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Effect of stitch per inch (SPI) and yarn count on seam strength of twill fabric

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Abstract

Stitch per inch (SPI) and seam strength are complex as well as important parameters in garments production. This study concern with thread count and stitch density's effect on seam strength along with non-stretch and stretch twill fabric. We also find seam efficiency and seam strength factor through this work. Breaking force as well as breaking elongation of fabric were counted by grab method and fabric strength test performed by titan (version 3) by following ISO 13934-2. For seam testing, the fabric samples used sewed by seam stitch type 301 with stitch densities SPI 8, 10 and 12 respectively. Test of seam strength performed by Titan (version 3) according to ISO 13035-2 with grab method. It is observed that SPI and thread count have significant effect on strength of seam.

Keywords: Seam, twill fabric, strength, stich density, thread count.

Introduction

Actually stitches are used to join the different parts of a garments as well as seam line determine the model of the garments. Quality of the final garments depend on seam quality[1]. The seam strength characteristic can influence the properties of seam and deformation properties also affect by it. During manufacturing sewed seam as well as fabric pass through different load. Seam strength and fabric strength should maintain a proper combination for gaining uniformity because the product face different force when wear. During wearing, the garment should maintain a capability to resist these forces. Seam elasticity should be more than the fabric elasticity to get the better service. Safety of seam capitally depend on width of sewing, fabric yarn slippage and on sewing thread count and stitch per inch (SPI). For confirming better quality of the final garments it is very important to make a good combination of these parameters. Due to lack of knowledge about the impact of each parameter we are unable to choose the appropriate parameter. Here we show an experimental work targeted on find the effect of stitch per inch (SPI) and yarn count on seam strength of twill fabric.

Objectives: The seam enhances durability and stability of the garments. The apparel manufacturers have established standards for developing a product and these standards are based on customer's choice. Hence the prime objective is to match the seam strength according to serviceability of the garments. Other objectives are as below: i. Determination of the strength and efficiency of seam. ii. Determination of fabric strength. iii. Define relation between stitch per inch (SPI) and thread count. iv. Identification of the factors affecting the seam strength. v. Define thread breaking force. vi. Determination of seam strength factor.

Literature review: Many researchers showed relation between seam strength with changing parameters such as material type, thread type and count, type of seam, type of stitch and stitch density etc[2-8]. This research work was done to determine seam strength on non-stretch and stretch twill fabric with various yarn count changing stitch per inch. We also found data of seam efficiency and seam strength factor. Akter M. and Khan M.R. focused on stitch types-stitch class 300, stitch class 400 effect on seam strength[9]. Daniela Barbulov et al, experimented on density of stitch effect on seam strength for various composition inthread[10]. Glock R.E. and Kunz G.I. analyzed product produced by sewing and its serviceability[11]. Brown P.K. and Rice J. investigated sewn product and its criteria of parameters[12]. Gribaa S. et al, researched with influence of sewing parameters on tensile strength of seam[13]. J. Stepanovic Characteristic and comparison on single and double twisted yarn[14].

Materials and methods

Fabric selection: Two types of twill fabric were selected one is stretch and another is non-stretch fabric. The details of the fabric is mentioned below Table-1.

Thread selection: For investigating sewing thread effect on strength of seam of fabric various count were selected. Four polyester threads with different count with three different stich per inch were selected for construction of seam. In garment industry these thread counts are mostly used. The construction of the threads were different. These threads are 27(40/2), 60(20/3), 80(20/2) and 105(20/4) Tex in count.

Sewing machine selection: Single needle lockstitch machine-Industrial lock stitch machine was used.

Table-1: Specification of fabric.

Fiber	100% Cotton	72% Cotton, 17% Polyester, 9% Rayon and 2% Spandex
Warp count	20	16
Weft count	16	16+70D
Ends per inch	136	130
Picks per inch	60	42
Weight	7.25 Oz	8 Oz
Fabric type	3×1 Left hand twill	
Sample size	20cm×20cm	

Seam selection: The most common superimposed single needle lockstitch class 301 was selected for this study.

Sewing parameter: Stitch per inch are 8, 10 and 12 were selected.

Needle selection: Needle size 16 was used.

Tensile strength tester: James Heal tensile strength tester machine (model 710 Titan) was used for measuring the seam strength and efficiency.

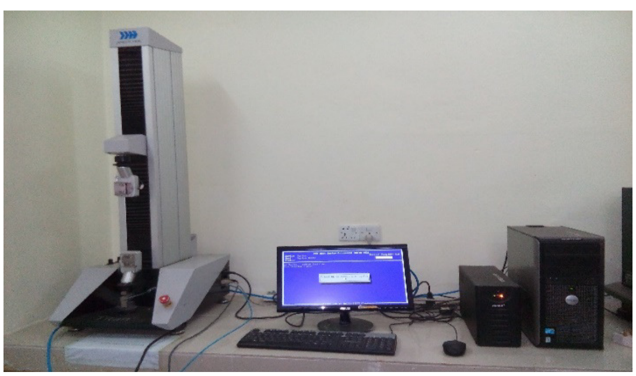


Figure-1: James Heal tensile strength tester machine.

Along with the mentioned components some other components were also used. These are scissor, scale, chalk etc.

Test specimen preparation: For testing seam strength, the test specimen were prepared according to below:

By following ASTM method the samples were prepared. It is possible to measure seam strength and efficiency of seam assembly of any fabric by this method. From both twill fabric about 60 samples were taken by avoiding the selvedge side. The fabrics were taken from warp direction (parallel to selvedge)to dimensions of 20cm×20cm. According to specimen size the specimens were cut from the samples. Then the fabrics were fold to 6cm from one end and sewing was according to direction of warp with a significant seam allowance with different count of threads changing stitch density.

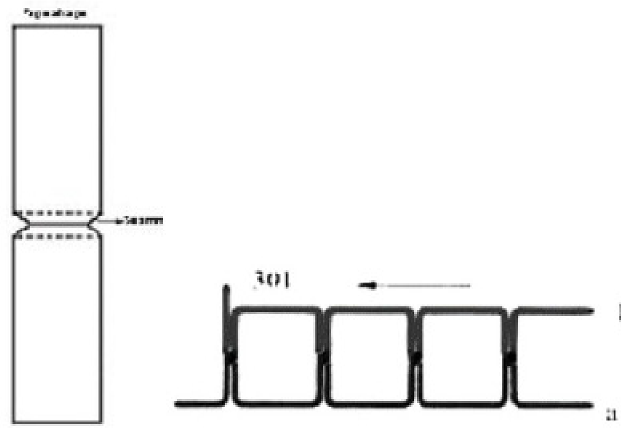


Figure-2: Sketch of sample with machine lockstitch.

The stitch density was determined by counting the stitches per inch. After seaming, as per method five samples were prepared for each test. Each test specimen was hold about100mm seam from one side. Along with each test specimen was contained sufficient dimension for one fabric and seamed test. Then seam strength was tested using Grab Method. For testing the following parameters were set according to method.
Load range: 3000N Maximum
Extension rate/Machine speed: 50mm/min
Number of specimen: 03/slot
Jaw: Plain faces

The specimen along with fabric was setin the open front position of the clamp. The seam line located centrally between the clamp faces and the pulling force was perpendicular to it. After that marked the highest force required for breaking seam parallel to stretch direction. Special care was taken to confirm that the seam fail for break but not for tear. At the seam line a seam was ruptured for sewing thread breakage. After that mean of marked highest forces for rupture of seam was calculated for each fabric's samples.

For tensile strength-perform ISO 13934-2 (use plain rubber face jaw for gripping): No of specimen-5 for warp and 5 for weft, Reporting unit-Newton, Specimen size-200mm (warp)× 100mm(weft)-when warp, 200mm (weft)×100mm(warp)-when weft, Avoided 150mm from selvedge. Specimen was selected diagonally. Avoided crease mark.

For seam strength-perform ISO 13935-2(use plain rubber face jaw for gripping): No of specimen-5 for warp and 5 for weft, Reporting unit-Newton, Specimen size-200mm (warp) × 100mm (weft)-when warp, 200mm (weft) × 100mm (warp)-when weft, Avoided 150mm from selvedge. Specimen was selected diagonally. Avoided crease mark. Folded specimen at midway and stitch 20mm away from fold line. Excess fabric was cut above 12mm from seam line.

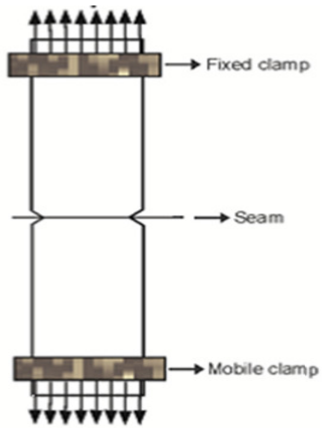


Figure-3: Sample on dynamometer.

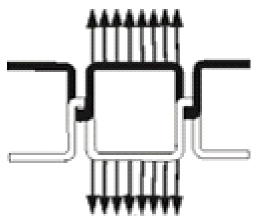


Figure-4: Application of stress in a stitch.

Data analysis: Evaluated results were recorded for each of the test identified for stitched and non-stitched specimens. The count of spun sewing threads was adjusted from 27 Tex, 60 Tex, 80 Tex and 105 Tex. The investigation was carried out upon anon-stretch twill weave fabric with the 136x60/20x16-100% cotton and as well as stretch twill fabric with the 130x42/16x16+70D-72% cotton, 17% polyester, 9% rayon and 2% spandex.

Seam efficiency: Sean efficiency calculated by the following formula:

$$\text{Seam efficiency \%} = \frac{\text{Seam strength X 100\%}}{\text{Fabric strength}}$$

Seam strength factor: Mentioned equation was used for calculation[10].

$F_k = F_p X\, G_u$

Where, F_k – Factor of seam strength (Ncm^{-1}), F_p–Breaking force thread (N), G_u–Density of stitch (cm^{-1}).

Results and discussion

Table-1 presents the result of experiment on non-stretch twill, while Table-2 presents the result of experiment on stretch twill.

The result on Table-1 shows that with increasing SPI seam strength and efficiency are also increasing. Seam strength and seam efficiency are also increasing with higher thread count in Tex. Fabric strength for non-stretch fabric (100% cotton) is 598.2N. Normally we find seam strength and efficiency is increased more in 10 SPI to 12 SPI than 8 SPI to 10 SPI.

Table-1: Experiment on non-stretch twill fabric.

Fabric Composition	Thread count	SPI	Seam Strength (N)	Fabric strength(N)	Seam efficiency (%)
100% Cotton	Tex-27(40/2)	8	100.6	598.2	16.82
Fabric Details		10	135.7		22.68
Normal Twill, 7.25 oz (136x60/ 20x16)×62"		12	139.6		23.34
	Tex-60(20/2)	8	169.6		28.35
		10	190		31.76
		12	207.4		34.67
	Tex-80(20/3)	8	198.17		33.13
		10	243.2		40.66
		12	246.6		41.22
	Tex-105(20/4)	8	220		36.78
		10	262.3		43.85
		12	266.9		44.62

The result on Table-2 shows that with increasing SPI and yarn count the seam strength and efficiency are increasing in case of stretch fabric also. Fabric strength for this stretch fabric is 518.9N.

Results found through this analysis is presented by Figure-1. Here Tex-60(20/2) and Tex-80(20/3) are presented for comparison.

Figure-2 shows that the seam strength is proportional to SPI, yarn count in Tex. Non-stretch fabric strength is more than stretch fabric in this research for the fabric we used. But seam strength and seam efficiency are more in stretch fabric than non-stretch fabric.

Efficiency of seam are more in stretch fabric than non-stretch fabric. But we find strength and efficiency of seam are increased more in 10 SPI to 12 SPI than 8 SPI to 10 SPI.

Seams breaking characteristics are influenced by stitch density and breaking force of used thread. Seam strength factor also introduced. Considering breaking forces of seam and construction of fabric and condition of thread in the seam (due to the stress), introducing breaking forces of sewed seams is important.

Breaking force of polyester thread as below: (1 centinewton; 1cN=0.01N and for SPI 1inch=2.54cm), Tex 27(40/2) - 980 cN=9.8N, Tex 60(20/2) - 2100 cN=21N, Tex 80(20/3) - 3300 cN=33N and Tex 105(20/4)- 4600 cN=46 N.

Table-2: Experiment on stretch twill fabric

Fabric Composition	Thread count	SPI	Seam strength (N)	Fabric strength (N)	Seam efficiency (%)
72% Cotton, 17% Polyester, 9% Rayon and 2% Spandex	Tex-27(40/2)	8	222.1	518.9	42.80
		10	312.2		60.17
Fabric details		12	328.9		63.38
	Tex-60(20/2)	8	224.3		43.23
		10	318.5		61.38
		12	337		64.95
	Tex-80(20/3)	8	402.2		77.51
Stretch twill, 8 oz (130x42/ 16x16+70D)×53"		10	449		86.67
		12	484.3		93.33
	Tex-105(20/4)	8	451.3		86.97
		10	490.6		94.55
		12	498.7		96.11

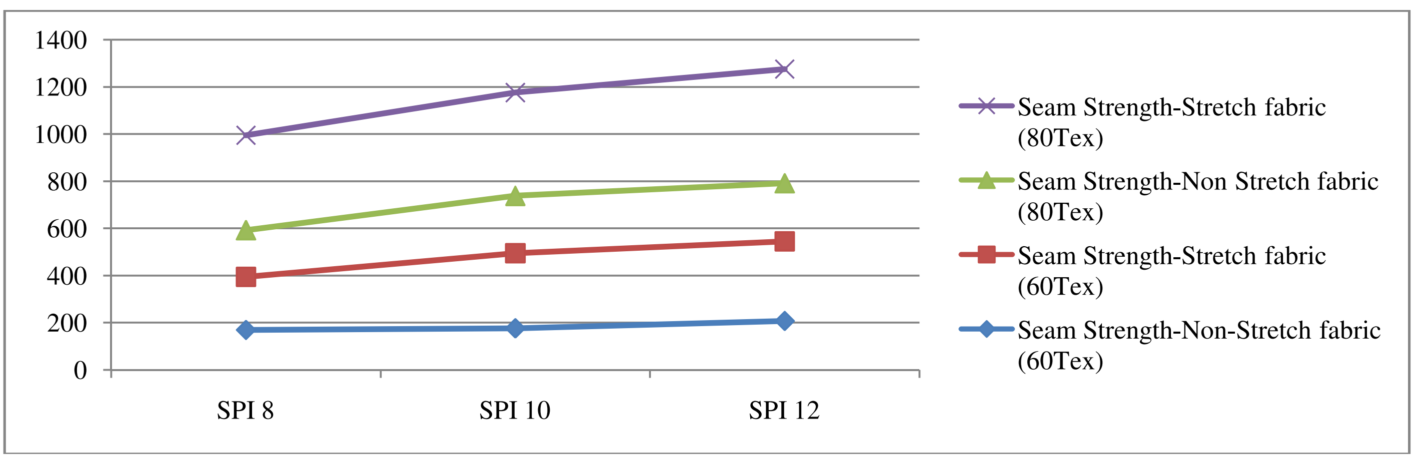


Figure-1: Seam strength comparing SPI, sewing thread count and fabric type.

Experiment shows the upper the stitch density upper the strength factor of seam and breaking strength of thread is increased due to increase in thread count in Tex.

We have found the increasing in seam strength factor according to increase in seam strength though seam strength factor is not directly dependent on seam strength.

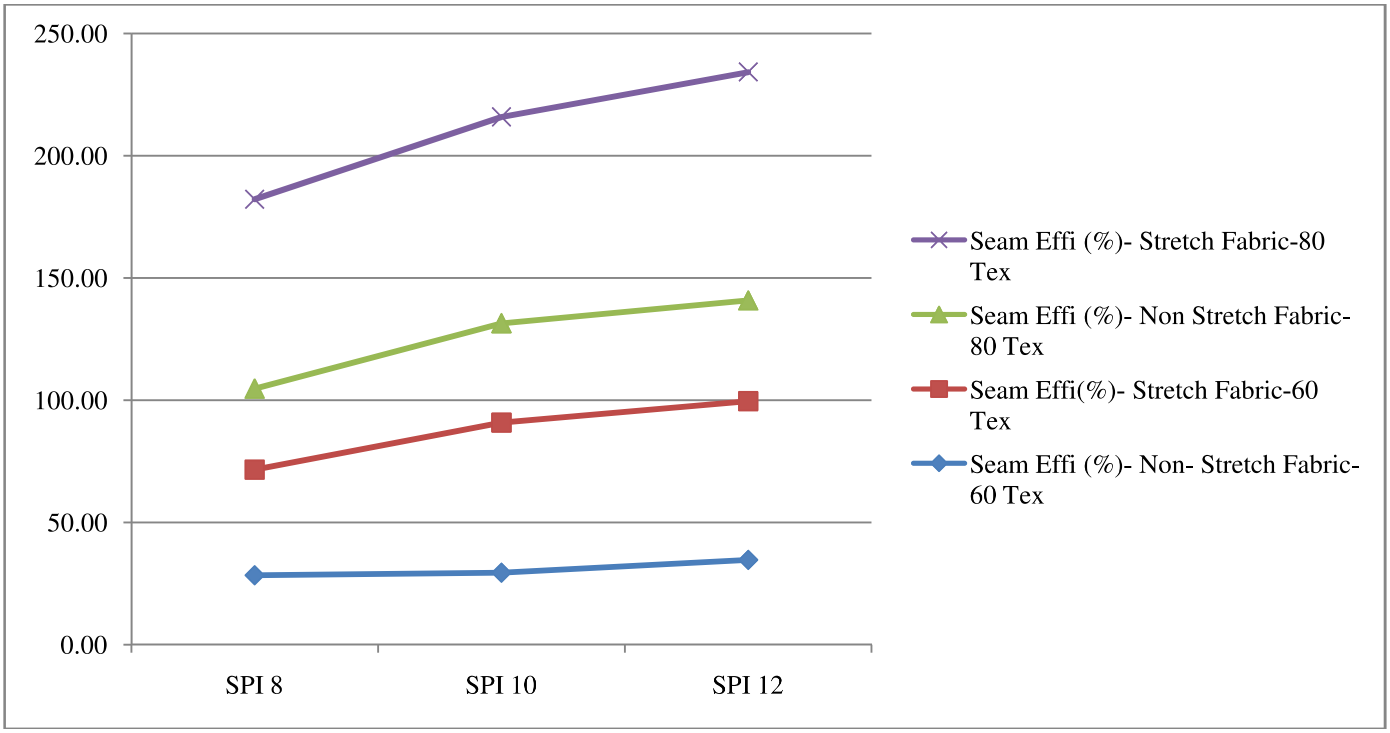


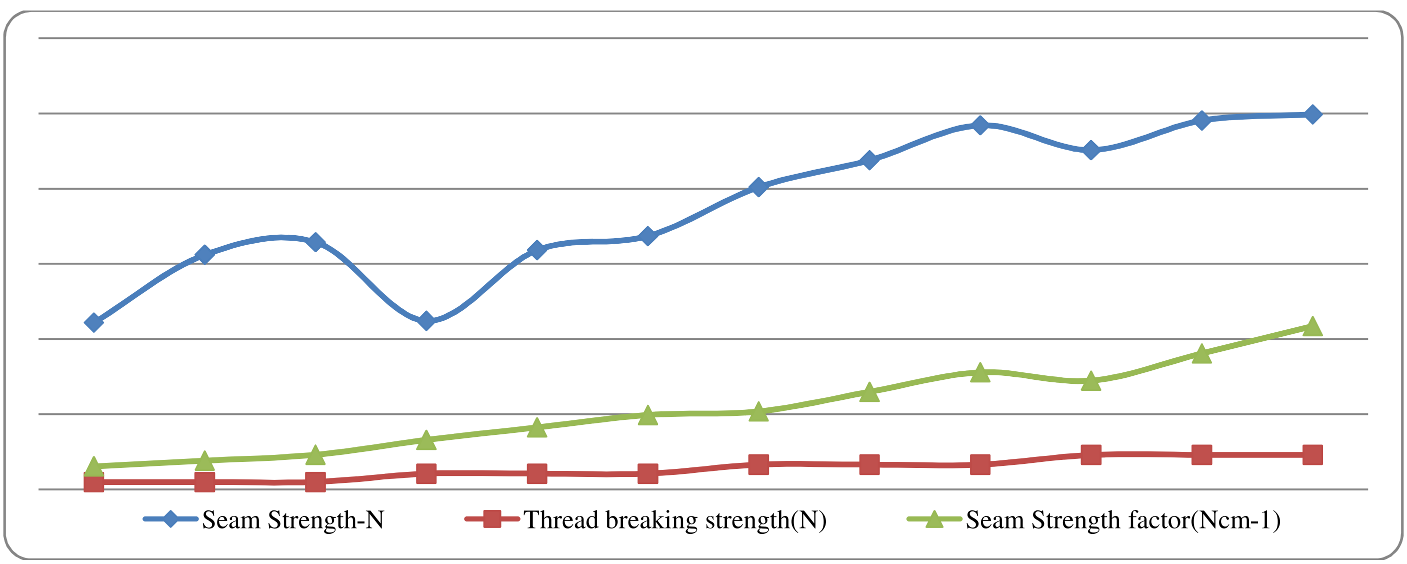
Figure-2: Seam efficiency comparing SPI, count of sewing thread and fabric.

Table-3: Experiment on thread.

Thread composition	Thread count	Stich/cm^{-1}	Thread breaking strength(N)	Seam strength factor (Ncm^{-1})
100% Polyester	Tex-27(40/2)	3.15	9.8	30.87
		3.94	9.8	38.58
		4.72	9.8	46.30
	Tex-60(20/2)	3.15	21	66.14
		3.94	21	82.68
		4.72	21	99.21
	Tex-80(20/3)	3.15	33	103.94
		3.94	33	129.92
		4.72	33	155.91
	Tex-105(20/4)	3.15	46	144.88
		3.94	46	181.10
		4.72	46	217.32

Table-4: Seam strength factor determination.

Thread Composition	Thread count	Stich density(cm^{-1})	Seam strength-N	Thread breaking strength (N)	Seam strength factor (Ncm-1)
100% Polyester	Tex-27(40/2)	3.15	222.1	9.8	30.87
Fabric Composition		3.94	312.2	9.8	38.58
72% Cotton, 17% Polyester, 9% Rayon and 2% Spandex Stretch twill, 8 oz (130x42/16x16 + 70D)×53"		4.72	328.9	9.8	46.30
	Tex-60(20/2)	3.15	224.3	21	66.14
		3.94	318.5	21	82.68
		4.72	337	21	99.21
	Tex-80(20/3)	3.15	402.2	33	103.94
		3.94	449	33	129.92
		4.72	484.3	33	155.91
	Tex-105(20/4)	3.15	451.3	46	144.88
		3.94	490.6	46	181.10
		4.72	498.7	46	217.32



Stitch/cm increased →

Figure-3: Seam strength factor analysis.

Graph showed seam strength factor is increasing with stitch/cm. Also we see with increasing of stitch density value increase the strength of seam and thread breaking strength.

From the above discussion the findings are as follows: i. Seam strength increased due to increase of SPI. ii. Seam strength increased due to increase of thread count (Tex). iii. For the high tensile strength of fabric, seam strength should be high accordingly. iv. Seam efficiency increased with increased of SPI, v. Seam efficiency increased due to increase of thread count. vi. Seam efficiency increased due to increase of strength of fabric and seam. vii. Thread breaking strength increased because of thread count (Tex) increased. viii. Seam strength factor is increased due to increase of thread breaking strength. ix. We find seam strength and efficiency is increased more in 10 SPI to 12 SPI than 8 SPI to 10 SPI.

Conclusion

Seam strength rely on sewing, fabric, thread, yarn and fiber parameters. Strong relationship already developed in the above experiment. From the study it is possible to predict the breaking force of seam for mentioned thread varying from 8 to 12 SPI. Seam quality is also influenced by numerous parameters such as material type, thread type and count, type of seam, type of stitch and stitch density etc. It is possible to conduct more study by correlating these parameters. This report will be very beneficial for the persons who are associated with garments manufacturing by developing productivity and seam quality.

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