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Effect of Home Laundering on Sewing Performance of Cotton Fabrics

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ABSTRACT

Clothing should attain durability and stability. Since cotton fabrics characterized by its comfort properties, the aim of this study is to determine the effect of home laundering on seam performance expressed as seam strength, seam elongation, and seam efficiency in both warp and weft directions for woven cotton fabrics. The tests were done on Instron tensile tester. Two plain cotton fabrics with different constructions were used in this study. The effect of fabric type, some sewing parameters such as (stitch density, sewing thread type, needle count) besides laundry on seam breaking load, seam displacement at auto break, and seam efficiency were studied. It was found that laundering has a significant effect on seam performance besides fabric type, stitch density and their interaction.

KEY WORDS: Seam strength, seam elongation, seam efficiency, stitch density, and experimental design.

INTRODUCTION

To maintain good seam and garment quality, seam performance is the essential parameter that should be taken into account. The effect of chemical and mechanical finishing process (desizing, scouring, bleaching, dyeing and sueding) on the behavior of the seams was studied. The three factors under study were: treatment, number of stitches per centimeter, and seam direction (warp or weft direction). They found that with increasing frequency of treatment the seam resistance decreased in both directions warp and weft. That is because chemical treatments can attack fiber components other than the cellulose one, so inter-fiber cohesion is reduced, and the resistance of fabric threads decreased. Also with increasing of stitch density the breaking force increased, while this does not affect the elongation at break [1]. The effect of blend composition, sewing thread size, needle thread tension, and needle size on seam strength and seam efficiency was investigated. Three types of cotton polyester medium weight suiting fabrics varying in blend composition were used with four factor L9 orthogonal design of experiment at three levels. The higher the polyester percentage of the fabric the lower the seam efficiency. The low seam efficiency of the polyester dominated fabrics as a result of less uniform fiber matrix which may lead to fiber slippage and yarn failure. While the fiber matrix becomes uniform in cotton dominated fabrics (100% cotton) so the seam efficiency increased. The needle thread tension has significant effect on seam efficiency, and the decrease in needle thread tension during stitching improves the seam strength and hence the seam efficiency [2].The effect of laundering on the quality of sewn cotton and bamboo plain woven fabrics was studied. The seam efficiency for cotton fabric decreased or remained unchanged after fabric chemical treatment. Contrary to bamboo fabric in which the seam became more efficient after washing or washing with chemical softening [3].The effect of silicon finish on seam strength and slippage for woven cotton/ polyester fabrics with three different structures was studied. It was found that fabric construction (EPI, PPI, count, weave type) play a major role in the performance of seam. The cover factor increases with the increase in EPI and PPI, so fabric strength increased, which results in greater seam breakage. Plain fabric has higher seam performance than the other weave types. Sewing thread type and the fiber content in the sewing thread influence seam performance [4]. The effects of sand blasting with industrial enzyme silicon wash on denim apparel characteristics for regular denim (100% cotton with twill 3/1 weave construction) were determined. The denim has been processed by enzyme and silicon washes after sand blasting. The effect of washing on denim was studied by studying changes of fabric handle, fabric specification (ends/inch, picks/inch, surface density, warp &weft yarn linear density), fabric strength, seam strength & fabric stiffness after sandblasting with enzyme silicon wash. After sandblasting and enzyme silicon wash the denim fabric changed from harsh to softer. Ends/inch and picks/inch of denim fabric has been decreased due to abrasion damage, as a result surface density of fabric increased. Tensile strength of fabric and seam strength has been decreased due to enzyme washing with sandblasting [5]. The influence of some sewing parameters (sewing thread, the stitch type, the stitch density, the needle size and the edge of seam) on the breaking strength, breaking elongation and deformation energy were

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determined. The investigation was carried out on cotton polyester fabric, using experimental design. Experimentation has revealed two major phenomena occurring before rupture (contracting of seam or seam slippage). Analyzing experimental designs for each type of assembly gave them the following results: it confirmed the high influence of sewing thread (fiber type) and demonstrated as well the importance of interactions between factors, in particular, the interaction between stitch density and the edge of seam. Some differences was found between results in warp direction and weft direction, then, fabric construction affects the behavior of sewn fabrics [6]. The seam quality for two types of wool fabrics heavy and light with commercial sewing threads and different stitch densities were analyzed. Seam quality was characterized by seam strength, seam elongation, seam efficiency and seam puckering. A full mixed factorial design was used. The stitch density, sewing thread size and fabric type all have a significant influence on seam tensile strength and seam elongation. The two-way and three-way interaction effects all have a significant impact on seam tensile strength while the two-way interaction (sewing thread size* fabric weight) have a significant effect on seam elongation whereas three-interaction has no significant effect on seam elongation. All independent variables and their interactions have a significant influence on seam efficiency [7]. Cotton sewing thread exhibits a higher initial modulus but lower strength, whereas polyester thread has lower initial modulus but higher strength. Different Sewing thread of high strength results in high seam strength and good seam serviceability. Cotton sewing thread exhibits a higher dry dimensional stability where as synthetic sewing thread has higher wet dimensional stability. High wet and dry dimensional stability are essential for the better seam quality. Sewing thread with high bending rigidity is also unacceptable for sewing industry [8]. The changes in knitted fabric characteristics after repeating laundry, ten cycles, for plain and 1×1 rib patterns produced from cotton, polyester and their blends were determined. Changes in fabric characteristics due to repeating laundering have affected significantly with the fabric content of fibers. The changes in characteristics due to laundry are different by changing the composition of fabrics and its construction. Fabrics produced from cotton have less stability than polyester and blended fabrics of Cotton/Polyester. The cotton fabrics have the roughest surfaces that increased after repeating laundering however they achieved the lowest values of static charge on their surfaces [9].The relation between sewing thread and sewing conditions (stitch density, seam type, needle size, and seam allowance) to optimize the performance of two basic kinds of military fabrics was studied. The most effective factors on seam strength and efficiency were stitch density, seam type, thread elongation, and seam allowance. The same factors were the most effective in seam extension except thread elongation was less important. Also the fabric type found to have less effect than the previous mentioned important parameter [10].

MATERIALS AND METHODS

Two 100% cotton plain fabrics commercially available for women blouses varying in their weight are used in this work. The details of these fabrics specifications are given in table1.

(Table1)

Samples number	Fabric weight (GSM)	Warp density (per cm)	Weft Density (per cm)	Warp linear density (Ne)	Weft linear Density (Ne)
1	81	35	28	50	50
2	120	43	28	40	80/2

Two commercially polyester spun sewing threads were used one is 40/2 Ne with tensile strength 1024 CN, 16.8% elongation, 20. 7 turns/inch while the other is 60/3 Ne with 903 CN Tensile strength, 14.9% elongation and 22.5 turns per inch. Two needle sizes were used in stitching Organ 11, 14. Two levels of stitch densities were used low and high.

Seam preparation

All stitch working has been done on industrial lock stitch sewing machine to produce a balance seam. Similar sewing thread is used as needle and bobbin thread. The stitch density adjusted at high level (7 stitches/ cm) and the experiments with this were done then the stitch density was changed to low level (3.5 stitches/ cm) and the residual experiments were done.

Study of stitches per centimeter and percentage shrinkage of stitch line

The percentage shrinkage along the stitch line parallel to warp and weft direction was calculated by measuring the length of 10 cm of stitch line before and after 10 cycles laundering for each experiment, and then the percentage shrink was calculated as follows

% Shrink= ((10 – the length of 10 cm stitch line after laundry)/10) *100

The number of stitches per five centimeters was measured for each experiment before laundering and after 10 cycles laundering in both warp and weft directions.

The paired comparison t test was applied to study the significance difference between each of seam breaking load, seam displacement at auto break, seam efficiency, and number of stitches per five centimeters before and after laundering. By applying multi regression analysis, the individual and interactive effects of fabric type, needle size, sewing thread, and laundering on seam strength, seam elongation, and seam efficiency are studied at two level full factorial design.

The following table shows the design of experiment.

Table (2)

Experiment No	X1	X2	X3	X4
1	2	1	1	1
2	2	1	1	2
3	2	1	2	1
4	2	1	2	2
5	2	2	1	1
6	2	2	1	2
7	2	2	2	1
8	2	2	2	2
9	1	1	1	1
10	1	1	1	2
11	1	1	2	1
12	1	1	2	2
13	1	2	1	1
14	1	2	1	2
15	1	2	2	1
16	1	2	2	2

X1: stitch density**, X2:** sewing thread**, X3:** sewing needle count**, X4:** fabric type

The laundry was expressed as X_5**,** when it is included in the experimental design, 1 indicates no laundry, while 2 indicates 10 cycles laundry.

Seam strength and elongation

The seam strength and elongation test was done in both warp and weft directions for all experiments according to ISO 13953 [11]. Applying seam strength in warp direction means that stitch line follows weft thread yarns and vice versa.

Fabric strength and seam efficiency

The fabric strength for the two fabrics used in the study was measured before and after 10 cycles washing.

The seam efficiency was measured in both directions according to ASTM 1683-04 standard method [12], and it was calculated according to the following formula

Seam efficiency= (seam strength/fabric strength)*100

RESULTS AND DISCUSSION

Fabric strength and elongation

The results of fabric strength (breaking force) and elongation (displacement at auto break) before and after 10 cycles laundering are shown in table (3)

Table (3)

	Fabric type	Direction	Load at auto break (Kg.f)	Displacement at auto break (mm)
Before laundry	**1**	Warp	52.5	10.3
		Weft	40.2	48.3
	2	Warp	82.8	23.1
		Weft	53	40.8
After laundry	**1**	Warp	36	13.4
		Weft	35.8	77.7
	2	Warp	88	26
		Weft	54.1	41.7

Study of stitches per centimeter and percentage shrinkage of stitch line

The following figure shows the results of percentage shrink for all the experiment.

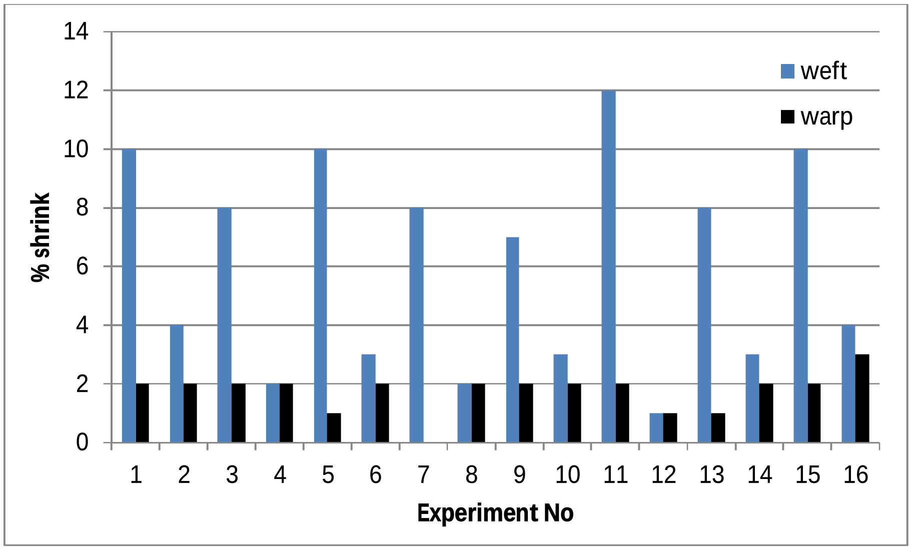
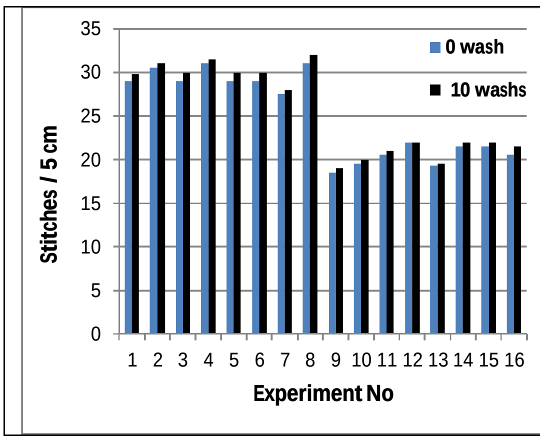


Figure (1) % Shrink of stitch line in both directions

From figure (1) it is clear that percentage shrink of stitch line in weft direction higher than in warp direction especially for odd experiment (fabric 1 light weight fabric).

The number of stitches per 5 centimeter was measured before laundering and after 10 cycles laundering. The results are shown in figures (2a, 2b)



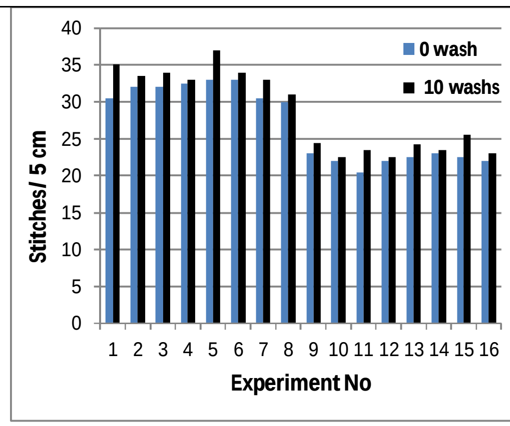


Fig. (2a) Number of stitches in warp direction **Fig.(2b) Number of stitches in weft direction**

From figures (2a),(2b) it is obvious that the number of stitches per centimeter increased after laundering in both warp and weft directions. The significance difference between number of stitches before laundering and after 10 cycles laundering in warp direction is 2.9 E-07, in weft direction is 2.4 E-05.

Study of seam strength

Figures (3-a, 3-b) shows the results of seam strength before and after 10 cycles laundering.

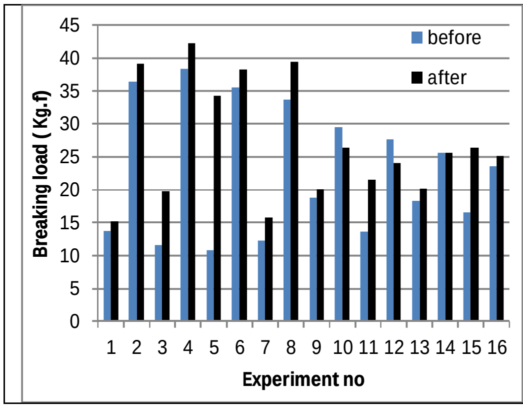


Fig. (3-a) Seam strength in warp direction

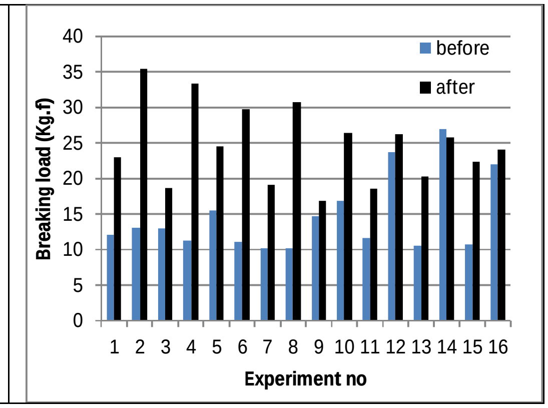


Fig. (3-b) Seam strength in weft direction

From figures 3-a, 3-b it is clear that seam strength increased in both directions after laundering. This is due to the increase in number of stitches per centimeter after laundering. Applying seam strength in warp direction means that stitch line follows weft direction yarns. The number of ends per centimeter increased from 43 before washing to 48 after 10 cycles in fabric 2 (even experiments). This means that the number of ends that are subjected to the force applied during seam strength test on the width of sample test increased after washing which leads to increase in seam strength. Also this could explain the high rate of increase in seam strength in weft direction for even experiment especially in the first eight experiments (high stitch density). The significant difference between seam strength before and after 10 cycles laundering in warp direction is 0.009 and in weft direction is 3.36E-05.

The relationship between seam strength before and after 10 cycles laundering and sewing parameters under study was concluded as follows

$$Y_1 = 11.2\, X_4 + 2.8\, X_1 X_4 \qquad R^2 = 0.98 \qquad (1)$$

$$Y_2 = 3 + 9.8\, X_4 + 0.37\, X_1 X_2 \qquad R^2 = 0.96 \qquad (2)$$

Where Y_1: breaking load in warp direction before laundering, Y_2: breaking load in warp direction after 10 cycles laundering. From equations 1, 2 it is obvious that fabric type has high effect on seam strength, fabric type 2 (the higher weight fabric gives higher strength).The higher the stitch density the higher the seam strength [1]. From equation 2 the sewing thread type with stitch density affects the breaking load after laundering.

The relationship between percentage difference in seam breaking load before and after 10 cycles laundering in weft direction and, fabric type, stitch density, and laundry was obtained as follows

$$Y_3 = 28.1 - 162.8\, X_1 - 214.5\, X_4 + 164.3\, X_1 X_2 \qquad R^2 = 0.85 \qquad (3)$$

Y_3: % difference in seam breaking load before and after 10 cycles laundering in weft direction.

From equation 3 it is obvious that both fabric type and stitch density have negative effect on difference in seam breaking load after and before washing. This means that the higher the stitch density the lower the difference between seams breaking load after and before laundering in weft direction. This may be because with high stitch density the deterioration that happened to the seam after washing is less than that happened in case of low stitch density. Also Fabric type has negative effect on the same difference. Fabric 2(higher weight fabric gives higher difference in breaking load in weft direction this may be due to shrinkage that happened in weft direction of this fabric (ends/cm changed from 43 before laundering to 48 after laundering). The interaction between stitch density and sewing thread type affects the % difference in seam breaking load before and after 10 cycles laundering in weft direction.

3.4 Seam elongation

Figures (4-a, 4-b) shows the results of seam displacement before and after 10 cycles washing. Seam displacement is an indicator to seam elongation.

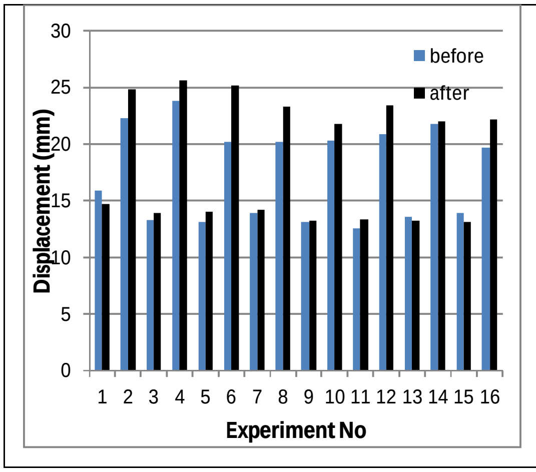


Fig.(4-a) Seam displacement in warp direction

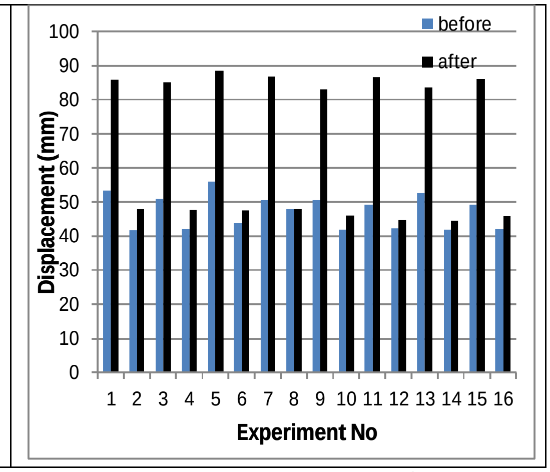


Fig.(4-a) Seam displacement in weft direction

The significant difference between seam displacement before and after 10 cycles laundering in warp direction is 0.0045 and in weft direction is 3.9 E-08. The relationship between seam displacement in warp direction before and after laundering and sewing parameters was obtained as follows

$$Y_4 = 6.2 + 6.7\,X_4 + 0.5\,X_1 X_4 \qquad R^2=0.93 \qquad (4)$$

$$Y_5 = 3.9 + 8.1\,X_4 + 1.1\,X_1 X_4 \qquad R^2=0.98 \qquad (5)$$

Where Y_4: displacement in warp direction before laundering, Y_5: displacement in warp direction after 10 cycles laundering.

From equations 4, 5 it is obvious that fabric type has high effect on seam displacement, contradicts with [10]. Fabric 2 gives higher displacement. Referring to table 3 it was found that fabric 2 has higher displacement than fabric 1 in warp direction before and after laundering. Also the stitch density interacts with fabric type and affects seam displacement in warp direction.

The relationship between seam displacement in both directions and sewing parameters under study and laundering was conducted as follows

$$Y_6 = 1.5\,X_1 + 8.9\,X_4 + 1.5\,X_5 \qquad R^2=0.99 \qquad (6)$$

$$Y_7 = -4.98 + 22.25\,X_4 + 65\,X_5 - 30.7\,X_4 X_5 \qquad R^2=0.99 \qquad (7)$$

Where Y_6: displacement at warp direction, Y_7: displacement at weft direction.

From equations 6,7, it can be concluded that the laundry has the higher effect on seam displacement in weft direction. This may be due to the high shrinkage that happened in weft direction. While in warp direction the fabric type has the higher effect on seam displacement since the shrinkage in this direction was low. From equation 7, fabric type 1 with laundering gives higher seam displacement in weft direction than fabric type 2. This is emphasized by the displacement values after laundering for both fabrics in warp direction (seam displacement of fabric 1 is 77.7 mm, for fabric 2 is 41.7 mm)

Seam efficiency

The significant difference between seam efficiency before and after 10 cycles laundering is 0.01 in warp direction and is 8.4 E-06 in weft direction.

The following regression equation were obtained for seam efficiency in warp direction.

$$Y_8 = 53.4 - 27.5\,X_1 - 16.4\,X_4 + 19.4\,X_1 X_4 \qquad R^2=0.91 \qquad (8)$$

$$Y_9 = 70 - 23.9\,X_1 - 21.4\,X_4 - 6.9\,X_5 + 19.1\,X_1 X_4 \qquad R^2=0.6 \qquad (9)$$

Where Y_8: seam efficiency in warp direction before laundering, Y_9: seam efficiency in warp direction before and after 10 cycles laundering.

From equation 8 it is obvious that fabric type has negative effect on seam efficiency in warp direction. Fabric 2 gives lower seam efficiency than fabric 1. This may be due to that fabric 2 has more shrinkage than fabric 1. Also the stitch density affects the seam efficiency in warp direction. In equation 9 it was found that laundry decreased the seam efficiency in warp direction. From both equations 8 and 9, it was found that the interaction between stitch density and fabric type affects seam efficiency in warp direction as well as their single effect. It was found that for seam efficiency in weft direction the only factor that was significant is laundering. This may be due to the high shrinkage of seams in this direction which prevent other factors from appearing.

Conclusion

It was found that there is a significant difference between each of seam breaking load , seam displacement at auto break, seam efficiency, and between stitch density before and after 10 cycles laundering.

The fabric type is a major factor that affects breaking load, displacement and efficiency of seams.

The interaction between stitch density and fabric type is a significant factor that affects seam breaking load, seam displacement at auto break, and seam efficiency. The higher the stitch density the higher the seam breaking load in warp direction.

The stitch density affects the difference between seam breaking load before and after laundry in weft direction and it interacts with sewing thread type. The higher the stitch density the lower the differences between seam breaking load before and after laundry.

The laundering is a major factor that affects the performance of seams. It has a significant effect on seam efficiency and elongation. It decreases seam efficiency.

When shrinkage is high in a fabric, the effect of laundering may prevent appearing of other sewing factors effect like what happened in seam efficiency in weft direction, no other factors could appear to be significant on seam efficiency besides laundry.

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