Study of the Relationship between sewing and fabric Parameters and Seam Strength

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Abstract:
Seam performance plays a vital role in the quality of clothing products. Seam strength is one of the key parameter to seam performance. This study aimed at studying the effects of sewing parameters: thread count (59/2 dtex, 35/2 Nm and 20/2 Nm), sewing needle size (14, 16 and 18 of Singer system) and stitch density (3, 5 and 7 stitches/cm) as well as fabric characteristics: yarn count (10/1, 20/1 and 30/1 Ne) and weft density (20, 21 and 22 picks / cm). The results of Analysis of variance of the main findings of this study revealed that seam strength is significantly and positively affected by both sewing and fabric characteristics. A value of correlation coefficient 0.97 was obtained for regression lines between needle size and seam strength and a value 0.99 between sewing thread count and the seam strength.

Keywords:
Seam Strength
Clothing
Sewing Needle
Sewing Machine
Fabric Characteristics

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Introduction
In general, seams are formed when two or more pieces of fabrics are held together by stitches in apparel products. The seams are considered one of the essential requirements in apparel construction. Seam performance and its quality rely on many parameters such as seam strength, elasticity, durability, puckering, appearance and yarn severance [1-5]. Also seam quality depends on its type, stitch density, sewing thread tension and seam efficiency [6].

Seam strength indicates the force required to break a seam. Seam strength results from fabric or swing thread breakage, or both simultaneously in more cases. Most researchers approved that the force required to break the seam is usually less than that needed to break the un-sewn fabric [7, 8].

Seam efficiency which is the ratio of seam strength to fabric strength of the fabrics sewn, refers to the durability of the seam. Mostly, seam efficiency ranges between 85% and 90% and it can be optimized by means of many factors, such as seam type, and density of stitches, and the selection of sewing threads and needles [9, 10].

Fabric properties such as breaking strength, breaking elongation, weight, thickness, extensibility cover factor, air permeability, compressibility, bending and shear rigidities have been investigated in many papers [11-14]. Some of these properties were found to have a significant influence of seam quality and performance. Behera [15] and Miguel et al. [16] assured that fabric cover factor has substantial influence on seam quality. Their study proved that fabrics with high cover factor have an increased tendency to break the fabric yarns at the time of sewing.

This study sheds light upon the effects of fabric and sewing characteristics on seam quality. Seam quality in this work was characterized in terms of seam strength. The effects of weft yarn count, sewing yarn count, weft density, stitch density and sewing needle size on seam strength will be examined.

Materials and Methods
Throughout this study, nine woven fabric samples with plain 1/ 1 weave structure were produced. These fabric samples were woven with three weft yarn counts i.e. 10/1, 20/1 and 30/1 Ne and three weft yarn densities namely, 20, 21 and 22 picks / cm. All warp yarn in all fabric samples were with count 30 / 1 Ne and warp density 21 ends / cm.

Each fabric sample was sewn with a supper imposed seam of type SSa-1 on sewing machine of type Juki DL-5550 with different sewing parameters. Figure 1 shows the general view of the supper imposed seam used in this study. Three different sizes of sewing needles were used to perform the desired stitches, namely 14, 16 and 18 of Singer system. Also, sewing threads made up of staple polyester fibers with different three counts, i.e. 59/2 dtex, 35/2 Nm and 20/2 Nm which corresponds to 3, 14 and 20 Tex were used. Three stitch densities, i.e. 3, 5 and 7 stitches/cm were also used. The general view of the sewing needle used during this study was depicted in figure 2. A Lockstitch of class 301 as shown in figure 3 was used for all stitches and seams in this study.

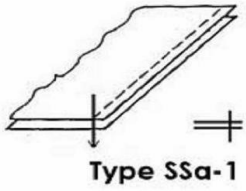

Figure 1: Supper imposed seam of type SSa-1

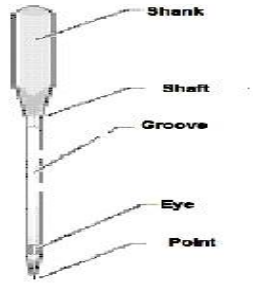

Figure 2: General view of sewing needle

Figure 3: General view of Lockstitch 301

In this study, seam strength was measured and evaluated in accordance with ASTM D1683-11 standard in the weft direction of the woven fabrics. Experimental data was statistically analyzed using SPSS software package. One-Way ANOVA is used to detect the significant effects of independent parameters on the seam strength at 0.01 significance level. Also, a regression analysis was carried out to predict seam strength at different levels of weft density, weft yarn count, sewing thread count, sewing needle size, and stitch density.

Discussion

Effect of weft yarn count on seam strength:

Seam strength of sewn woven fabrics at different levels of weft yarn count was depicted in figure 4. The statistical analysis showed that weft yarn count has a huge influence on the seam strength. It was determined that weft yarn count accounted for 85% of the effects on seam strength. From this figure, an increasing trend was disclosed confirming that as the weft yarn count increases the seam strength also increases. Increasing the weft yarn count from 10 Ne to 30 Ne leads to an increase of seam strength from 11 kg to 26 kg. Increasing weft yarn count means the finer the weft yarn which in turn increases the compactness of the woven fabric, then increasing the seam strength as shown in this figure. Increasing seam strength with the increase in weft yarn count may be due to increase fabric weight and thickness which results in an increase in seam strength.

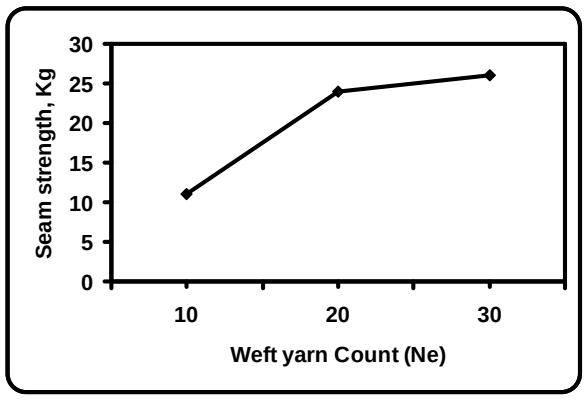

Figure 4: Effect of weft yarn count on seam strength

The relationship between weft yarn count and the seam strength has the following linear form:

Seam strength (Kg) = 7.5 × weft yarn count (Tex) + 5.33

The correlation coefficient between the two variables equals 0.92 which means that there is a positive correlation between weft yarn count and the seam strength.

Effect of sewing thread count on Seam strength

The variation of seam strength according to the variation of sewing thread count was depicted in figure 5. The statistical analysis proved that sewing thread count has a significant impact on seam strength at 0.01 significant levels. From this figure it can be seen that seam strength has a positive trend at the different levels of sewing thread counts. That is the coarser the sewing thread counts the higher the seam strength. It was determined that sewing thread count accounted for 52% of the effects of the sewing thread on seam strength. It was also shown that increasing sewing thread count from 59/2 dtex (3 Tex) to 25/2 Nm (20 Tex) leads to an increase of seam strength from 13.2 to 20 kg. The significant impact of sewing thread count on seam strength may be related to its higher strength with count in one hand, and higher thickness of sewing thread count increases the frictional forces between sewing thread and fabric during seam rupture in other hand.

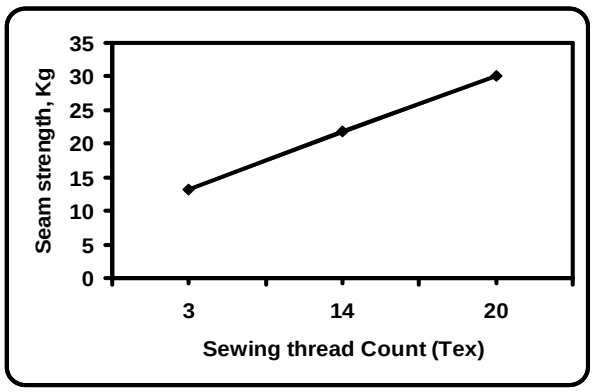

Figure 5: Effect of sewing thread count on seam strength

The regression relationship which correlates seam strength with sewing thread count was found to be

linear in the following form:
Seam strength (Kg) = 8.4 × sewing thread count (Tex) + 4.9
The correlation coefficient between the two variables equals 0.99 which means that there is a positive and strong correlation between sewing thread count and the seam strength.

Effect of weft density on Seam strength

The impact of weft density on seam strength was illustrated in figure 6. The statistical analysis proved that weft density has an exorbitant influence on the seam strength at 0.01 significance level. The effect of weft density was found to account 89% of the effects on seam strength. From this figure it can be noticed that as the weft density increases, the seam strength has the same trend. In general, seam strength increased from 7 to 35 kg with the increase in weft density from 20 to 21 picks / cm, while increasing weft density to 22 picks/ cm led to decrease seam strength to 24 kg.

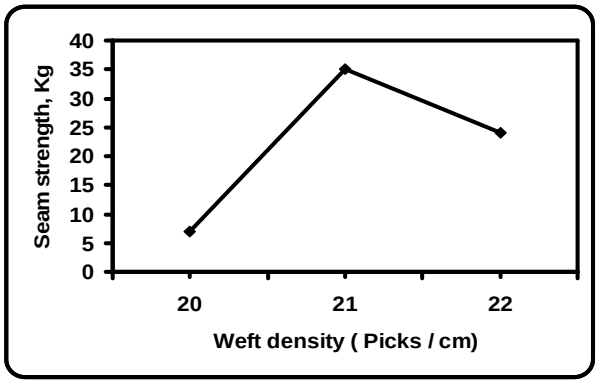

Figure 6: Effect of weft density on seam strength

Increasing weft density means increasing the fabric cover factor. Higher cover factor denotes tighter and compactness of the woven fabrics which in turn increases the seam strength.
The regression relationship which correlates seam strength to the weft density is a parabola of the following form:
Seam strength (Kg) = -19.5 × (weft density) ^{2} + 86.5 × weft density – 60
The coefficient of determination for this non-linear model equals 0.98, which means that this regression model fits the data very well.

Effect of sewing needle size on Seam strength

Sewing needle size denotes the needle diameter. In apparel industry, there are different systems to express the sewing needle size, namely metric and singer systems. Metric system, which is used in this study, is considered the simplest and most widely used in the apparel industry. The higher metric count, the higher needle size is.
The values of seam strength versus different levels of sewing needle sizes were drawn in figure 7. The statistical analysis showed that seam strength is affected significantly at 0.01 significance level by sewing needle size. As shown in figure 6, an increasing trend was detected assuring that as the sewing needle size increases the seam strength reacts in the same manner. It was estimated that the effect of seam size accounted for 69% of the effects on seam strength. Increasing sewing needle size from 14 to 18 led to increase the seam strength from 14 to 40 kg. The chance of sewing thread strength loss or breakage will be very high when using a lower sewing needle sizes, which in turn diminishes the seam strength.

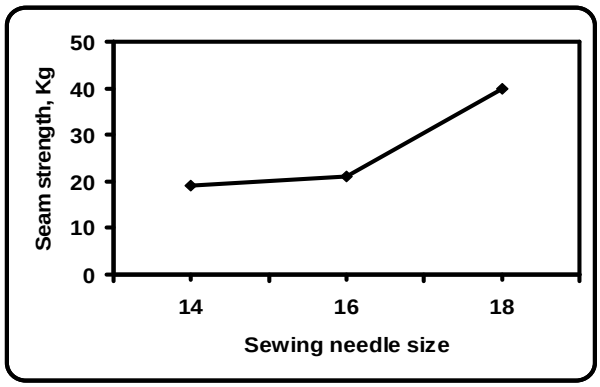

Figure 7: Effect of sewing needle size on seam strength

The regression relationship which correlates sewing needle size with seam strength is a straight line of the following form:
Seam strength (Kg) = 10.5 × needle size + 5.7
The correlation coefficient between the two variables equals 0.91 which means that there is a positive and strong correlation between needle size and the seam strength.

Effect of stitch density on Seam strength

Stitch density can be defined as the number of stitches per unit length. High stitch density means short stitch length, while lower stitch density denotes long stitch length. The variation of stitch density against the seam strength was pictured in figure 8. The statistical analysis revealed that stitch density has a profound impact on seam strength. The effect od stitch density accounted for 84% of the effects on the seam strength.

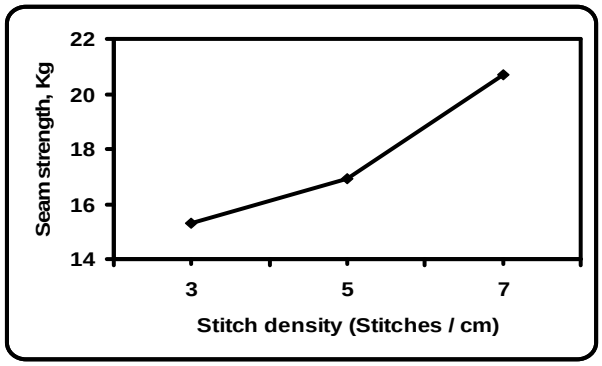

Figure 8: Effect of stitch density on seam strength

From figure 8, it can be seen that as the stitch density increases the seam strength increases. This is because the friction between sewing thread and the fabric with increasing the stitch density becomes higher . Increasing stitch density from 3 stitches / cm to 7 stitches / cm leads to an increase in the seam strength by approximately 35%.

The regression relationship which correlates stitch density with seam strength is a straight line of the following form:

Seam strength (Kg) = 2.7 × stitch density + 12.2

The correlation coefficient between the two variables equals 0.97 which means that there is a positive and strong correlation between needle size and the seam strength.

Conclusions:

In this study, the influence of sewing and woven characteristics on seam strength wee examined. Woven cotton fabric characteristics were weft yarn density and weft yarn count. Sewing characteristics to be studied were sewing thread count, sewing needle size and stitch density. Analysis of variance of type One-Way was used to detect the significant effects of independent variables on seam strength. The conclusion of the experimental results can be summed up as follows:

- Seam strength was found to be affected significantly by weft yarn count. As the weft yarn count increased from 10Ne to 30Ne seam strength increased from 11 to 26 kg.
- The relationship between seam strength and sewing thread count were found to be in the linear form.
- The correlation coefficient between seam strength and stitch density were positive and strong with value 0.97. This means that as the stitch density increases the seam strength reacts in the same manner.
- Sewing needle size has a positive and significant impact on seam strength.

The derived regression relationships can be used to predict the seam strength with high degree of reliability. These regression models can benefit the researchers and producers in the field of the ready-made garments to detect seam strength at different levels of sewing and woven fabric characteristics.

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