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The effect of stitch types and sewing thread types on seam strength for cotton apparel

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Abstract— The purpose and objective of this study is to investigate and scrutinize the impact of sewing thread types and stitch types on seam strength and efficiency of superimposed seam for cotton apparel. An experimental design was employed for the study which included four types of thread and two stitch classes for cotton apparel. The performance properties investigated were seam strength and efficiency. The seam strength and efficiency of the fabric were determined using the tensile testing machine (Tinius Olsen).Seam strength have been measured and analyzed both in warp and weft directions.. Mean and inferential statistics (Analysis of Variance at 0.05 alpha levels) were used for the analyses of the data. The results in this study revealed that differences existed between the four thread types with regard to seam strength and efficiency. Polyester-wrapped threads with a polyester filament core thread shows better seam strength and seam efficiency in all stitch types involving in this study. The study has also brought to light the behavior of seams in the different stitch and threads of cotton fabric.The statistical analysis showed that the significant and positive impact of the stitch types and thread types on the seam strength and efficiency. Finally this work will therefore help manufacturers of apparels to know the suitable thread type on the market to decide on and stitch types that would help to achieve quality seams to meet consumers' desire in terms of seams.

Index Terms— Apparel, Cotton fabric, Experimental design, Statistical analysis, Seam Strength, Seam efficiency, Quality.

1 INTRODUCTION

Stitches and seams are two important basic constituent of structure of apparel product. Stitches are used to join the apparel component together and seams give the shape of the apparel for wear. These two factors together with their performance properties add to the quality of the apparel. Seam will interrelate with the components of the fabric to ensure the best product stability. The quality of apparel depends on two factors: physical and performance features [1]. The physical features are inclined by the tools and methods used to accumulate the apparel. The visual and functional requirements of the apparel are mainly contingent with the performance features. Visual requirements are grounded on patterns, design, colors, trends and accessories. The functional requirements are more associated to the durability of the apparel end use. The Seam enhances serviceability and durability for functional performance of the fabric. Both the functional and aesthetic performance of an apparel product in terms of durability and stability are affected by seam strength.The apparel manufacturers have established standards as a guideline for the product development and these standards are based on customers' preferences [2].Tensile strength and seaming properties are the key performance indicators for giving surety that the final apparel is fit or not for the end use at that time [3].

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Quality seams in apparel contribute to the overall performance of the apparel in use. Poor quality seam makes apparel unusable even though the fabric may be in good condition. "If a product bought has a deficiency, it cannot be used and poor quality of seams is a deficiency mostly encountered in the life of sewn garments. "[5]

The characteristics of a properly constructed sewn seam are strength, elasticity, durability, security and appearance. These characteristics must be balanced with the properties of the material to be joined to form the optimum sewn seam [6]. Other factors also influence to accomplish of these characteristics in a properly constructed sewn seam. Such factors include type and weight of fabric, seam type, type of needle, thread type and size, and stitches per inch [3].

The apparel manufacturer is concerned with the characteristics of the fabric and emphasis on the seam quality during production of apparel. Alternatively, consumers are mainly considering appearance, comfort, wear ability and assess seam quality based on the seam appearance.Once a fabric has been selected and cut for a particular apparel item, the next thing is to shape the flat fabric pieces to the desired three-dimensional form. Seams, darts, and dart equivalents are the means used to create that third dimension [7].

The length of life of a seam in a garment should be as long as that of the other materials and both should be appropriate to

International Journal of Scientific & Engineering Research, Volume 6, Issue 7, July-2015
ISSN 2229-5518

the required end use of the garment [8]. For manufacturers to be able to select appropriate thread types and stitch densities to achieve quality in seams, conditions are exposed to during use must also be examined. Seam performances are dependent on the quality of sewing threads and their behavior. The type of thread used in stitching, its construction, size and finishing influence the seam strength of apparel [9].

The determination of the best stitch type, seam structure and thread type which should be used for particular apparel requires a thorough knowledge of many variables. The inappropriate choice of any one element can cause in failure of the sewn seam and finally failure of the finishing product [6].

From above discussion it is clear that seam is very much important for finished product stability. In Bangladesh, clothes are usually made by tradition and there are variations in the stitch types employed by various apparel manufacturers. There is a point that there are wide-ranging varieties of threads on the market. Initial investigations made revealed that some of the apparel manufacturers select stitch types and sewing threads without giving consideration to their impact on the overall performance of the apparel being made, in effect resulting in failure of the seam during use and care.

A seam is the application of a series of stitches or stitch types to one or several thickness of material .Seam line is a stitch line of a seam; it is usually parallel to and always an appearance of the seams affects overall attractiveness of a garment. Straight, neat, smooth, even seams that are not twisted, ropey, or rippled contribute to aesthetics [10].

"Seam strength is an important factor in determining the durability of a garment"[11]. Strength is known as one of the tensile properties of textile materials. It refers to the strength when a seam finally ruptures or when the fabric breaks.

This is measured by using the following equation:

$Ss = K \times Sb$

Where:
Ss= sewn seam strength (N)
K= a Constant equal to 1000 for SI units
Sb= observed seam breaking force (N).
Seam efficiency which is the ratio of seam strength to fabric strength of the fabrics sewn. In general, it ranges between 85% and 90%, which can be optimized through various factors, such as seam type, type and density of stitches, and the selection of sewing threads and needles. [13]To calculate seam efficiency using below formula: $E = 100\ Ss/Fb$

Where:
E = seam efficiency, %,
Ss= sewn seam strength, N (lbf), and Fb= fabric breaking force, N (lbf).
Seam performance of PET/Nylon-elastane woven fabrics was studied by Gurarda (Gurarda 2008). To investigate the impact of laundering on the seam strength of suiting materials was done by Mukhopadhyay and Sikka 2004.Here different values of stitch density and different sewing thread types and fabric were used .There are lots of notable and distinguished dissertations which have been done on seam performance**.** But no study has been done on seam performance properties on cotton fabrics on various stitch types and sewing thread types.

The following specific objectives will be addressed in this study:

1. To investigate the performance of seams constructed with different sewing threads.
2. Determine the effect of various stitches on seam strength.
3. Find out which sewing thread produces better seam strength and seam efficiency.
4. Determine the significant level of impact of stitch types & sewing thread types on seam Strength and efficiency using data analysis.

There are limited notable and distinguished dissertations which have been done on seam strength. But I believe my work will open a new window in apparel industry. This study will therefore help producers of apparels to know the appropriate thread type on the market to choose and stitch types that would help to achieve quality seams to meet consumers' desire in terms of seam.

2 MATERIALS AND METHODS:

2.1 Seam selection:

The most common superimposed seam was selected for this study.

2.2 Thread selection:

In order to investigate the effect of different sewing threads on seam strength, four different threads were used for the seam constructions. These threads are commonly used in the apparel industry. These threads are different in terms of fiber compositions and constructions. These threads consist of:

Table 1: Thread construction

Thread ID	Substrate	Tex
T1	100% staple spun polyester thread	27
T2	Polyester core spun with cotton wrap	30
T3	100% Cotton	30
T4	Polyester-wrapped thread with a polyester filament core	30

International Journal of Scientific & Engineering Research, Volume 6, Issue 7, July-2015
ISSN 2229-5518

2.3 Fabric selection and testing

Here one fabric was collected for this study collected from Bangladeshi local market.

Table 2: Fabric construction

Fabric ID	Fabric type	Fabric Weight (g/m^2)	Yarn count		Fabric count	
			warp	weft	EPI	PPI
Plain woven fabric	100%Cotton	144	27	30	99	59

2.4 Selection of sewing Parameters:

The fabrics were sewn with different stitch types based on the feasibility of the fabric.

ASTMD 1683 – 04 method assert that if fabric mass up to 270 g/m2 then Stitch density should be (4.7±1⁄2) stitches per centimeter or (12 ±1⁄2 stitches per inch) and Needle Size should be Metric 90 as Standard for seam preparation for seam strength test .From the table 2 it was observe that cotton fabrics weight were below 270 (g/m^2) that's why Stitch density 12 and Needle size Metric 90 were selected for seam preparation.

2.5 Selection of stitch types:

Among the Six classes of stitch, two stitch classes were chosen for this study. Two types of stitch were selected from each class they are:

- Stitch Class 300 lockstitch (301 and 304)
- Stitch Class 400 Multi thread chain stitch (401 and 406)

2.6 Seam strength: preparation

For seam strength, the fabrics were prepared according to Method **ASTM D 1683 – 04**

Standard Test Method for Failure in Sewn Seams of Woven Apparel Fabrics. [14]

This test method can be used to determine the sewn seam strength of textiles or the efficiency of a seam assembly with any given fabric.

- ✓ About 160 samples were obtained by randomly cutting for cotton fabric. Fabrics were cut to dimensions of 350 mm (14 in.) by 100 mm (4 in.) with their long dimensions parallel both warp (machine) direction and filling (cross) direction.
- ✓ Specimens are cut from samples to achieve specimen size.
- ✓ Then the fabric was fold 100 mm from one end and then sewn in both warp and filling direction with a seam allowance of 20 mm with different types of threads.
- ✓ The stitch density was determined by counting the stitches per inch.
- ✓ After seaming, from 20 mm the fold was cut by 8 mm for opening. As per method five samples were prepared for each test.
- ✓ The test specimen was contain a seam approximately 100 mm (4 in.) from one end and each test specimen will contain sufficient material for one seamed and one fabric test.
- ✓ Seam strength was tested using the **Tinius Olsen tester** according to method **ASTM D1683 – 04.**
- ✓ As per method the following parameters were set for testing.
  - Load Range : 1124 lbf
  - Extension Range : 39.37 in
  - Test Speed : 12.00 in/min
  - Pre load : 1.00 lbf
  - Jaw separation : 75 mm
- ✓ With the fabric in the open front position the specimen into the clamp with the seam line centrally located between the clamp faces and perpendicular to the pulling force.
- ✓ Maximum force needed to break the seam perpendicular to the direction of extension was recorded. Observation was made in order to make sure that the seam failure is due to break not due to fabric tears. A seam was rupture at the seam line due to sewing thread breakage.
- ✓ The mean of the recorded maximum forces for seams to rupture for all samples of one fabric was calculated.

2.7 Sewing Machine selection:

Table 3: Sewing machine selection

Machine Name	stitch type
Industrial lock stitch m/c	301
Industrial zigzag lock stitch m/c	304
Single needle chain stitch m/c	401
Flat lock machine	406

2.8 Data Analysis:

Evaluations result was recorded for each of the tests identified for stitched and unstitched specimens. The statistical mean was used in the analysis of the data collected was the **S**oftware **P**ackage for the **S**ocial **S**ciences (SPSS) for Windows version 20. Analysis of Variance(One-way) at 0.05 alpha levels) were employed in testing the hypotheses since they are measures used in measuring differences, and the purpose of this study was to establish if any difference existed between and among

International Journal of Scientific & Engineering Research, Volume 6, Issue 7, July-2015
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the stitch types of same class and thread types which was involved in the study.

3 Result And Discussion:

3.1 Seam Strength for Stitch class 300:

Seam Strength for Cotton fabric in both warp and filling directions is shown in
Table 4 presented for Stitch class 300 (type 301 and 304).
Overall, All stitch has higher seam strength in warp direction compared to filling direction.T4 thread shows better seam strength in both types of stitch which is made from Polyester-wrapped thread with a polyester filament core thread. T2 thread also shows better strength than T1 and T3.Multiple Bar diagram (Fig 1) also shown on below table. These findings approve the common accepted idea that the warp direction of fabrics is stronger than the weft, and weft threads stretch more than warp threads.
Stitch type 301 shows better strength compared to stitch type 304.

Table 4: Seam strength test result for Stitch class 300

AVERAGE SEAM STRENGTH								
	WARP (lbf)				FILLING (lbf)			
Thread/ Stitch	T1	T2	T3	T4	T1	T2	T3	T4
301	29.51	32.44	27.37	37.59	26.51	30.39	26.59	33.13
304	27.37	28.68	24.68	33.73	25.71	22.91	22.17	32.99

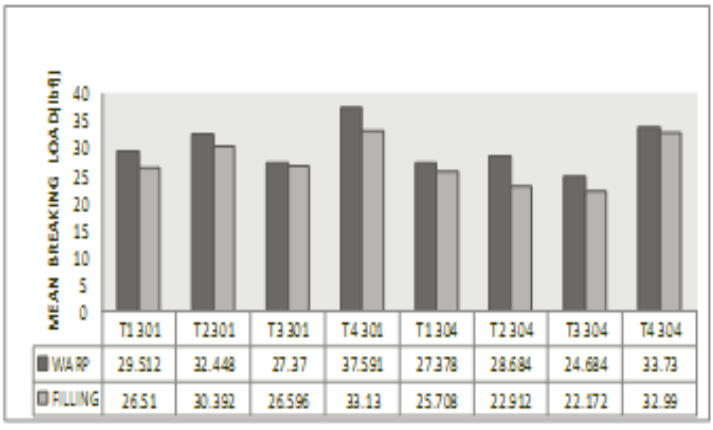

Fig 1: Average Seam Strength for stitch class 300

3.2 Seam Efficiency for Stitch class 300:

Seam Efficiency for Cotton fabric in both warp and filling directions is shown in Table 5 for Stitch class 300 (type 301 and 304).Overall, All stitch has higher seam efficiency in warp direction compared to filling direction.T4 thread shows better seam Efficiency in both types of stitch which is made from Polyester-wrapped thread with a polyester filament core thread. T3 thread also shows lowest efficiency than T1 and T2. Multiple Bar diagram (Fig 2) also shown on below table.
Stitch type 301 shows better Efficiency compared to stitch type 304 in both warp and filling directions is shown in below table.

Table 5: Seam Efficiency test result for Stitch class 300

AVERAGE SEAM EFFICIENCY (%)								
	WARP				FILLING			
Thread/ Stitch	**T1**	**T2**	**T3**	**T4**	**T1**	**T2**	**T3**	**T4**
301	**52.2**	**57.37**	**46.76**	**72.5**	**29.66**	**30.59**	**30.08**	**32.52**
304	**55.05**	**58.73**	**36.86**	**53.42**	**29.22**	**28.43**	**22.21**	**34.81**

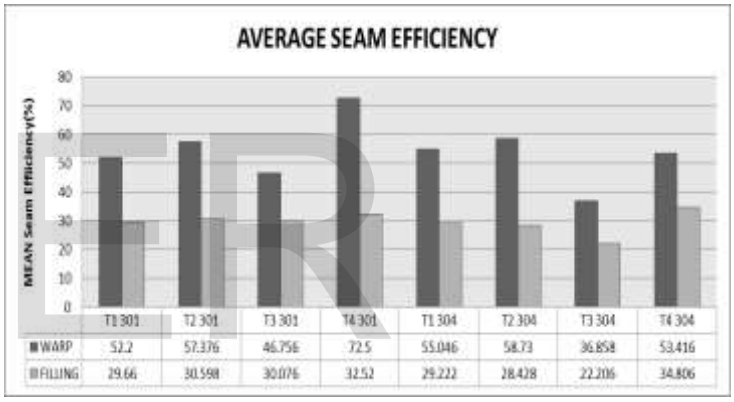

Fig 2: Average Seam Efficiency

3.3 Seam Strength for Stitch class 400

Seam Strength for cotton fabric in both warp and filling directions is shown in Table 6 for Stitch class 400.
Overall, All stitch has higher seam strength in warp direction compared to filling direction.T4 thread shows better seam strength in stitch type 401 which is made from Polyester-wrapped thread with a polyester filament core thread. T2 thread also shows better strength than T1 and T3.Multiple Bar diagram (Fig 3) also shown on below table.
Stitch type 401 shows much closer strength compared to stitch type 406.

Table 6 : Seam strength test result for Stitch class 400

AVERAGE SEAM STRENGTH								
	WARP (lbf)				FILLING (lbf)			
Thread/ Stitch	**T1**	**T2**	**T3**	**T4**	**T1**	**T2**	**T3**	**T4**
401	**33.90**	**42.85**	**27.00**	**43.63**	**28.69**	**34.12**	**25.20**	**40.36**

International Journal of Scientific & Engineering Research, Volume 6, Issue 7, July-2015
ISSN 2229-5518

406	**32.63**	**43.54**	**24.19**	**40.84**	**31.09**	**35.00**	**24.82**	**35.97**

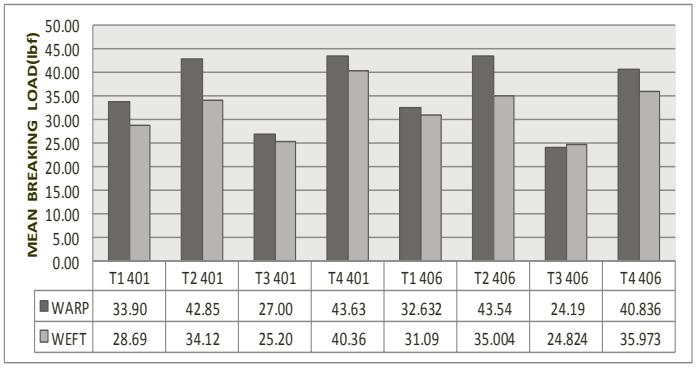

Fig 3: Average Seam Strength

3.4 Seam Efficiency for Stitch class 400

Seam Efficiency for cotton fabric in both warp and filling directions is shown in Table 7 for Stitch class 400.

Overall, All stitch has higher seam Efficiency in warp direction compared to filling direction.T4 and T2 thread shows better seam Efficiency in both types of stitch which is made from Polyester-wrapped thread with a polyester filament core thread. T3 thread also shows lowest strength than T1 and T2. Multiple Bar diagram (Fig 4) also shown on below table.

Stitch type 401 shows better strength compared to stitch type 406 in both warp and filling directions is shown in below table.

AVERAGE SEAM EFFICIENCY (%)								
	WARP				FILLING			
Thread/ Stitch	T1	T2	T3	T4	T1	T2	T3	T4
401	65.85	87.42	50.82	84.78	27.76	40.42	25.87	42.99
406	59.13	84.86	41.80	75.60	32.71	40.63	26.19	39.34

Table 7: Seam Efficiency test result for Stitch class 400

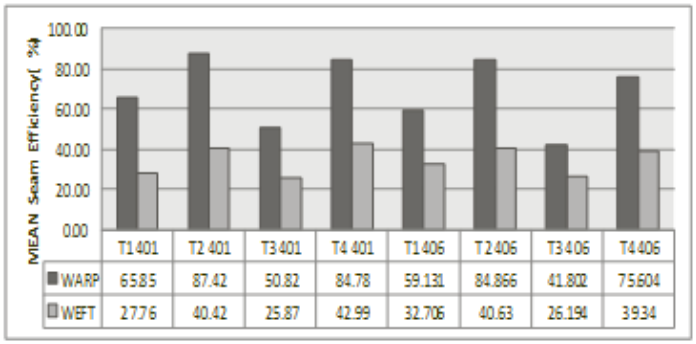

Fig 4: Average Seam Efficiency

3.5 Comparison between stitch class 300 with thread for cotton fabric:

For Warp:

In this study,four types of thread are taken for comparison with stitch class 300.Statistical One way ANOVA test was employed for doing this comparison. In table 8 the outcome is presented: Mean Square, degree of freedom, F-values, Significance for Seam Strength by four Thread Types.

Table 8: Class 300, Seam Strength-WARP

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
T1	Between Groups	11.385	1	11.385	4.131	.077
	Within Groups	22.049	8	2.756		
	Total	33.434	9			
T2	Between Groups	35.419	1	35.419	21.241	.002
	Within Groups	13.340	8	1.668		
	Total	48.759	9			
T3	Between Groups	18.036	1	18.036	3.522	.097
	Within Groups	40.973	8	5.122		
	Total	59.009	9			
T4	Between Groups	80.855	1	80.855	63.232	.000
	Within Groups	10.230	8	1.279		
	Total	91.085	9			

The results from Table 8 showed the analysis of seam strength in warp direction.

Comments: From One-way ANOVA analysis it is found that thread type T1 and T3 have the significance value (P-value :): 0.077& 0.097which are greater than alpha (.05) value, thus null hypothesis is accepted.

For thread type T2 and T4 the significance value (P-value) is: 0.002& 0.000 which is less than alpha (.05) value, thus null hypothesis is rejected.

Decision: The null hypothesis is accepted for thread T1 and T3, which means there is no significant difference between thread type T1 and T3 with seam strength of stitch class 300.

The null hypothesis is rejected for thread T2 and T4, which means there is significant difference between thread type T2 and T4 with seam strength of stitch class 300.

For Filling

Table 9: CLASS 300, Seam Strength –Filling

International Journal of Scientific & Engineering Research, Volume 6, Issue 7, July-2015
ISSN 2229-5518

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
T1	Between Groups	1.608	1	1.608	.367	.562
	Within Groups	35.067	8	4.383		
	Total	36.675	9			
T2	Between Groups	139.876	1	139.876	22.062	.002
	Within Groups	50.720	8	6.340		
	Total	190.596	9			
T3	Between Groups	48.929	1	48.929	17.542	.003
	Within Groups	22.314	8	2.789		
	Total	71.243	9			
T4	Between Groups	1.369	1	1.369	.169	.692
	Within Groups	64.881	8	8.110		
	Total	66.250	9			

The results from Table 9 showed the analysis of seam strength in filling direction.

Comments: From One-way ANOVA analysis it is found that thread type T1 and T4 have the significance value (P-value :): 0.562 & 0.692 which are greater than alpha (.05) value, thus null hypothesis is accepted.
For Thread Type T2 and T3 the significance value (P-value): 0.002& 0.003which are less than alpha (.05) value, thus null hypothesis is rejected.

Decision: The null hypothesis is accepted for thread T1 and T4, which means there is no significant difference between thread type T1 and T4 with seam strength of stitch class 300.
The null hypothesis is rejected for thread T2 and T3, which means there is significant difference between thread type T2 and T3 with seam strength of stitch class 300.

3.6 Comparison between stitch class 400 with thread for cotton fabric:

For Warp:
In this study,four types of thread are taken for comparison with stitch class 400. Statistical One way ANOVA test was employed for doing this comparison.
In table 10 the outcome is presented:

Table 10: CLASS 400, Seam Strength (WARP)

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
T1	Between Groups	4.020	1	4.020	.781	.403
	Within Groups	41.179	8	5.147		
	Total	45.199	9			
T2	Between Groups	1.183	1	1.183	.136	.722
	Within Groups	69.649	8	8.706		
	Total	70.832	9			
T3	Between Groups	19.796	1	19.796	3.763	.088
	Within Groups	42.083	8	5.260		
	Total	61.879	9			
T4	Between Groups	19.460	1	19.460	1.823	.214
	Within Groups	85.404	8	10.675		
	Total	104.864	9			

The results from Table 10 showed the analysis the seam strength of cotton fabric in warp direction.

Comments: From One-way ANOVA it is found that thread type T1, T2, T3 and T4 have the significance value (P-value :): 0.403, 0.722, 0.088 and 0.214 which are greater than alpha (0.05) value, thus null hypothesis is accepted.
Decision: The null hypothesis is accepted for thread Type T1, T2, T3and T4, which means there is no significant difference between thread types T1, T2, T3and T4 with seam strength of stitch class 400 for cotton fabric.
Filling :

Table 11: CLASS 400, Seam Strength (Filling)

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
T1	Between Groups	14.400	1	14.400	14.049	.006
	Within Groups	8.200	8	1.025		
	Total	22.600	9			
T2	Between Groups	1.945	1	1.945	3.890	.084
	Within Groups	4.000	8	.500		
	Total	5.945	9			
T3	Between Groups	.353	1	.353	.054	.822
	Within Groups	52.237	8	6.530		
	Total	52.591	9			
T4	Between Groups	48.114	1	48.114	88.146	.000
	Within Groups	4.367	8	.546		
	Total	52.481	9			

The results from Table 11 showed the analysis the seam strength of cotton fabric in filling direction.
Comments: From One-way ANOVA it is found that thread type T2 and T3 have the significance value (P-value): 0.084 & 0.822 which are greater than alpha (0.05) value, thus null hypothesis is accepted.
For Thread Type T1 and T4 the significance value (P-value): 0.006 & 0.000which are less than alpha (.05) value, thus null hypothesis was rejected.
Decision: The null hypothesis is accepted for thread T2 and T3, which means there is no significant difference between thread types T2 and T3 with seam strength of stitch class 400 for cotton fabric.
The null hypothesis is rejected for thread T1 and T4, which means there is significant difference between thread type T1 and T4 with seam strength of stitch class 400 for cotton fabric.

4 Conclusion

Only one type of deformation were observed in this study was rupture of the stitching line (sewing thread breakage) for both Warp and filling directions. Overall, All stitch has higher seam strength and seam efficiency in warp direction compared to filling direction.

Among Four types of sewing thread below Findings are observed:

1) T4 thread shows better seam strength and Seam Efficiency in both stitch types 301,304,401 and 406 which

International Journal of Scientific & Engineering Research, Volume 6, Issue 7, July-2015
ISSN 2229-5518

is made from Polyester-wrapped thread with a polyester filament core thread for cotton apparel.

2) T3 thread shows poor Seam Strength and Efficiency for all four types of Stitch which are made from 100% cotton.
3) T1 thread shows average seam Strength and Efficiency for all four types of Stitch for cotton apparel which is made from 100% spun polyester.

Analysis of Variance (One-way) at 0.05 alpha levels were employed in testing the hypotheses, the purpose of this study was to establish if any difference existed between and among the stitch types of same class and thread types which was involved in the study. The statistical analysis proved the effect of the stitch types and sewing thread types on the seam strength at significant level. It is vary for different thread types and different stitch classes. The statistical analysis also showed that the significant and positive impact of the stitch types and thread types on the seam efficiency.
Seam strength and efficiency may depend on the thread type and stitch types for various cotton fabric. In accumulation, it has provided information that the different thread types in the market produce different seam performances.

The current study had many limitations that various types of seam could be selected instead of one. In addition, just four thread types out of the several types on the market were used which also add to the limitations regarding the generalization of the research findings.

Based on the outcomes of the current study, it is recommended that apparel manufacturers should be more conscious about using appropriate thread types in the construction of apparels; since some of the apparel makers select stitch types and sewing threads without paying attention to their effect on the overall performance of the apparel being made.

The threads must be tested to guarantee that they meet those standards before entering the International market to enable consumers be assured of the quality of sewing threads in the market. This would help consumers achieve desired results from threads in terms of seam.

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