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Research Article

An Experimental Overview of Seam Performance for Different Types of Denim Fabrics

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Abstract

This study was designed to explore the seam performance with special focus on seam strength and efficiency for commercially obtainable different types of denim fabrics. Technically seam performance is portrayed by strength of seam, elongation of seam and efficiency of the seam. Seam performance can contribute as an imperative factor in determining the durability of a garment. Different combinations of denim fabrics were used for seam strength and efficiency analysis together with four different types of commonly used stitch structures along with three types of sewing threads like 40, 60, and 80 tex. Seam strength and efficiency for different denim fabrics were changed consecutively with varying types of stitches combined with increasing stitch density. More specifically, supreme seam performance was observed at light indigo 170 g/m² (GSM) 100% cotton twill denim fabric for overlock stitch structure alongside higher stitches rather than others. Characteristically the seam line which contains more stitch density encompassed in different denim fabrics demonstrates more seam eminence.

Keywords: *Stitch, Denim Fabric, Seam Strength, Seam Efficiency, Stitch Density*

1. Introduction

In the modern fashion world, different factors like colour, aesthetic, affordability, durability influence the clothing selection for consumers' (Rengasamy *et al.,* 2011). Therefore, clothing manufacturing needs to increase demand steering along with rapid response and feedback towards technically comprehensive and sustainable manufacturing (Malek *et al*., 2017, Toshikj *et al*., 2015, Asif 2017). The relationship between raw material characteristics, sewing performance and seam quality, have become significant because seams have been widely used in the clothing industry to construct garments with desired features (Zervent, 2012). The mechanical properties of the seams can be used as one of the most noteworthy perimeters for the structure of durable garment (Patra and Pattanayak, 2015). Seam slippage in a piece of clothing can happen due to either the displacement of the sewing thread leaving the fabric flawless or texture burst, leaving the seam unblemished (Sarioğlu and Babaarslan, 2017). Numerous elements influence the nature of the dress like texture, sewing thread, needle, sewing machine, and sewing capacity (Yücel, 2007).

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Texture and sewing threads are the essential ingredients for garments fabrication. Above all else, garment designers are keen on the critical material properties for getting excellent seams (Sular *et al.,* 2015, Chavhan *et al.,* 2020). The buyers are mainly interested in particular attributes of the clothing, such as appearance, wear-ability and comfort of the clothing (Chowdhary *et al*., 2006, Rashid *et al*., 2020, Haghighat *et al*., 2014). Correct selection of primary material helps the manufacturer to formulate comfortable items to the end-users; additionally, also helps in smooth sewing operation working and manufacturing of garments; that process leads to high-quality apparel without defect (Nayak *et al.,* 2010).

Traditionally, denim is characterized as a 3/1 twill texture produced using coloured yarn and undyed yarn (Phebe and Chandrasekaran, 2014). The use of denim clothing has been growing sharply every year, and its global market share has increased at a cumulative rate in the past few decades (Babaarslan *et al.,* 2019). Consumer needs and demands have tweaked for the latest developments and new styles; they are also aware that clothing has unique surface treatments and craftsmanship to make it both environmentally friendly and user-friendly (Değirmenci, 2017). Therefore, it is imperative to study the relationship between the essential items that make up denim garments and the sewing thread that binds these individual components together (Haghighat *et al.,* 2014).

While undergoing special finishes and chemical treatments, there is a considerable loss in the strength and physical dimensions of the fabric (Ateş *et al.,* 2019). Appropriate sewing threads and seams must be selected to maintain the durability, quality and wear resistance of the fabric (Arikan *et al.,* 2015). It is essential to choose the correct seam category for a particular constituent because the incorrect selection of stitch type, seam type, or thread type can lead to failure of sewing seams and failure of garments (Bharani *et al.,* 2012). The most significant parts of an appropriately developed stitch are quality, flexibility, solidness, security, and appearance (Samuel and Rengasamy, 2017). These attributes must be offset with the qualities of the material to be associated with the structure of the best stitch (Maarouf, 2015). To obtain a product with the final desired quality, it needs to specify the most suitable seam and suitable SPI for a specific type of denim with a suitable count of sewing threads (Midha *et al.,* 2009). Although several researchers (Jaouachi *et al.,* 2012, Ezzatollah and Seyed, 2013, Islam *et al.,* 2020) already have studied the effect of seam on woven fabrics with different sewing parameters. Thus, current research work was carried out sumptuously using four commercially available denim fabrics, sewing seams in warp direction with four different stitch categories and assessing the seam performance. This investigation will help to understand the impact of sewing parameters on the seam performance for various types of denim fabrics commonly used in the denim business around the world.

2. Materials and Method

2.1 Material

2.1.1 Fabric

The denim fabrics selected for this experiment were Light Indigo 100% cotton twill, Dark Indigo 75% cotton, 25% Polyester twill; Blue Black 100% cotton twill, Navy Blue 85% Cotton, 15% Polyester twill. The weight of the denim fabrics was accounted for 170, 254, 271 and 322 g/m^2 (GSM) respectively.

2.1.2 Sewing Parameters

In this research work, four different types of stitches were used like lockstitch, flatlock stitch, overlock stitch and chain stitch. The stitches were designated by code A, B, C, and D following lockstitch, flatlock stitch constituted with three thread, overlock stitch comprised with four thread and chain stitch respectively for experimentation. Different sewing machines (Brand name: Juki, Kansai, Yamato) were employed to produce these stitches. Stitch density was accounted for 7, 9, and 12 while needle size was 18.

2.1.3 Sewing Thread Specification

For this experiment, three different types of sewing thread count were used like 40, 60 and 80 tex respectively. All of the threads were core-spun polyester. Besides these materials, the following materials were also used.

- Measuring Tape
- Electronic balance
- Tensile Strength Tester (James heal)
- Scissor and tailoring chalk

2.1.4 Tensile Strength Testing Machine Specification

Name: Titan Universal Strength Tester
Model No.: Titan[5]
Company: James Heal (Richmond Works)
Origin: United Kingdom

Figure 1: Universal Tensile Strength Testing Machine (James Heal)

2.2 Methodology

The experiment was carried out by ASTM standard method for sample preparation and testing. Five samples from each stitch type (lockstitch, flatlock, overlock and chain stitch) along with sewing thread count (40, 60, 80 tex) with different stitch density (7, 9, 12) were employed to conduct the study. Then sewn fabrics were tested for seam strength and efficiency on James heal tensile strength testing machine at a speed of 305 mm/min and 75 mm gauge length as per ASTM-D1683 standards. Five tests were conducted consecutively in warp direction for each sample. The tensile strength for four different types of denim (light indigo 100% cotton twill; dark indigo 75% cotton, 25% polyester twill; blue black 100% cotton twill; navy blue 85% cotton, 15% polyester twill) un-seamed fabrics were measured by universal tensile strength testing machine and the results were accounted about 640N, 702N, 863N and 743N respectively. For seam strength testing, the sample of (10×10) cm^2 was cut from the base fabric and sewn in warp direction with seam allowance of 1 inch. Seam efficiency was measured by following formula:

Seam efficiency (%) = (Seamed fabric tensile strength / Un-seamed fabric tensile strength) × 100

Furthermore, Box plot analysis was used for explanatory data analysis to visually demonstrate the distribution of numerical data and skewness by displaying data quartiles and averages. Sensitivity analysis model was also used to regulate how target variables are affected by changes in additional variables acknowledged as input variables.

3. Results and Discussion

3.1 Determination of Seam Strength and Efficiency for Light Indigo 170 g/m² (GSM) 100% Cotton Twill Fabric

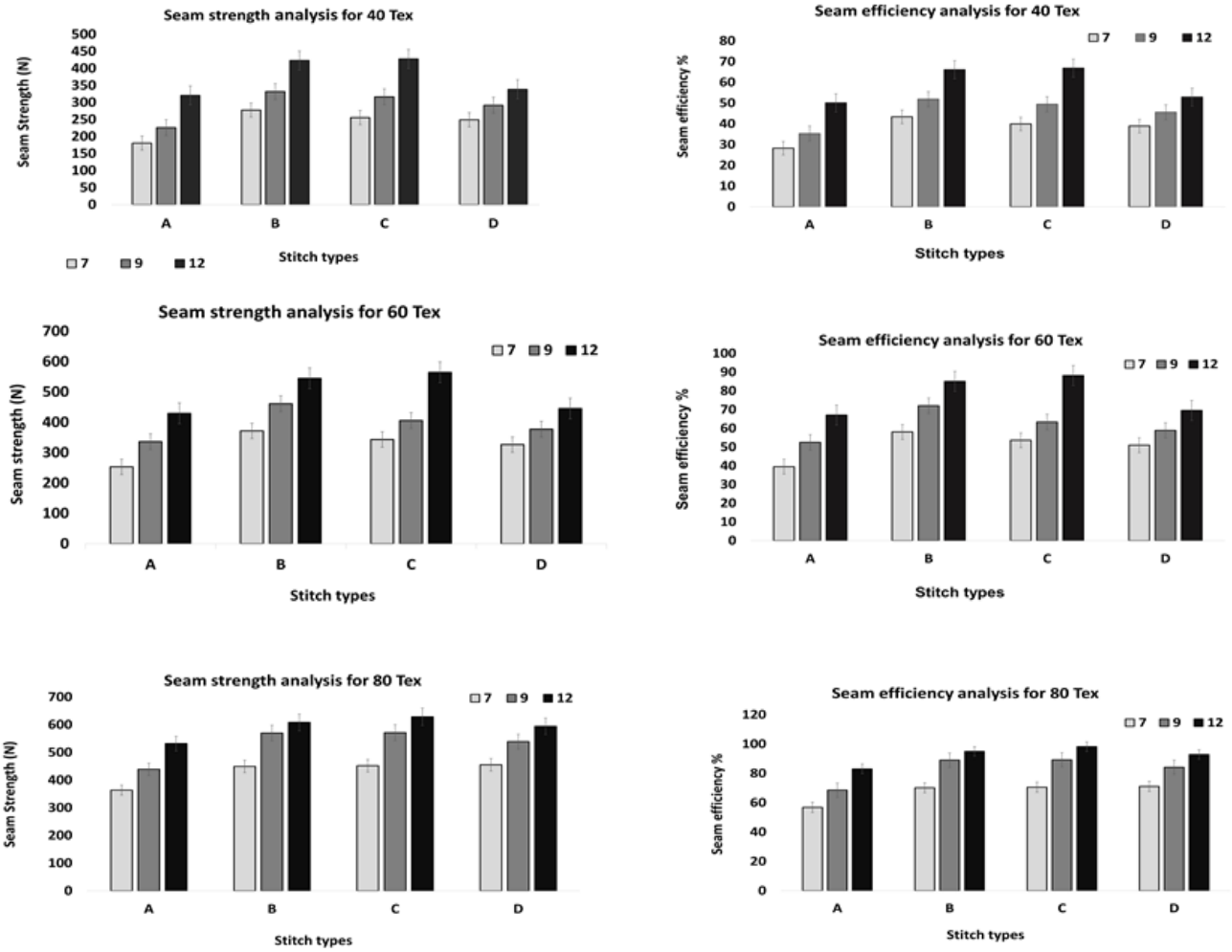

Figure 2: Seam strength and efficiency for light indigo 170 g/m² (GSM)100% cotton twill denim fabric in response to 40, 60, 80 tex

The following figures reveal about the seam strength and efficiency analysis for 40, 60, 80 tex at light indigo 170 g/m² 100% cotton twill denim fabric. It is perceived from the above figures that; seam strength along with seam efficiency increased with the surging of stitch per inch (SPI) for light indigo 170 g/m² 100% cotton twill denim fabric. More precisely, in case of light indigo 170 g/m² 100% cotton twill denim fabric; seam performance is upsurged gradually with different stitch types by increasing SPI. Maximum seam strength and efficiency witnessed for light indigo 170 g/m² 100% cotton twill denim fabric upon overlock stitch structure (C) and more specifically four thread overlock stitch structure (428N) with seam efficiency (67%) in comparison with other stitches for 40 tex in cooperation with 12 SPI because overlock stitch encloses seam while using multiple threads to lock each edge which prevents it from fraying.

Flatlock stitch structure (B) also demonstrates better seam strength (423N) and efficiency (66%) in comparison with others. For 60 tex sewing thread count, maximum seam strength (565N) has been observed for 12 SPI at light indigo 170 g/m² 100% cotton twill denim fabric upon overlock stitch structure (C) with seam efficiency (88%) in comparison with other stitches. For 80 tex linear density, maximum seam strength (627N) and efficiency (98%) perceived for 12 SPI at light indigo 170 g/m² 100% cotton twill denim fabric upon overlock stitch structure (C) in contrast to other stitches. For 80 tex sewing thread, flatlock stitch structure (B) also provides better seam strength (608N) and efficiency (95%) in contrary to other stitch structures. Seam that contains more stitch per inch in seam line illustrates more seam strength along with seam efficiency as it grips both ends of the fabrics more tightly.

3.2 Assessment of Seam Strength and Efficiency for 254 g/m² (GSM) Dark Indigo 75% Cotton, 25% Polyester Combination Twill Denim Fabric

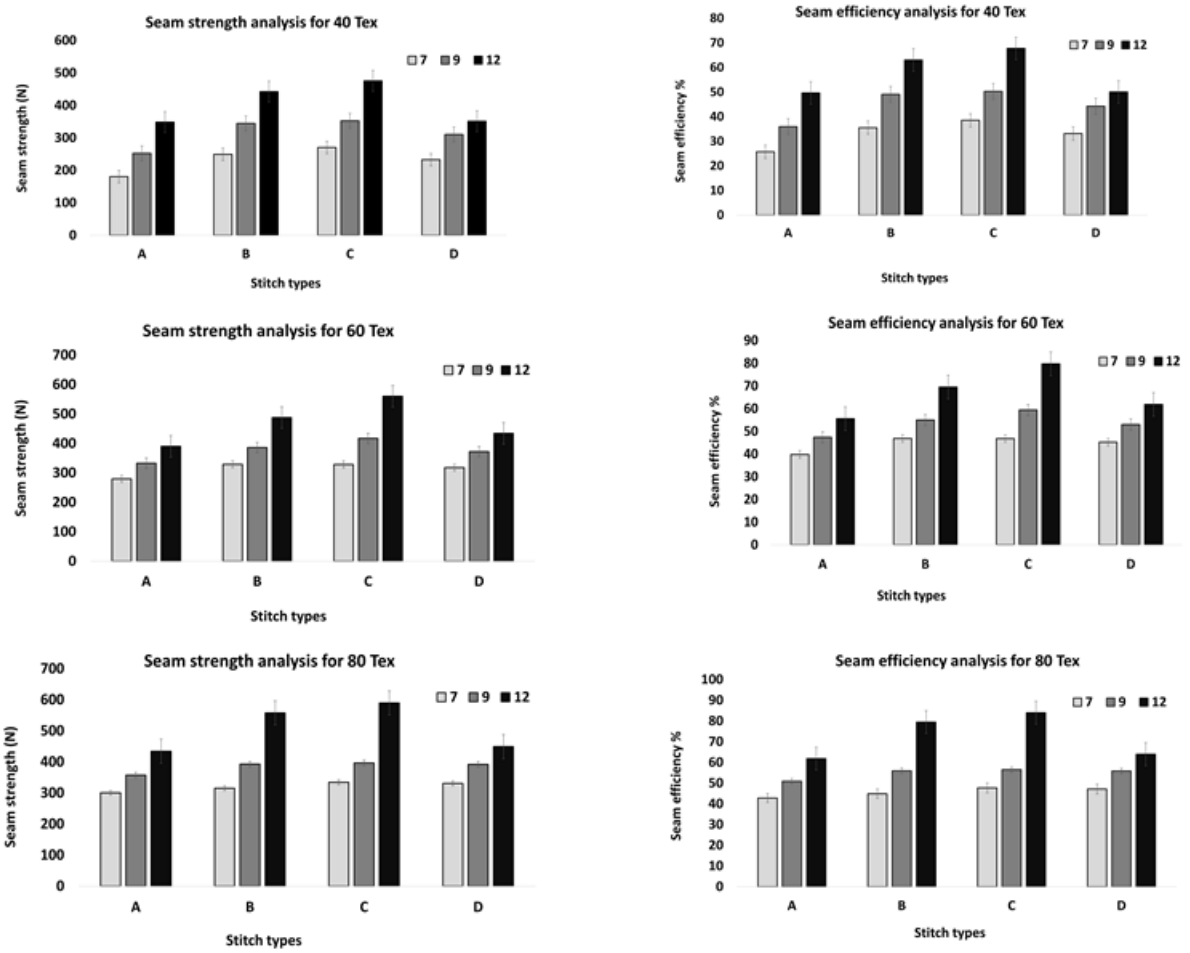

Figure 3: Seam strength and efficiency for 254 g/m² dark indigo 75% cotton, 25% polyester combination twill denim fabric in rejoinder to 40, 60, 80 tex

The above figures disclose about the seam strength and efficiency analysis for 40, 60, 80 tex at 254 g/m² dark indigo 75% cotton, 25% polyester twill denim fabric. It is remarked from the figures that seam strength along with seam efficiency increased with the surging of stitch per inch (SPI) at 254 g/m² dark indigo 75% cotton, 25% polyester twill fabric. More specifically in case of 254 g/m² dark indigo 75% cotton, 25% polyester twill fabric, seam performance changed gradually with different stitch types by increasing SPI. Maximum seam strength and efficiency witnessed for 254 g/m² dark indigo 75% cotton, 25% polyester twill fabric upon overlock stitch structure (C) and more specifically four thread overlock stitch structure (476N) with seam efficiency (68%) in comparison with other stitches for 40 tex in cooperation with 12 SPI. Overlock stitch is such kind of stitch which sewn over the edge of one or two pieces of cloth for edging and sewing. Technically loopers are used to generate thread loops which pass from the needle thread to the edges of the fabric so that the edges of the fabrics contained inside the seam. Flatlock stitch structure (B) also demonstrates better seam strength (443N) and efficiency (63%) in comparison with others. The reason behind that, unlike an overlock stitch structure there are no layers upon on underside, the seam is buckled together.

For 60 tex linear density, maximum seam strength (517N) observed for 12 SPI at 254 g/m² dark indigo 75% cotton, 25% polyester twill fabric upon overlock stitch structure (C) with seam efficiency (74%) in comparison with other stitches. For 80 tex linear density, highest seam strength (590N) and efficiency (84%) noticed for 12 SPI at 254 g/m² dark indigo 75% cotton, 25% polyester twill fabric upon overlock stitch structure (C) in contrast to other stitches. For 80 tex, flatlock stitch structure (B) also provides better seam strength (558N) and efficiency (79%) in divergent to other stitch structures. Chain stitch structure (D) also represents better seam performance in comparison with lockstitch structure because in case of chain stitch, sewing threads are bound together by interloping and interlacing while in lockstitch sewing threads are bound together by interlacing. More specifically, chain stitch is formed by two or more sets of threads termed as needle thread and looper thread.

3.3 Formulation of Seam Strength and Efficiency for Blue Black 271 g/m² (GSM) 100% Cotton Twill Denim Fabric

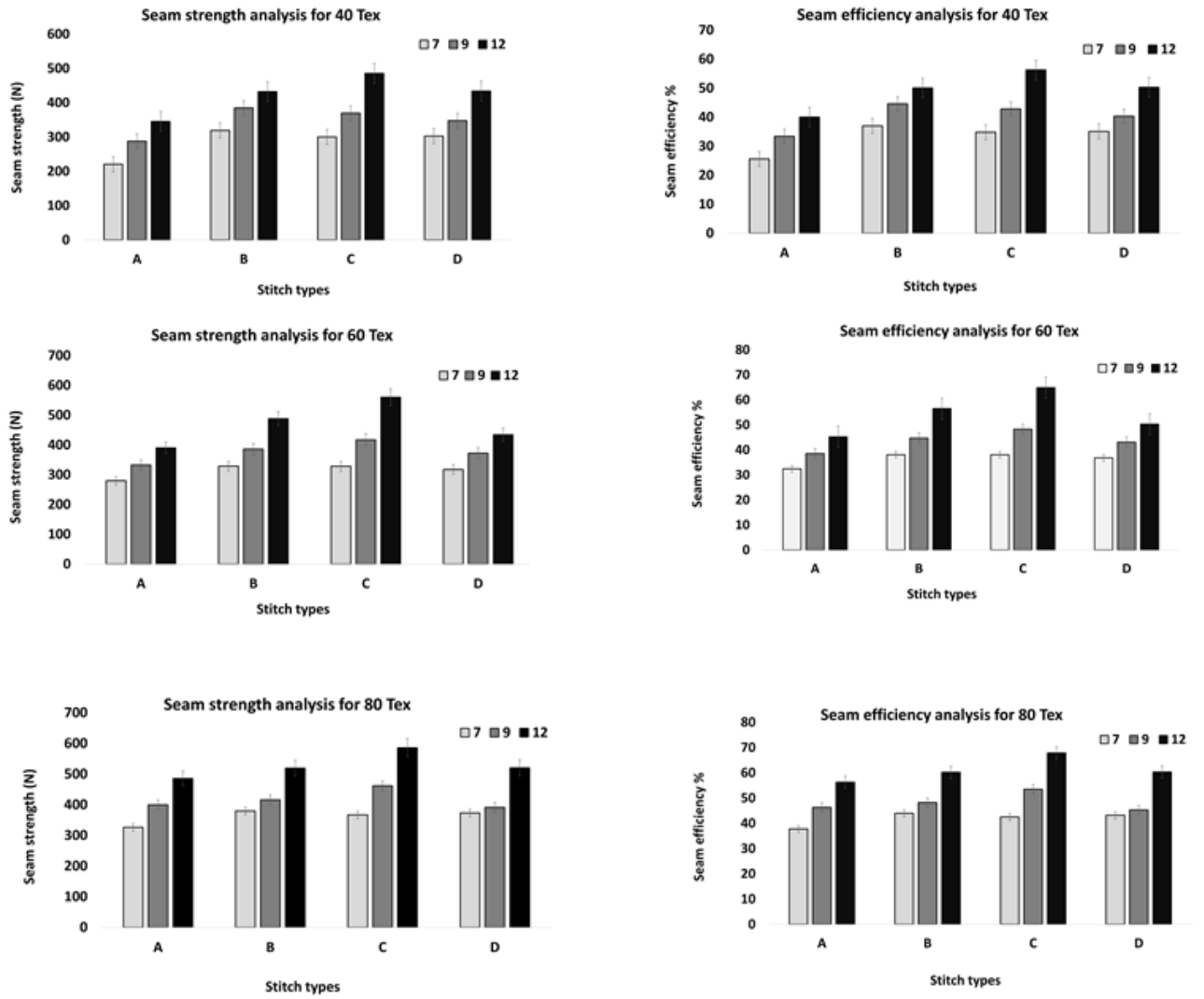

Figure 4: Seam strength and efficiency for blue black 271 g/m² 100% cotton twill denim fabric in retort to 40, 60, 80 tex

The above figures unveil about the seam strength and efficiency analysis for 40, 60, 80 tex for 271 g/m² blue black 100% cotton twill denim fabric. It is pronounced from the figures that; seam strength and seam efficiency increased with the surging of stitch per inch (SPI) for 271 g/m² blue black 100% cotton twill fabric. More specifically, in case of 271 g/m² blue black 100% cotton twill denim fabric, seam performance changed gradually with different stitch types by increasing SPI. Maximum seam strength and efficiency witnessed for 271 g/m² blue black 100% cotton twill denim fabric upon overlock stitch structure (C) and more specifically four thread overlock stitch structure (486N) with seam efficiency (56%) in comparison with other stitches for 40 tex in cooperation with 12 SPI. Flatlock stitch structure (B) also demonstrates better seam strength (432N) and efficiency (50%) in comparison with others. For 60 tex linear density, maximum seam strength (560N) observed for 12 SPI at 271 g/m² blue black 100% cotton twill denim fabric upon overlock stitch structure (C) with seam efficiency (64%) in comparison with other stitches.

For 80 tex sewing thread count, highest seam strength (586N) and efficiency (68%) noticed for 12 SPI at 271 g/m² blue black 100% cotton twill denim fabric upon overlock stitch structure (C) in contrast to other stitches. For 80 tex, flatlock stitch structure (B) also provides better seam strength (520N) and efficiency (60%) in divergent to other stitch structures. Lockstitch structure (A) with 7 SPI represents less seam strength (326N) and seam efficiency (38%). This is due to the fact that, for lockstitch structure stitch formation occurs only by needle thread and bobbin thread while threads are bound together by interlacing.

3.4 Analysis of Seam Performance for Navy Blue 322 g/m² (GSM) 85% Cotton, 15% Polyester Combination Twill Denim Fabric

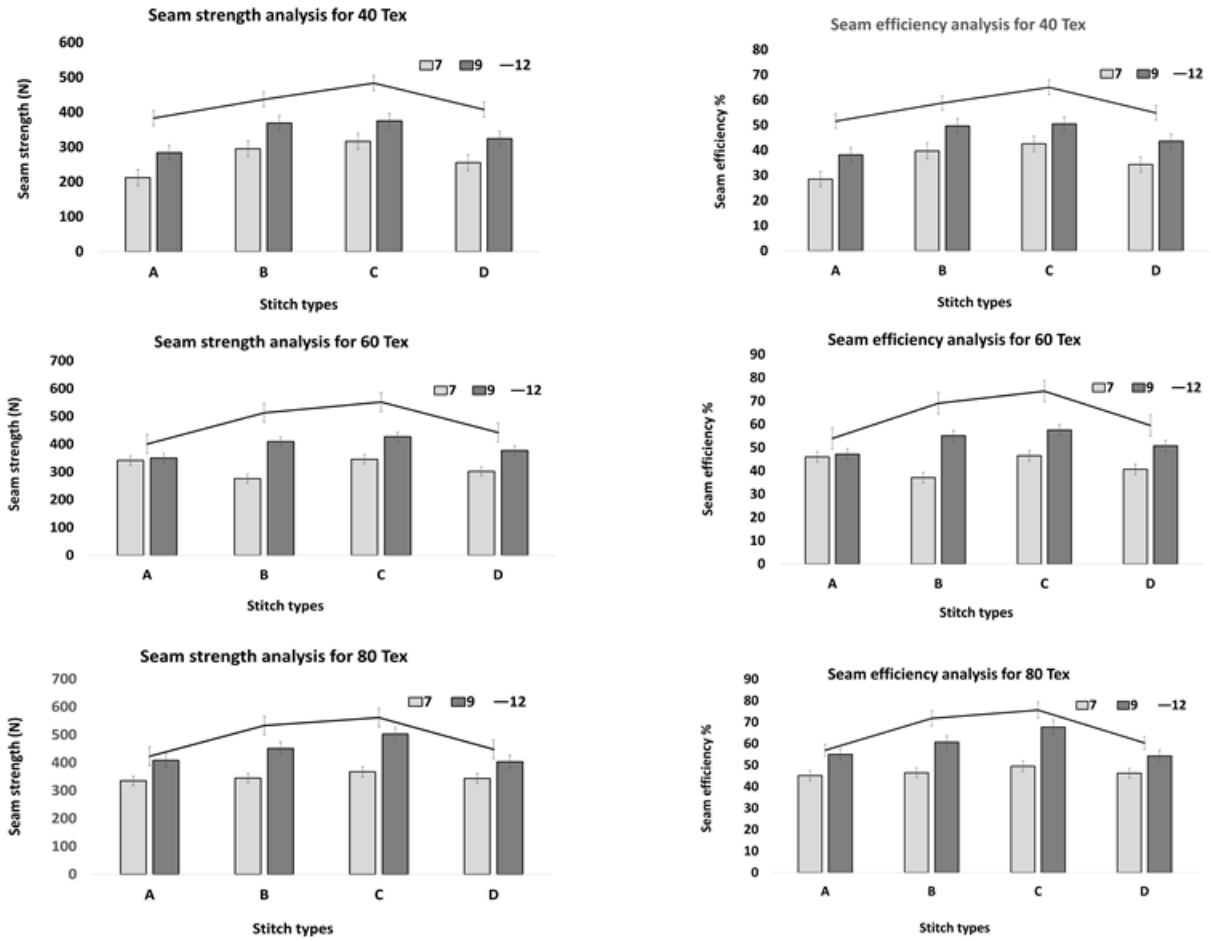

Figure 5: Seam strength and efficiency for 322 g/m² navy blue 85% cotton, 15% polyester combination twill denim fabric in response to 40, 60, 80 tex

The above figures divulge about the seam strength and efficiency analysis for 40, 60, 80 tex at 322 g/m² navy blue 85% cotton, 15% polyester combination twill denim fabric. It is observed from the figures that seam strength along with seam efficiency increased with the surging of stitch per inch (SPI) at 322 g/m² navy blue 85% cotton, 15% polyester combination twill fabric. More specifically in case of 322 g/m² navy blue (85% cotton, 15% polyester) combination twill denim fabric, seam performance changed gradually with different stitch types by increasing SPI. Maximum seam strength and efficiency witnessed for 322 g/m² navy blue (85% cotton, 15% polyester) combination twill denim fabric upon overlock stitch structure (C) and more specifically four thread overlock stitch structure (483N) with seam efficiency (65%) in comparison with other stitches for 40 tex in cooperation with 12 SPI. The reason is that overlock stitch structure encompasses seam while using multiple threads to lock each edge which prevents it from fraying. Flatlock stitch structure (B) also demonstrates better seam strength (437N) and efficiency (59%) in comparison with others. For 60 tex thread count, maximum seam strength (552N) observed for 12 SPI at 322 g/m² navy blue (85% cotton, 15% polyester) combination twill denim fabric upon overlock stitch structure (C) with seam efficiency (74%) in comparison with other stitches. For 80 tex linear density, highest seam strength (562N) and efficiency (76%) noticed for 12 SPI at 322 g/m² navy blue (85% cotton, 15% polyester) combination twill denim fabric upon overlock stitch structure (C) in contrast to other stitches. Lockstitch (A) structure with 7 SPI represents less seam strength (335N) and seam efficiency (45%). This is because, for lockstitch structure stitch formation occurs only by needle thread and bobbin thread while threads are bound together by interlacing not interloping. Technically seam line which contains more stitch density illustrates more seam strength along with seam efficiency due to clutching capacity between two parts of fabrics more tightly.

3.5 Box Plot Analysis for Seam Efficiency

The Box Plot analysis was done with the help of Minitab 18 software. Generally, box plot analysis is used to represent the relationship between different variables.

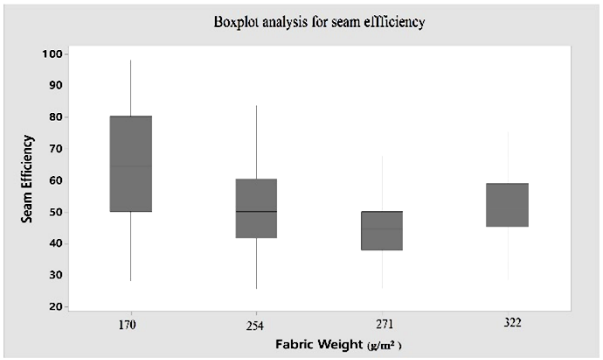

Figure 6: Box Plot analysis of seam efficiency vs. fabric weight

Following figure shows associate consequences on the seam efficiency by changing the weight of fabric. It is observed that 170 g/m^2 fabric exhibits prominent seam performance.

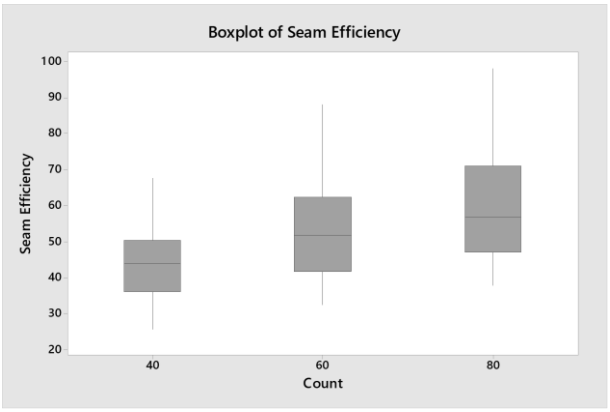

Figure 7: Box Plot analysis of seam efficiency vs. thread count

Figure 7 shows minimum effect on the seam efficiency by changing the sewing thread count. Seam efficiency and thread count is directly proportional. Therefore, by increasing thread count, seam efficiency will also increase and experimentally 80 tex shows better performance than others.

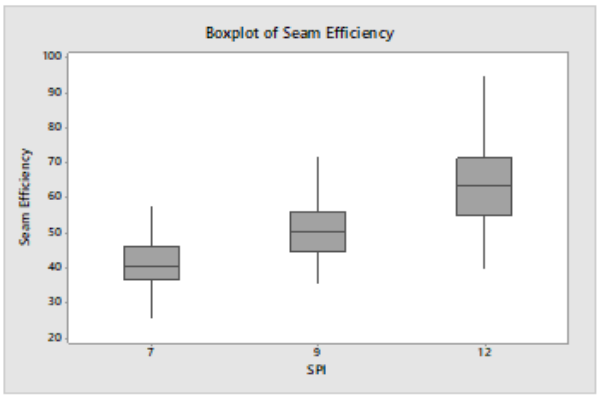

Figure 8: Box Plot analysis of seam efficiency vs. stitch density

Figure 8 shows a noteworthy relationship between seam efficiency and SPI. Seam efficiency and SPI is directly proportional. Thus, by increasing SPI, seam efficiency will also increase and experimentally higher stitch density illustrates substantially better seam performance.

3.6 Sensitivity Analysis for Seam Efficiency

The sensitivity analysis for seam performance specifically seam efficiency was used to determine how target variables are affected by deviations in context with other variables.

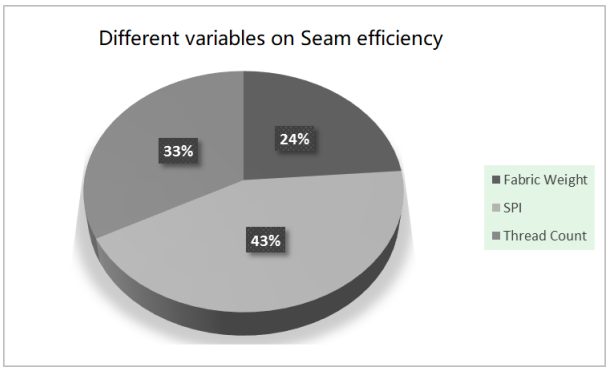

Figure 9: Upshot of different variables on Seam efficiency

Pearson correlation coefficient of fabric weight and seam efficiency = -0.330

Pearson correlation coefficient of SPI and seam efficiency = 0.604

Pearson correlation coefficient of thread count and seam efficiency = 0.455

A negative (inverse) correlation occurs when the correlation coefficient is less than 0. It is an indication that both variables move in the opposite direction. Hence the contribution percentage of fabric weight, SPI and thread count are 24%, 43%, and 33% respectively. The sensitivity analysis showed that seam efficiency has highest dependence on SPI while fabric weight has minimum effect on seam efficiency.

Conclusion

In this research work, four different denim fabrics were used to analyze seam performance in context with seam strength and efficiency. Those kinds of denim fabrics are commercially available around the world more than any other fabrics. Three different types of sewing thread count along with four different types of stitch structures in warp direction and three different stitch density were used to measure the seam strength and efficiency. It has been observed that, seam strength and efficiency increased consecutively while surging the stitch density upon different stitch structures for light indigo 100%

cotton twill, dark indigo (75% cotton, 25%) polyester twill; blue black 100% cotton twill, navy blue (85% cotton, 15% polyester) twill denim fabrics among the stitch density 7, 9 and 12; 7 SPI was recorded as poor quality due to smaller number of stitches present in seam line which results in insufficient seam strength along with efficiency. By increasing the amount of stitch density like 9, 12; for each type of stitch structures like lockstitch, flatlock, overlock, chain stitch; overlock stitch encompasses seam structure utilizing several threads to latch individual edge averting it from fraying successively and for 12 SPI, it demonstrates the superlative performance than other stitch density in case of 80 tex rather than other counts. From this investigation, it is undoubtedly stated that light indigo 170 g/m^2 (GSM) 100% cotton twill denim fabric exhibits highest seam strength and efficiency for 80 tex sewing thread count with overlock stitch structure than others. The box plot analysis and sensitivity analysis both presented that seam performance explicitly seam efficiency has the highest dependence on stitch density than others. Based on the finding of this research, fashion retailers will be cautious about the use of relevant threads and stitches for denim apparel sewing. Such understanding will help consumers and retailers to achieve the best outcome from the finished products based on seam.

Conflict of Interest

The authors have declared no conflict of interest.

Compliance with Ethics Requirements

This article does not contain any studies with human or animal subjects performed by any of the authors.

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