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# Effect of Different Sewing Parameters on Lockstitch Seam Strength for Denim Fabric

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**ABSTRACT**

Seam strength plays a very important role in acquiring the desired quality seam which ultimately defines the quality of any clothing. The paper is aimed to study the strength of seam produced from denim fabric, how different sewing parameters like sewing thread type, type of seam, seam direction as well as the density of stitches influence the strength of seam, and it is observed that they have direct effect on lockstitch seam strength of denim fabric with various degree. For research denim fabric with 3/1 weaves structure and three different sewing threads namely 100% cotton spun with 14tex linear density, 100% polyester spun with 24tex and 60tex linear density were used. Seam class used for the research was superimposed seam prepared with two layers, SSa and three layers, SSb. The samples were made by stitching with lockstitch sewing machine both in warp and weft way. Three different stitch densities were used to sew the samples and they were-7, 9 and 11 stitches per inch. The strength of the produced seams was tested on a universal strength tester machine-the titan tensile strength tester. Test was performed according to ASTM D5034 test method. The outcome of the research shows that seam type, seam direction, thread types, and stitch density have direct effect on lockstitch seam strength of denim fabric with various degrees. Higher seam strength was obtained for the SSb type seam produced in warp direction with coarser sewing thread (60tex) and 11 stitches per inch (SPI). The influence of independent variables on the seam strength was assessed statistically using a multivariate variance analysis (ANOVA) with the help of SPSS software and it was found that they effect significantly. Regression analysis was done to develop the regression equation to predict lockstitch seam strength before production process.

Keywords: Denim Fabric, Seam Strength, Stitch Density, Seam Type, Stitch per Inch.



## 1. Introduction

Apparel manufacturing technology depends on the conversion of the fabric from two dimensional (2D) into three dimensional (3D) structures to fit human body [1]. Though there is a considerable improvement of techniques and technologies has been emerged in the apparel manufacturing, still the dominating group of methods for joining the garment elements is the sewn seams made by sewing threads [2].

The clothing industries are mainly concerned about the secondary characteristics of fabric that is the reactions of the fabric to an applied dynamic force and focus on the quality of seam at the time of fabrication and production of clothing [3],[4]. So good seams are important factors to determine clothing quality which is a big deal in today's competitive world market as quality can be seen as the synonym of excellence [5] and as a means to make differentiation of different products having perceived value [6].

On the other hand, quality of a seam can be viewed from its performance and appearance [7]. Seam performance that is, appearance, seam strength, elastic property, and durability depend on the seam type and stitch density of the seam, tension of the sewing thread and the seam efficiency of the fabric.

Seam durability can be measured through seam efficiency where seam strength is the driving factor [8]. As the standard of any garments is dependent on the quality of seam, the applied seams to make the garments have to fulfill the above mentioned criteria, among which seam strength and appearance of the seams have big importance [9], [10].

Another important matter is that the seam should have such stretchability so that the users can have free movement without breaking the seams.

In general, seam efficiency ranges between 85% and 90% but it can be optimized by optimizing seam strength considering different sewing parameters like type of seam, stitch types, stitch density, and type of sewing threads and selection of needle [12].

Rengasamy *et al.* [13] and Nayak *et al.* [14] showed the influence of types of sewing thread on the seam efficiency. Impact of linear density of sewing thread has been studied by different researchers [10],[15],[16] and it has been found that the linear density of sewing thread is one of the most influencing factors for the seam strength. Barbulov *et al.* [11] studied the impact of stitch density and of the type of sewing thread on seam strength. Akter and Khan (2015) [17] studied the influence of stitch type and sewing thread on seam strength and efficiency of the superimposed seam for cotton apparel. The effect of the different number of sewn layers was first studied by [1] Frydrych *et al.* (2016) along with other sewing parameters. Yassen (2017) [18] showed the effects of sewing thread count, sewing needle size, stitch density along with fabric characteristics on seam strength, and found that seam strength is significantly influenced by both sewing and fabric characteristics.

This research work is an attempt to investigate and show how different sewing parameters for example sewing thread, seam type, stitch density, sewn fabric layers affect seam quality in terms of seam strength as well as to develop a regression equation to predict the lockstitch seam strength for denim fabrics.

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## 2. Experimental Details

Denim fabric of 98% cotton and 2% spandex yarn, 3/1 twill was taken with the specifications given in Table 1. Sewing parameters and sewing threads properties were given in Table 2 and Table 3. A simplified flow chart of research methodology is given in Fig. 1.

Table 1 Fabric characteristics

| Parameters | Unit | Value | Parameters | Unit | Value |
|---|---|---|---|---|---|
| Thickness | mm | 0.52 | Warp yarn count | tex | 80 |
| Surface density | $g/m^2$ | 182 | Weft yarn count | tex | 70 |
| Warp breaking force | cN | 1025 | Warp yarn elongation at break | % | 11 |
| Weft breaking force | cN | 890 | Weft yarn elongation at break | % | 8 |
| Warp density (EPcm) | $cm^{-1}$ | 28 | Warp yarn tenacity | cN/tex | 12.81 |
| Weft density (PPcm) | $cm^{-1}$ | 20 | Weft yarn tenacity | cN/tex | 12 |

Table 2 Selection of different sewing parameters

| Sewing parameters | Expression/ Value | Elaboration |
|---|---|---|
| Seam class | SS | Superimposed seam * |
| Seam type | SSa | Superimposed seam with two layers* |
| | SSb | Superimposed seam with three layers* |
| Seam direction | Warp, Weft | Seams were prepared in warp and weft direction |
| Stitch density (SPI) | 7, 9, 11 | They are expressed as SD1, SD2 and SD3 respectively |
| Sewing thread | ST1, ST2, ST3 | Represent sewing thread one, two and three respectively |
| Needle size (Metric) | 100,100, 150 | Corresponding sewing threads are ST1, ST2 and ST3 respectively |

(* According to ASTM D 6193)

Table 3 Sewing threads properties

| Parameters | Unit | ST1 | ST2 | ST3 |
|---|---|---|---|---|
| Ply number | - | 2 | 2 | 3 |
| Composition | - | 100% polyester Spun | 100% Cotton Spun | 100% polyester Spun |
| Linear density | tex | 14 | 24 | 60 |
| Ticket number | | 215 | 125 | 50 |
| Breaking force | N | 8.4 | 10.6 | 24 |
| Elongation at break | % | 17.87 | 7.37 | 46 |

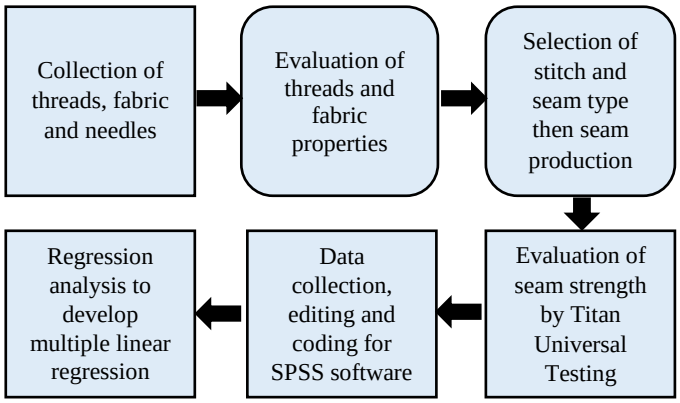


Fig. 1 Simplified research methodology

### 2.1 Sample Preparation

A superimposed seam class of SSa and SSb type with 25.4 mm seam allowance and according to ASTM D 6193, lockstitch class 301 were used for sewing the samples. Selection of needle size to sew the samples has been shown in the Table 2. Samples were stitched along the seam line both in warp and weft way of the fabric. The fabric was sewn with three different stitch densities to see the effect of stitch density on seam strength.

### 2.2 Seam strength evaluation

Grab test (ASTM D5034) as a test method was used to determine the seam strength. Samples with 350 mm length among which 150mm in one side of the seam line and 200mm on another side of the seam along with 100 mm in width which is parallel to the seam line were made as shown in Fig. 2. During the test, samples were subjected to 1% tension of the approximate breaking load. The value presented here is the average of five specimen tested consecutively.

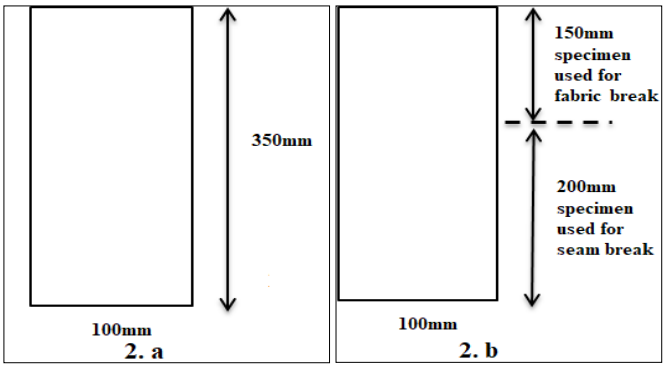


Fig. 2 Dimension of cut specimen from fabric (2.a) and Seamed specimen (2.b)

## 3. Results and Discussion

### 3.1 Effect of Seam Type on Seam Strength

Two different types of superimposed seams were made and they were SSa and SSb type seam that is they were different by their layers. Seam SSa has two layers of fabric whereas seam SSb has three layers of fabric. The graphical representation presented in Fig. 4(c) shows that there is noticeable difference in seam strength with the increase of layers of fabric in the seam and this can also be understood from the variance analysis presented in Table 4. It is also found that seam strength gets increased as the increase of fabric layers for all kind of sewing parameters that is seam direction, sewing thread and stitch density [see Fig. 3].

The fact is that, an increase in fabric layer increases contact points number between fabric yarns and sewing threads, as a result a tighter surface is obtained. Thus, the distribution of tensile forces will take place over a larger number of points and the resistance will be higher.

### 3.2 Effect of Seam Direction on Seam Strength

Though warp seam strength was higher than that of weft in most of the cases, in some cases, warp and weft seam strength were found equal [see Fig. 3]. From the Fig. 4(d), it is obvious that direction of seam has significant effect on strength of the seam of the sewn fabrics. The fact can be supposed that the lower seam strength of the fabric can result from the lesser number of intersection points between sewing thread and yarns of the fabric.

### 3.3 Effect of Sewing Thread on Seam Strength

It is an established truth that the higher the strength of sewing threads the higher the seam strength of the sewn fabrics. This is because, the strength of the sewing threads adds the strength to the seam sewn by the threads. This study also reveals the same result and supports the results of many other researchers [19],[20]. From the correlation analysis it is found that there is very strong correlation between sewing thread linear density and seam strength [see Table 4]. The effect of sewing threads on seam strength has been presented graphically in Fig. 4. a. The effect of sewing threads varying other sewing parameters has been represented in the Fig. 3 and it is found that seam strength always gets increased as the increase of sewing thread size for all kind of sewing parameters that is seam direction, fabric layers and stitch density. The fact is that the coarser sewing thread contains more number of fibres resulting in high seam strength.

### 3.4 Effect of Stitch Density on Seam Strength

The effect of stitch density on the strength of the lockstitch seam is found very prominent (see Fig. 4(b)) and it is found as the second most influential factor of seam strength; statistical analysis also reports the same issue (see Table 4). It has also been found that with the increase of stitch density the seam strength also increases and the effect is obvious for all kind of other sewing parameters like seam type, seam direction, sewing thread types (see Fig. 3). In fact, with the increase of stitch density the number of loops per unit length of the fabric increases; therefore, the higher force is required to deform such a seam.

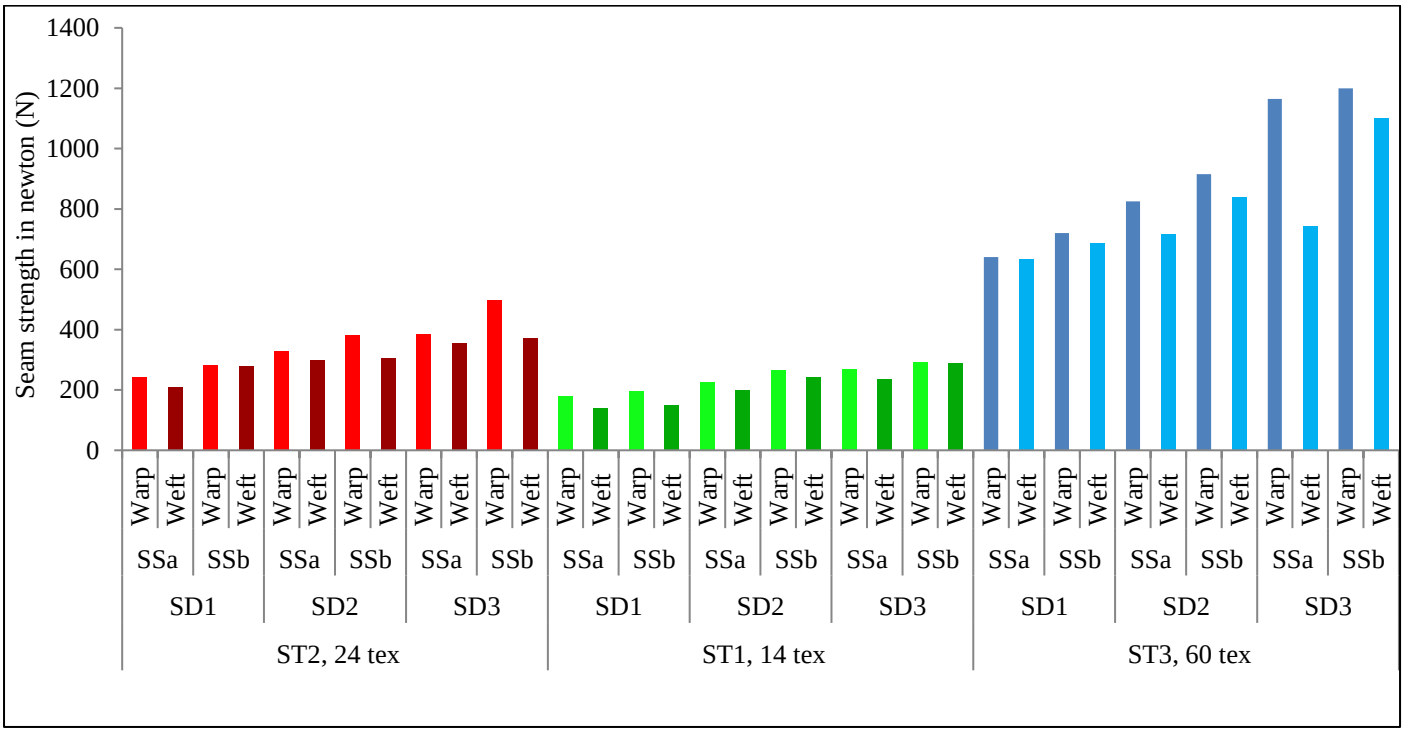


Fig. 3 Effect of seam type, seam direction, sewing thread, and stitch density on seam strength

Table 4 Correlation analysis of different parameters

| Correlations | | | | | |
|---|---|---|---|---|---|
| **Variables** | Seam strength | Sewing Thread | Stitch Density | Seam type | Seam direction |
| **Seam strength** | 1 | 0.851** | 0.289 | 0.113 | -0.113 |
| **Sewing Thread** | 0.851** | 1 | 0 | 0 | 0 |
| **Stitch Density** | 0.289 | 0 | 1 | 0 | 0 |
| **Seam type** | 0.113 | 0 | 0 | 1 | 0 |
| **Seam direction** | -0.113 | 0 | 0 | 0 | 1 |

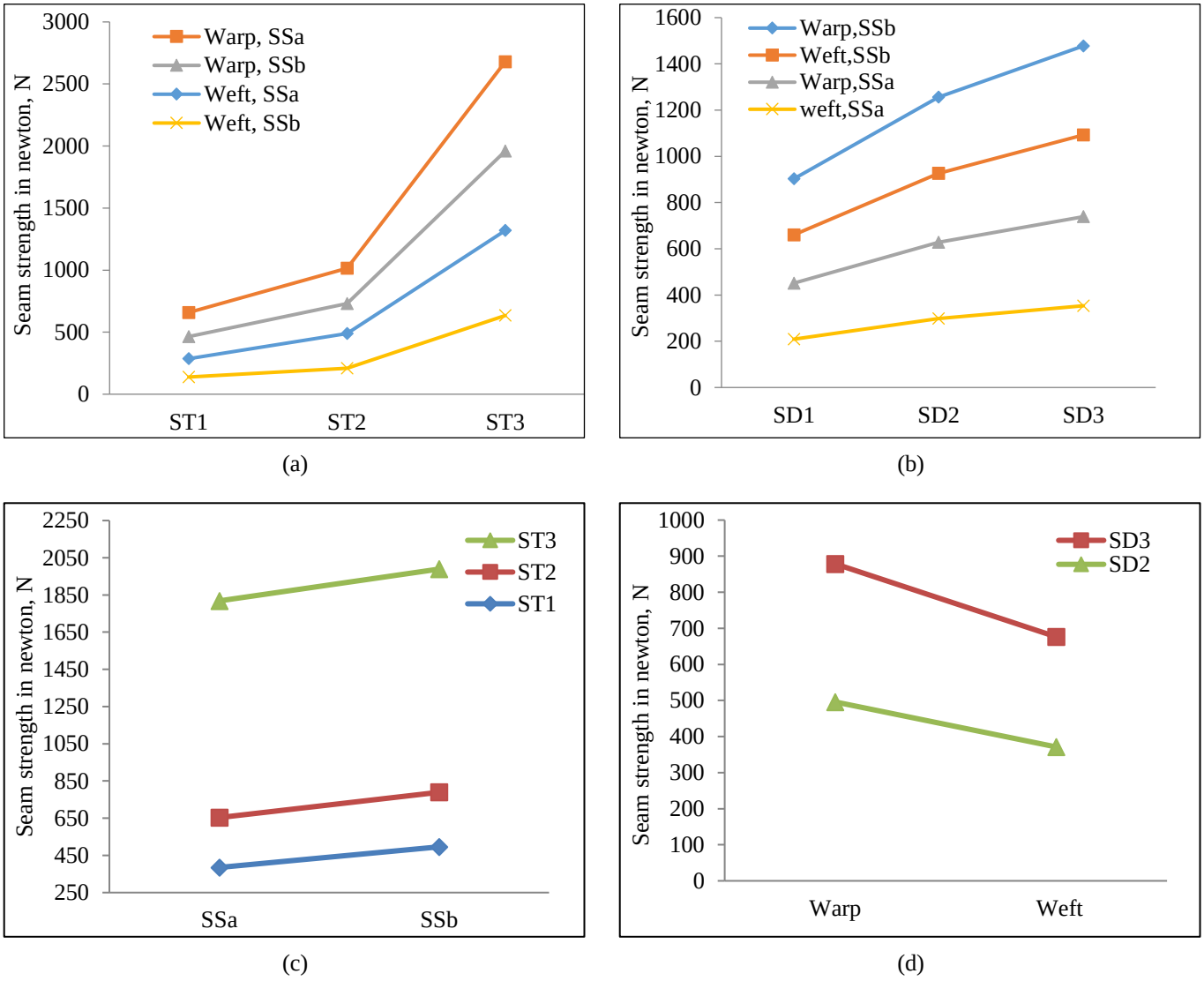


Fig. 4 Seam strength for various (a) seam type & (b) stich density and (c) seam type & (d) seam direction

3.5 Regression Analysis to Develop Regression Equation

The regression equation is given below:

$$\text{Seam strength} = -568.318 + 312.742 \times \text{Sewing Thread} + 53.029 \times \text{Stitch Density} + 68.011 \times \text{Seam type} - 67.996 \times \text{Seam direction} \quad (1)$$

Table 5 Regression model summary

| R | $R^2$ | Adjusted $R^2$ | Std. Error | Sig. |
|---|---|---|---|---|
| .913[a] | .833 | .812 | 131.9538486 | .000 |

a Predictors: (Constant), Seam direction, Seam type, Stitch Density, Sewing Thread, Stitch Type

As in the Table 5, the $R^2$ value is 83.3% which indicates the prediction level of the model. The $R^2$ value also denotes that 83.3% of the changes in seam strength (dependent variables) can be explained by independent variables in the model. According to the results of ANOVA test presented in Table 6, it is found that the relation between dependent and independent variables was significant at 99% significance level as the significance value was found as $p < 0.01$**.** The regression equation (equation 1) given above was made with the coefficients obtained by the analysis in this study. The regression equation will help to predict seam strength when the other independent variables are known before the production process.

Table 6 Regression analysis, ANOVA[a]

| Model | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Regression | 2700578.351 | 4 | 675144.59 | 38.78 | 0[b] |
| Residual | 539766.363 | 31 | 17411.82 | | |
| Total | 3240344.714 | 35 | | | |

a. Dependent Variable: Seam strength
b. Predictors: (Constant), Seam direction, Seam type, Stitch Density, Sewing Thread

## 4. CONCLUSION

The outcome of the research shows that the studied sewing parameters affect the strength of lockstitch seam significantly. There is slight increase in seam strength as the layers of the fabric increased. Though seam strength is found higher with the coarser sewing threads and with the higher stitch densities, these two

factors should be selected in such a way so that the seam quality remains satisfactory because some samples were found with slipped seam at eleven stitches per inch; this may denote the unsuitability of eleven stitches per inch for the fabric. The effect of seam direction was more visible for the sewing thread three, ST3 (60 Tex). Prediction of seam quality before seam production is the most important issue for the manufacturers. And for this reason, regression model has been developed that will allow the producers to predict seam strength from given input parameters. The outcome of the work can be more generalized by including kind of fabrics as an independent variable and by producing seams with other stitches that are commonly used for denim fabrics.

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