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Impact of Stitch Density and Sewing Thread Ticket Number on Seam Strength in Plain Weave Cotton Woven Fabric

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Abstract
Seam quality is an important factor in determining the durability and performance on the finished garment. As per the established seam quality concepts and theory, this study aims to experimentally investigate the influence of stitch density (SPI) on seam strength in woven cotton fabrics when the stitching is performed using the Industrial single needle lock stitch machine. Two plain-woven cotton fabrics with different structural parameters were stitched using Superimposed Seam (SSa) with spun polyester sewing threads of two linear densities. Stitch densities of 10, 12, and 14 stitches per inch (SPI) were employed. Seam performance was evaluated using standardized tensile testing methods, and statistical analysis was carried out to determine the significance of stitch density on seam behaviour. The results demonstrate that increasing stitch density significantly improves seam strength. The findings confirm the critical role of stitch density in determining seam quality and provide practical guidance for apparel manufacturing and quality control.

Keywords: Seam quality, stitch density, seam strength, Sewing Thread Ticket Number, Woven cotton fabrics, Plain Weave Design, woven garments.

1. Introduction

In garment manufacturing process the two dimensional fabrics are converted into three dimensional ready to wear garments mainly through the process of stitching, and this stitching is the most widely adopted joining method despite the availability of alternative technologies (Kadolph S J 1998; Solinger Jacob 1989). Joining of two pieces of fabric together by stitch is called as seams and these seams serve as important structural element in the garments that holds fabric components together and ensure integrity and durability in the finished garments (Carr H & Latham B 1995).

The performance of the seam is evaluated using both functional and aesthetic criteria of the garments. Functional aspects include seam strength, elasticity, abrasion resistance, and durability under repeated laundering and mechanical stress (Burtonwood D G & Chamberlain J 1989; Glock R E & Kunz G I 1995). Aesthetic aspects of the garments that include seam alignment, smoothness, and uniformity significantly influence consumer perception and garment acceptance (Choudhry A . K. R 2000; Sandow

R & Hixon D 1999). As seams often represent mechanically vulnerable regions in garments, their quality plays a decisive role in product longevity and wearer satisfaction (Laing R M & Webster J 1998).

2. Theoretical Background

Seam quality represents the combined functional and aesthetic performance of a stitched joint in a garment. Theoretical studies describe seam are both positively and negatively impacted by the interactions among fabric mechanical properties, sewing thread characteristics, stitch geometry, and seam construction. Among sewing parameters, stitch density is considered one of the most influential variables affecting seam strength and durability. Higher stitch density increases the number of interlacements per unit length, improving load distribution along the seam line, but may also intensify yarn displacement and seam slippage in loosely structured fabrics.

3. Materials and Methods

The materials used in this experimental investigation are Cotton Fabrics, Spun Polyester Sewing Thread of two variations. In regard to the method, the cotton fabrics are stitched by using Sewing thread using Industrial Single Needle Lock Stitch Sewing Machine (SNLS) using stitch class 301 with a most common seam class – Super Imposed Seam [SSa].

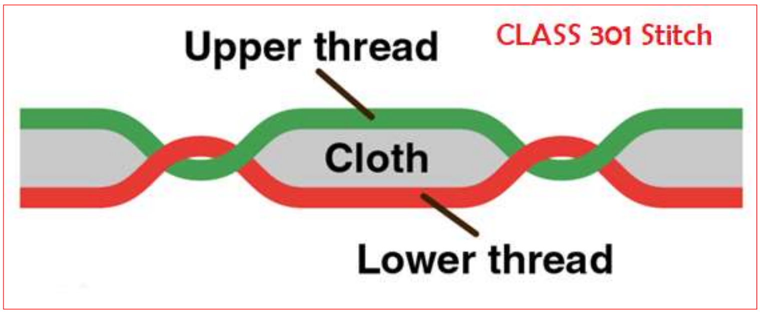


Figure 3.1 – Stitch Class 301

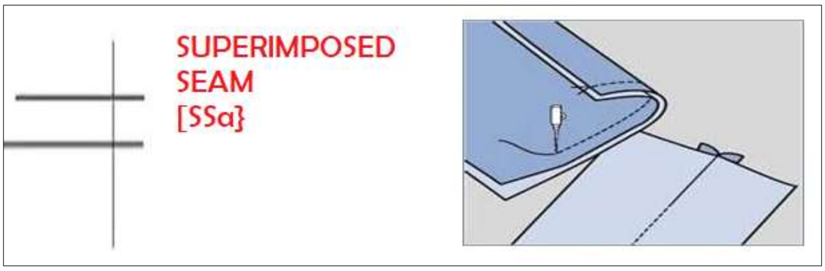


Figure 3.2 – Super Imposed Seam (SSa)

3.1 Fabric Selection

Two plain-woven cotton fabrics, designated CS#01 and CS#02, were selected due to the widespread use of cotton in apparel manufacturing process and as well as due to the Sustainability Fashion requirement. The fabrics differed in yarn density, fabric mass, and tensile strength, allowing comparison of seam behaviour across structural variations.

TABLE I: FABRIC PROPERTIES

Fabric Sample	EPI	PPI	GSM	Strength (lbs)	Weave
CS # 01	60	56	195	21	Plain
CS # 02	60	52	180	18	Plain

3.2 Sewing Threads and Seam Construction

Commercially available spun polyester sewing threads of two linear densities (2-ply and 3-ply) were used. A conventional plain seam (SSa, ISO 4916–1.01) was constructed using a single-needle lockstitch industrial sewing machine. Stitch densities of 10, 12, and 14 stitches per inch were applied.

TABLE II: SPECIFICATIONS OF SELECTED SEWING THREADS

Global Offer Tex No.	Ticket No. (Nm)	Ply	Average Strength		Elongation %
			cN	Grams	
27	120	3	974	993	12 - 19
60	50	2	2,081	2,122	13 - 21

3.3 Evaluation of Seam Quality

Seam quality was assessed in terms of seam strength using standardized tensile testing procedures. Multiple specimens were tested for each sewing condition to ensure reliability. Statistical analysis using analysis of variance (ANOVA) was conducted to determine the significance of stitch density and thread type on seam performance.

4. Results

Seam strength increased consistently with increasing stitch density for both cotton fabrics and both sewing thread types. Specimens sewn at 14 SPI exhibited the highest seam strength, followed by those at 12 SPI, while 10 SPI samples showed the lowest strength. Seams constructed with the finer 3-ply polyester thread generally demonstrated higher strength than those sewn with the coarser 2-ply thread. Statistical analysis confirmed that the effect of stitch density on seam strength was significant ($p < 0.05$).

Table – III – Evaluation of Seam Strength

Fabric Sample	Sewing Thread	Stitch Density (SPI)	Seam Strength in lbs
Fabric Sample (CS#01)	50 Ticket No. 2 PLY Spun Polyester Thread	10 SPI	6.15
			6.09
			6.1
		12 SPI	6.42
			6.45
			6.5
		14 SPI	6.70
			6.74
			6.65

	120 Ticket No. 3 Ply Spun Polyester Thread	10 SPI	6.46
			6.39
			6.41
		12 SPI	6.74
			6.77
			6.83
		14 SPI	7.04
			7.08
			6.98
Fabric Sample (CS# 02)	50 Ticket No. 2 PLY Spun Polyester Thread	10 SPI	5.97
			5.91
			5.92
		12 SPI	6.23
			6.26
			6.31
		14 SPI	6.50
			6.54
			6.45
	120 Ticket No. 3 Ply Spun Polyester Thread	10 SPI	6.26
			6.20
			6.21
		12 SPI	6.54
			6.57
			6.62
		14 SPI	6.82
			6.86
			6.77

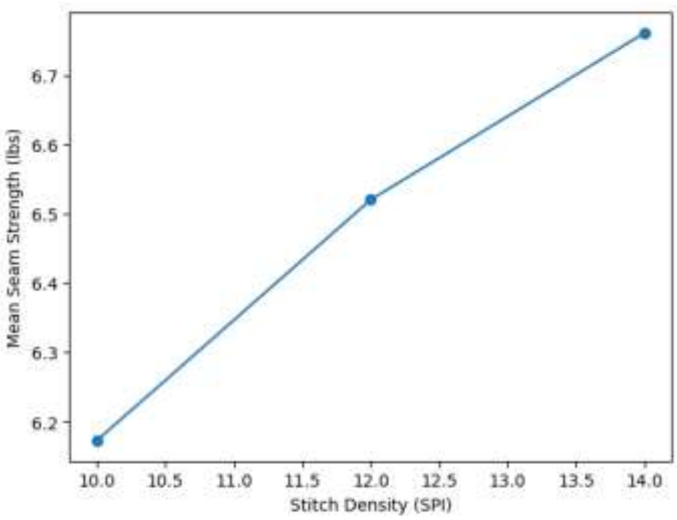


Figure 1: SPI vs. Seam Strength

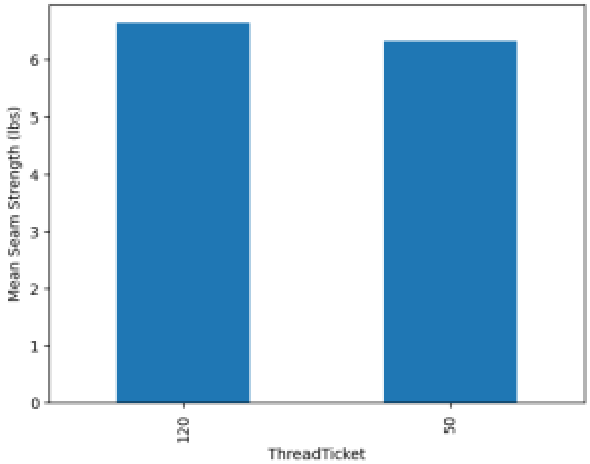
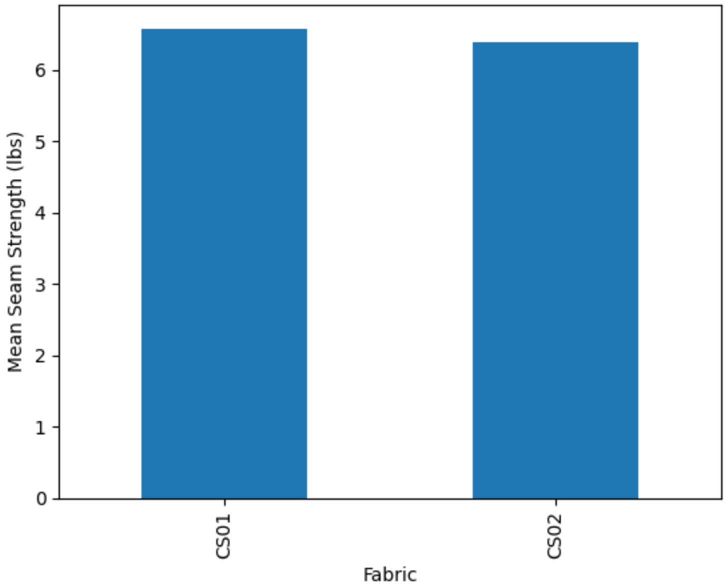


Figure 2: Thread Ticket vs Seam Strength



Fabric Type vs Seam Strength

Based on the dataset, the following independent variables were analysed:

- **Fabric Type (F)**: CS#01, CS#02
- **Sewing Thread Ticket Number (T)**: 50, 120
- **Stitch Density (S)**: 10 SPI, 12 SPI, 14 SPI
- **Response Variable**: Seam Strength (lbs)

A **three-factor factorial ANOVA** with interactions was employed to evaluate the statistical significance of main and interaction effects.

Table – IV – ANOVA for Seam Strength

Source of Variation	Sum of Squares	df	F-value	p-value
Fabric (CS#01 vs CS#02)	0.3520	1	210.88	< 0.001
Thread Ticket Number (50 vs 120)	0.8899	1	533.04	< 0.001
Stitch Density (10, 12, 14 SPI)	2.0996	2	628.82	< 0.001

Fabric × Thread Ticket	0.0005	1	0.33	0.573
Fabric × Stitch Density	0.0006	2	0.18	0.835
Thread Ticket × Stitch Density	0.0014	2	0.41	0.668
Fabric × Thread × Stitch Density	0.0000	2	0.00	0.998
Error	0.0401	24	–	–

4.1. Effect of Fabric Type (CS#01 vs CS#02)

Fabric type shows a **highly significant effect** on seam strength ($F = 210.88$, $p < 0.001$). Across all sewing conditions, **Fabric CS#01 consistently exhibits higher seam strength values than CS#02**.

Interpretation: This indicates that inherent fabric characteristics—such as fabric construction, yarn fineness, weave compactness, or areal density—play a crucial role in seam performance. Fabric CS#01 demonstrates superior seam-holding capacity compared to CS#02, making it more suitable for applications where higher seam strength is critical.

4.2. Effect of Sewing Thread Ticket Number

Thread ticket number is statistically significant ($F = 533.04$, $p < 0.001$) for both fabrics. The 120-ticket (3-ply) spun polyester thread produces higher seam strength than the 50-ticket thread in both CS#01 and CS#02 fabrics.

Interpretation: The improvement in seam strength with the 120-ticket thread is attributed to better tensile characteristics, higher ply structure, and improved stress distribution at the seam line, irrespective of fabric type.

4.3. Effect of Stitch Density

Stitch density is the **most dominant parameter** influencing seam strength (highest F-value = 628.82, $p < 0.001$). For **both CS#01 and CS#02**, seam strength increases progressively from **10 SPI to 14 SPI**.

Interpretation: Higher stitch density increases the number of load-sharing points along the seam, reducing localized stress concentration and improving resistance to seam rupture. This trend is consistent across both fabric samples

4.4. Interaction effect involving Fabric

All interaction effects involving fabric, namely **Fabric × Thread Ticket**, **Fabric × Stitch Density, and Fabric × Thread × Stitch Density**, were found to be statistically non-significant ($p > 0.05$). This indicates that the influence of stitch density on seam strength follows a similar pattern for both fabric samples CS#01 and CS#02, and the improvement in seam strength obtained by using a higher ticket sewing thread is consistent across both fabrics. Although CS#01 exhibits higher absolute seam strength values than CS#02, the direction and magnitude of change in seam strength with respect to stitch density and thread ticket number remain unchanged. The absence of significant interaction effects confirms that the main factors act independently in an additive manner, demonstrating the robustness and stability of the sewing process across different fabric types and reinforcing the reliability of the optimized sewing parameters for broader industrial application.

5. Discussion

The ANOVA results clearly demonstrate that fabric type (CS#01 and CS#02), sewing thread ticket number, and stitch density each exert a statistically significant and independent influence on seam strength. Among these parameters, stitch density emerges as the most dominant factor, reflecting its critical role in enhancing load distribution and seam integrity through an increased number of interlacing points along the seam line. This is followed by sewing thread ticket number, where the use of a higher ticket, multi-ply thread significantly improves seam strength due to superior tensile characteristics and stress-bearing capacity. Fabric type also contributes significantly, with CS#01 consistently exhibiting higher seam strength than CS#02, attributable to inherent differences in fabric structure and mechanical properties. Importantly, the absence of significant interaction effects among the variables indicates that the influence of each parameter remains consistent across different fabric types and sewing conditions, resulting in stable and predictable seam performance. This additive behavior of the main factors confirms the robustness of the sewing process and validates the applicability of the present findings for the optimization and standardization of industrial sewing parameters across comparable fabric systems.

6. Conclusion

This study concludes that seam strength is significantly governed by sewing stitch density, sewing thread ticket number, and fabric type, with stitch density exerting the most pronounced influence, followed by thread characteristics and fabric structure. The experimental results and ANOVA analysis confirm that increasing stitch density and selecting an appropriate higher ticket, multi-ply sewing thread consistently enhance seam performance for both fabric samples CS#01 and CS#02. The absence of significant interaction effects among the variables demonstrates the robustness and predictability of the sewing process, indicating that the individual effects of sewing parameters remain stable across different fabric types. These findings provide a reliable scientific basis for optimizing sewing conditions in industrial garment manufacturing, enabling improved seam durability, process consistency, and product quality across comparable textile materials.

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