G. Dimensional and physical properties

of socks made from reclaimed fibre. The Journal of the Textile Institute. 2014; 105: 1108-1117.

38. Cuden AP, Hladnik A, Sluga F. Impact of material, structure and relaxation process parameters of elasticized single-knitted fabrics on loop length. Textile Research Journal. 2013; 83: 56-65.

39. Malik MH, Malik ZA, Hussain T, Ramzan MB. Effect of sewing parameters and wash type on the dimensional stability of knitted garments. Autex Research Journal. 2013; 13: 89-94.

40. Wong WY, Lam JKC, Kan CW, Postle R. Influence of knitted fabric construction on the ultraviolet protection factor of greige and bleached cotton fabrics. Textile Research Journal. 2013; 83: 683-699.

41. Senthilkumar M. Effect of spandex input tension, spandex linear density and cotton yarn loop length on dynamic elastic behavior of cotton/spandex knitted fabrics. Journal of Textile and Apparel, Technology and Management. 2012; 7.

42. Nigmatova FU, Kasimova AB, Shin EI. Deformation properties of knitted fabrics from blended yarn based on cotton and polyacrylonitrilefibres. Fibre Chemistry. 2012; 44: 21-25.

43. Longde MSCYG. Technology Key Points of Producing Polyester Covered Weft Elastic Yarn-dyed Fabric [J]. Cotton Textile Technology. 2011; 3.

44. Fadhel J, Mahdi S, Morched C. Physical properties of compressive knits compound with different matters impregnated by microcapsules moisturizing. Chemical Industry and Chemical Engineering Quarterly. 2011; 17: 429-435.

45. Chung HW, Kwon J, Kim HJ, Seok HJ. Comparison of mechanical properties and hand values of cotton/spandex twill with different tentering-extension rates after repeated washings. Textile Science and Engineering. 2010; 47: 240-246.

46. ElNashar E, Kalaoglu F, Hashem M. Crinkles Approach for Development of Aesthetics Wrinkled Fabrics Containing Spandex. In XIII International Workshop “Physics of Fibrous Materials: Structure, Properties, Science Intensive Technologies and Materials” (SMARTEX-2010) that take place in the Ivanovo State Textile Academy (Russia). 2010; 24-26.

47. Seok HJ, Chung HW, Kim HJ, Kwen J. Effects of tentering and washing on the shrinkage and elasticity of cotton/spandex fabric. Textile Science and Engineering. 2009; 46: 269-275.

48. El-Ghezal S, Babay A, Dhouib S, Cheikhrouhou M. Study of the impact of elastane’s ratio and finishing process on the mechanical properties of stretch denim. The Journal of the Textile Institute. 2009; 100: 245-253.

49. Kan CW, Yuen CWM. Evaluation of the performance of stretch denim fabric under the effect of repeated home laundering processes. International Journal of Fashion Design, Technology and Education. 2009; 2: 71-79.

50. Herath CN, Kang BC. Dimensional stability of core spun cotton/spandex single jersey fabrics under relaxation. Textile Research Journal. 2008; 78: 209-216.

51. Chen LI, Lan Jw, Hu A, Wu L, Liu B. Research on preparation of poly (ether-ester)/polypropylene self-crimping fibers and its performance [J]. Synthetic Fiber in China. 2008; 27: 14-16.

52. Uh MK, Suh MA. A study on the survey of production condition of jeans in casual brands. The Research Journal of the Costume Culture. 2007; 15: 702-712.

53. Cardamone JM. Activated peroxide for enzymatic control of wool shrinkage part II: wool and other fiber-type fabrics. Textile research journal. 2006; 76: 109-115.

54. Chung HW, Kim MK. The effect of washing conditions on the dimension and mechanical properties of spandex yarns. Journal of the Korean Society of Clothing and Textiles. 2005; 29: 1619-1626.

55. Lin JH, Chang CW, Lou CW, Hsing WH. Mechanical properties of highly elastic complex yarns with spandex made by a novel rotor twister. Textile Research Journal. 2004; 74: 480-484.

56. Kim SH, Oh KW, Bahk JH. Electrochemically synthesized polypyrrole and Cu-plated nylon/spandex for electrotherapeutic pad electrode. Journal of Applied Polymer Science. 2004; 91: 4064-4071.

57. Limin A. Performance Analysis of Sirofil Yarn and Doubling and Twisting Yarn as well as Fabric Made from Ramie and Groove Terylene Filament Called Coolnice [J]. Shanghai Textile Science & Technology. 2003; 3.

58. Xinyuan S. Structure, Properties and Dyeing and Finishing of Polyurethane Fiber (II). Dyeing and Finishing. 2002; 11.

59. Babaarslan O. Method of producing a polyester/viscose core-spun yarn containing spandex using a modified ring spinning frame. Textile Research Journal. 2001; 71: 367-371.

60. Kollegal MG, Sridharan S. Strength prediction of plain woven fabrics. Journal of Composite Materials. 2000; 34: 240-257.

61. Parés JM, van der Pluijm BA, Dinarès-Turell J. Evolution of magnetic fabrics during incipient deformation of mudrocks (Pyrenees, northern Spain). Tectonophysics. 1999; 307: 1-14.

62. Ismaıl WB; Mainprice D. An olivine fabric database: an overview of upper mantle fabrics and seismic anisotropy. Tectonophysics. 1998; 296: 145-157.