Research Journal of Recent Sciences ISSN 2277-2502
Vol. **1(12),** 7-14, December **(2012)** *Res.J.Recent Sci.*

Characterization of Seam Strength and Seam Slippage of PC Blend Fabric with Plain Woven Structure and Finish

Bharani M.[1*] and R.V. Mahendra Gowda[2]
[1]Department of Textile - Fashion Technology, Bannari Amman Institute of Technology, Sathyamangalam, Erode District, TN, INDIA
[2]VSB College of Engineering, Karur, Tamil Nadu, INDIA

Available online at: www.isca.in
Received 28th August 2012, revised 6th September 2012, accepted 15th September 2012

Abstract

This article deals the fabrics of different blend proportions ie. polyester/cotton were prepared with different woven structures like plain, twill, satin. These fabrics were treated with fabric softener like silicone. After all the above trials the seam strength and seam slippage were studied for both finished and unfinished materials. The seam strength and seam slippage were studied using instron tensile strength tester, the studies were performed at 6.0mm breaking load and it was observed that the breaking load of unfinished samples were depicting higher strength than the finished without seam opening. The fabric samples of plain weave were found to have greater seam performance than the twill and satin. Various other factors influencing the seam strength and seam slippage are also discussed in detail

Keywords: Seam strength, seam slippage, woven structure, seam performance, silicone finish.

Introduction

The seam performance and quality depend on various factors such as seam strength, seam slippage, seam puckering, seam appearance and yarn severance. Sewing needle penetration forces and fabric deformation during sewing are effective factors for seam performance, too. Appearance and performance of the seam are dependent upon the quality of sewing threads and their dynamic behaviour. One essential requirement of any thread is that it must be compatible with the needle size, various sewing machine settings (sewing speed, thread tension) and the fabric on which it is being sewn. Seam damage can be a serious cost problem, often showing only after the garment has been worn. The most important parameters that have an influence on seam damage tendency are fabric construction, chemical treatments of the fabric, needle thickness and sewing machine settings with sewing thread. Fibre content, yarn construction, tightness and density are important parameters for fabric construction on seam damage. Seam damage caused by the needle penetration through the fabric may affect its seam performance. Needle cutting or yarn severance occurs due to stiffness of the fabric, yarn and its lack of the mobility. Instead of moving and deforming, when the needle penetrates the fabric structure, the yarn is ruptured or burned.

A fabric can be thermally damaged if the needle has a high warming- up value which results in the melting of the material being sewn. Some researchers stated that common apparel products, the seam is an essential part of the garment[1]. Seam damage also results due to high friction between the needle and the fabric. The damaged places are generally dense spread. There are especially dense fabrics which are sensitive to sewing damage. During the stitch formation the cloth being stitched may be damaged in a way which is more mechanical rather than thermal. Generally, in the seam operation, finishing with silicone reduces the friction (mechanical abrasion) between the fabric and the needle. Consequently, the needle penetration force and damage to the fabric is also decreased. The silicone finish reduces the friction between fabric yarns by increasing their mobility. Experience has demonstrated that the strength of many woven fabrics is considerably reduced by the sewing operation. Also, if the seam efficiency ratio falls below 80%, the fabric experiences excessive seam damage by sewing operation. The result of sewing should be a flawless seam, which is only possible when the sewing parameters are coordinated with thread and fabric properties. Hence, in the present study, an attempt has been made to study the sewing performance of the structurally varying cotton and polyester/cotton woven fabric structure with cotton and polyester spun sewing thread respectively. The size of sewing thread is denoted by linear density (tex, cotton count, metric count etc.) or ticket number (equal to three times the metric count of the thread). Tex is the universal system used to represent the sewing thread size[2,3,4] showed the impact of sewing thread size on seam strength. Higher sewing thread size was subjected to greater friction during sewing, which ultimately reduced its strength. This consequently led to poor seam strength.

A seam is manufactured employing sewing methods, with the idea that the seam should satisfy all the requirements imposed by a number of end-users of apparel products[5,6]. For any apparel product, it is necessary to clearly understand the seam, as it is the basic element of an article of clothing. A large number of studies[7,8,9,10,11,12,13]have determined the seam strength according to ASTM 1683-04 standards, which express the value of seam strength in terms of maximum force (in Newton (N)) to cause a seam specimen to rupture. This is measured by using the following equation: $S_s = KS_b$

Where: S_s= sewn seam strength (N); K = a constant equal to 1000 for SI units; S_b = observed seam breaking force (N).

In general, the seam quality mainly depends on the strength and the appearance of the seam itself. Seam strength and appearance affects both the functional and aesthetic performance of an apparel product and is important to its scalability and durability. A good quality seam must have flexibility and strength with no seaming defects such as puckering or skipped stitches; and the overall appearance of the seam must meet the design requirements of the apparel products. Besides the consideration of the quality level of the apparel product, judgement of seam quality requires consideration of the purposes of the apparel products as well. For some functional garments such as sportswear, the requirements of seam strength may be higher than the need for seam appearance, while for some apparel products such as nightgowns, the appearance of the seam is of higher importance.

In the apparel industry, overall seam quality defined through various functional and aesthetic performances desired for the apparel product during their end use. The functional performance mainly refers to the strength, tenacity, efficiency, elasticity, elongation, flexibility, bending stiffness, abrasion resistance, washing resistance and dry cleaning resistance of the seam under conditions of mechanical stress for a reasonable period of time[14,15,16]. Basically, seam quality may be examined from two main aspects: functional and aesthetic performance. Most previous studies[17,18] investigated the functional performance of seam mainly in terms of the seam strength and/or seam efficiency. The cut and sewn apparel product industry convert a two-dimensional fabric into three-dimensional apparel. Many processes are involved during apparel production, till the stage of finished apparel to be seen in a shop-window, on a tailor's dummy, or on a coat hanger is reached. While there are other methods of shaping fabrics into apparel products, stitch seaming is by far the most common method used worldwide.

Properties like as, strength, tenacity and efficiency is required for determining the serviceability of apparel. Elasticity, elongation, flexibility, and low bending stiffness of seam are needed to easily elongation, flexibility, and low bending stiffness of seam arc needed to easily bend, shift, and fold without damage to the seam or change to the silhouette of the garment. Seam also comes under abrasion with body parts at wear or at the time of washing or dry cleaning. It is expected that seam should have good abrasion and/or washing and/or dry cleaning resistance. There are also certain aesthetic requirements of a seam to the consumers' body sensory mechanism (hand, eye)[19].

Fabric properties which affect the seam quality are discussed by many previous researchers[20,21,22]. These properties arc cover factor, weight, thickness, strength, extensibility, bending rigidity, bending hysteresis, shear rigidity and shear hysteresis. In the following sections these fabric properties are discussed in brief. Lubrication finish protects the thread from strength reduction and/or breakage during sewing, which, in turn, produces high seam efficiency and less chance of seam damage[23,24]. There are various factors which can affect the seam strength and seam appearance. Many previous studies[25,26] showed that seam appearance and performance depend on the interrelationship of fabrics, threads, the stitch and seam selection, and sewing conditions, which include the needle size, stitch density, the appropriate operation and maintenance of the sewing machines etc. The combination of materials that are assembled with the sewing thread and sewing conditions vary from individual to individual. Selection of sewing thread and sewing condition for a particular type of material is an integral part of producing a quality seam.

The different parameters of sewing thread such as the thread type, size and finish would have a definite effect on seam strength and appearance[27,28]. The clothing industry tends to use the polyester spun thread with standard finish for most apparel products unless special requirements are demanded. In the apparel industry, after a particular type of seam and stitch is selected for the construction of an apparel product, the apparel designer and/or manufacturer needs to select the thread size and to determine the seam boldness required for seam construction. Seams with different degrees of boldness serve different purposes as design features. Some types of garments such as the jeans prefer a seam with more prominent design, while other garments such as the dress shirt conventionally prefer the seams be sewn more inconspicuously. The seam boldness is an important element of determining the seam appearance, and the size of sewing thread becomes the primary factor for the manufacturers to consider for the required seam quality. The sewing conditions such as the thread tensions and pressure of pressure foot should be adjusted based on the thread size and the material to be sewn. However, the stitch density may vary at different seam locations. Stitch density was deemed to be an important attribute in seam quality because it assembles the fabric components together. The change of stitch density exerts a great influence on seam strength and appearance.

There are also numerous studies[29] on the seam quality based on the aesthetic performance. However, these studies focus mainly on the seam defects such as the seam puckering, seam damage. Furthermore, few studies had been evaluated the seam quality from both aspects of seam: the functional and the aesthetic[30]. However, in these studies, in order to evaluate the seam quality, the authors did not combine the functional and aesthetic performance of the seam. Up to now, very limited work has been done to study the seam quality on functional and aesthetic performance together. This study attempts to analyse the seam quality from the aspects of both functional and aesthetic performance, and to study the effect of thread size, fabric properties and stitch density on seam quality in various types of fabric materials. The success of this study could help apparel manufacturers to evaluate the seam quality more effectively when a particular sewing thread size and stitch density arc applied to a particular type of fabric. In turn, this would facilitate apparel engineers in the production planning and quality control. For proper appearance, seam should not contain any defects including skipped stitches, unbalanced stitches, looseness, seam grin, distortion or unevenness or puckering, unsteadiness, improper drape-ability, uneven seam density and yarn severance or damage. A defect free seam is required for consumer satisfaction at the point of sale of apparel and helps to increase the scalability.

Apart from all the above aesthetic mentioned requirements, seam should also meet the design requirement of the consumers for apparel. The different degree of boldness of seam can help to fulfill different purposes as design features and affect the appearance of the garment. In the apparel industry, seam boldness is commonly used as a prime dimension for evaluating the design prominence of a seam[31,32]. Therefore, overall quality of a seam depends on the requirements imposed by the consumers. Good overall seam quality is essential for the longevity of an apparel product, which together with consumer satisfaction during wear and care procedures affect its sale-ability. The apparel industry uses different dimensions for the evaluation of seam quality on the basis of the requirements of a seam from the consumers' point of views[33]. In order to understand various seam performances, knowledge of various factors affecting the seam quality is necessary. Seam quality is governed by a broad spectrum of factors including sewing thread type and size, fabric, sewing machine speed, needle kind and size, stitch type and density and operator skills[34,35]etc. For better seam quality, it is important to consider the complete harmony of the key fabric properties, sewing thread properties and sewing condition parameters used. The functional and aesthetic performance of the seam line is the result of all these factors. Seam strength refers to the load required to break a seam. This measure the strength and tenacity of a seam. Two pieces of woven fabric are joined by a seam and if tangential force is applied the seam line, rupture ultimately occurs at or near the seam line. Every seam has two components, fabric and sewing thread. Therefore, seam strength must result from the breakage of either fabric or thread or, in more cases, both simultaneously. Research has revealed that the load required to rupture the seam is usually less than that required to break the un-sewn fabric.

The ASTM 1683-04 seam strength standard is worth emphasizing due to its accuracy and ease in processing measurements. Hence, this method is widely used by the apparel industry for the evaluation of seam strength worldwide. Seam slippage is expressed as the transverse ratio of seam strength to fabric strength including the ratio of elongation of fabric to the ratio of elongation at the seam[36]. Any movements of the warp and weft yarns away from a seam line under transverse stresses exacerbate the potential slippage. A lot of scholars[37,38] has suggested measuring seam slippage according to the ASTM 1683-04 standard for evaluation of seam quality. In this standard, the force required for slippage of 0.6mm of seam has been determined. The measurement of seam slippage from the ASTM 1683-04 standard is well established as an international standard and most apparel industries follow this method to evaluate seam slippage.

A few researchers conducted research on the effect of thread finishes on seam quality. They stated that the lubrication finish is used on a sewing thread to assure better seam quality due to its protective nature from needle heat in the course of garment manufacturing. There are various types of finishes; however, in general the clothing industry tends to use standard lubrication finish for better seam performance in apparel stated that mercerized and glazed cotton thread have higher strength, durability, abrasion resistance than normal soft cotton threads. Increased strength, durability and abrasion resistance help to get greater seam efficiency, seam strength and seam slippage. Additionally, they mentioned that other finishes like, water resistance, soil resistance, flame resistance is specific to the end use of the apparel and fabric to be sewn. On the other hand, few reseachers[39] found that sewing thread size is one of the important factors affecting seam strength. Generally, higher sewing thread size leads to greater seam strength for any apparel. Corroborate the fact that higher sewing thread size has a strong positive impact on seam strength. Some scholars emphasized that fabric cover factor has considerable effect on seam strength and/or seam efficiency. Their study revealed that fabrics with high cover factor have an increased tendency to break the fabric yarns (warp and/or weft) at the time of sewing[40]. The breakage of yarns in fabric ultimately reduces the seam functional performance such as seam strength and seam efficiency[41].

There are various factors for seam quality: fabric properties, sewing thread and sewing conditions and others (human factors, environmental factors). Fabric is the basic raw material for the apparel products. Generally, all the fabric properties such as. weight, cover factor, thickness, strength, extensibility, bending rigidity, bending hysteresis, shear rigidity, shear hysteresis and coefficient of friction have considerable effect on seam quality of apparel products. The different parameters of sewing thread are type, ply, finish, twist and size would have a definite effect on the functional and aesthetic performance of the seam. If there is no special requirement, the apparel industry mainly selects the spun-polyester, 3-Ply, normal twist and standard finish sewing thread for all types of sewing fabrics[15]. However, the size of the sewing thread is the most crucial for that seam quality as the improper selection of sewing thread size directly affects the seam quality of apparel products. There are also a lot of sewing conditions such as stitch type, seam type, stitch density, sewing machine speed, needle size, pressure of pressure foot, feed dog. Thread tension and needle plate, which affect the seam quality. Among the above mentioned sewing conditions, stitch density is the only attribute, which can vary at different seam locations and has a direct impact on the quality level of apparel products[17,39]. Therefore, stitch density deemed to be a most important sewing condition in the course of garment manufacturing. The remaining sewing conditions are adjusted during the course of apparel manufacturing based on the thread size and/or the material to be sewn. So, these are not considered as important factors for seam quality analysis in the present study.

Material and Methods

The detailed Experimental Procedure involved in carrying out this project work is described below

Procurement of Fabric: The fabrics of different weaves of Plain was procured, the fabric specifications clearly understood from table-1. The PC fabric procured is bleached and dyed. Silicone finish is applied to the conditioned fabrics.

Table-1
Specification of polyester cotton fabric

Weave	Warp count	Weft count	EPI	PPI	GSM
Plain	40	62	134	70	47.38
Twill	44	15	70	58	55.28
Satin	70	40	152	65	39.49

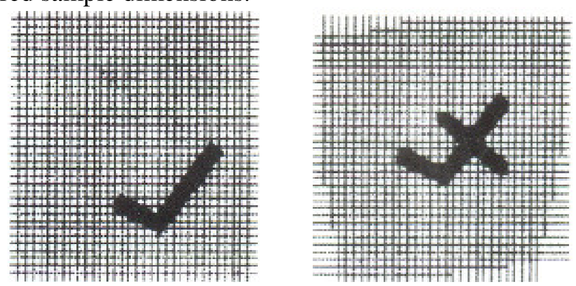
Bleaching Methodology: The bleaching bath is set to the required conditions according to the recipe given. The temperature is raised to 55°c. The fabric is immersed and worked for 2 minutes. Then the temperature of the bath is raised to 90°c and the material is worked for remaining time. The material from the bath is rinsed in hot water followed by cold water and dried.

Dyeing Methodology: The dye solution is prepared and the dye bath is set to 40ºC. The fabric is then immersed in water for 10 min. Common salt is added and worked for 20 minutes. The dissolved alkali solution is added to the bath. The temperature is raised to 80°c in 20 minutes and continued for 30-60 minutes. Dyed fabric was washed with warm water at about 60°C. The fabric was then washed with 1-2 gpl of soap and then dried.

Finishing Methodology: The bath is set to the required conditions according to the recipe given. The pH is brought to the required level by adding 50% concentrated acetic acid. The fabric is immersed in the solution and worked for one hour at room temperature. The fabric is padded, dried and cured.

Measurement of Fabric Tensile Characteristics: The samples were tested on an Instron for tensile characteristics, like seam strength, seam slippage. The fabric samples were tested at 500 mm gauge length at a constant speed of 5000mm/min and Pretension of 0.50cN/tex on Instron 7000 tensile tester. For each sample, required tests were conducted and the average values of breaking force, breaking time, tenacity, breaking elongation, breaking work are computed.

Fabric Breakdown: Fabric Testing: Sample Preparation: i. Fabric dimension required for testing should be 56Wx 320L mm is taken in warp and weft directions. ii. Remove the yarn from either side of the fabric width by 3mm each to ensure that the test width is 50mm. iii. The outer edge yarns in the test sample should be to the full sample length and width as shown in figure-1a not like in figure-1b, iv. The test sample with the exact dimension is prepared by cutting the sample from the lot with some allowance and unraveling the outer edge yarns to the required sample dimensions.



(a) (b)

Figure-1
Fabric preparation for testing

Testing: i. Click 'Start' button, ii. Place the test sample fabric in between the two clamps and tighten the bolts provided. iii. The clamping edge should be in line with the test sample and the sample centre should coincide with the clamp's (top and bottom) centre, iv. Press 'start' switch in the instrument front panel. v. The top clamp moves upwards till the testing fabric breaks at the weakest point and the bottom clamp remains fixed. vi. After sensing the maximum Force encountered, the top clamp returns to the next test length position. vii. Then continue the sample testing for the remaining in warp and weft directions.

Results and Discussion

The characteristics of fabrics measured are analyzed and discussed

Tensile Characteristics of Fabrics: The table 2-4 represents the finished fabric has reduction in its breaking load value since the presence of cotton fibre and the cohesion between the cotton fibres. The PC blended plain fabric has more binding point, EPI, PPI, stitch and polyester fibre may be contributing more for its higher value. From the figure 3-6 it is also analyzed that the sewing thread which is selected for study is having much influence on breaking load of the fabric. It is also observed that the finish which is applied over the fabric has considerable influence on the breaking load and seam strength as a function of polynomial law where as the seam slippage of the fabric as a function of power law.

Table-2
Polyester/Cotton Blend-Plain Fabric Breakdown

S.No	Breaking Load(Kgf)			
	Warp		Weft	
	With Finish	Without Finish	With Finish	Without Finish
1	29.5	31.2	36.4	25.9
2	31.2	26.8	37.5	27.1
3	29.7	33.5	32.4	25.1
Mean	30.1	30.5	35.4	26.0

Table-3
Polyester/Cotton Blend- Plain Fabric Seam Slippage (6.0mm seam opening)

S. No	Breaking Load at 6.0mm opening(Kgf)				Seam opening (mm)			
	Warp		Weft		Warp		Weft	
	With Finish	Without Finish	With Finish	Without Finish	With Finish	Without Finish	With Finish	Without Finish
1	9.4	14.4	>20(SONO)	>20(SONO)	6	6	1.2	2.0
2	12.7	11.2	>20(SONO)	>20(SONO)	6	6	3.4	1.3
3	7.8	11.7	>20(SONO)	>20(SONO)	6	6	2.1	-
Mean	10.0	12.4	>20(SONO)	>20(SONO)	6	6	2.2	1.1

Table-4
Polyester/Cotton Blend-Plain Fabric Seam Strength

S.No	Seam Strength(Kgf)			
	Warp		Weft	
	With Finish	Without Finish	With Finish	Without Finish
1	18.9(STB)	20.7(STB)	20.0(STB)	14.9(STB)
2	17.8(STB)	15.8(STB)	19.1(STB)	14.4(STB)
3	14.8(STB)	18.1(STB)	20.8(STB)	14.4(STB)
Mean	17.2(STB)	18.2(STB)	20.0(STB)	14.6(STB)

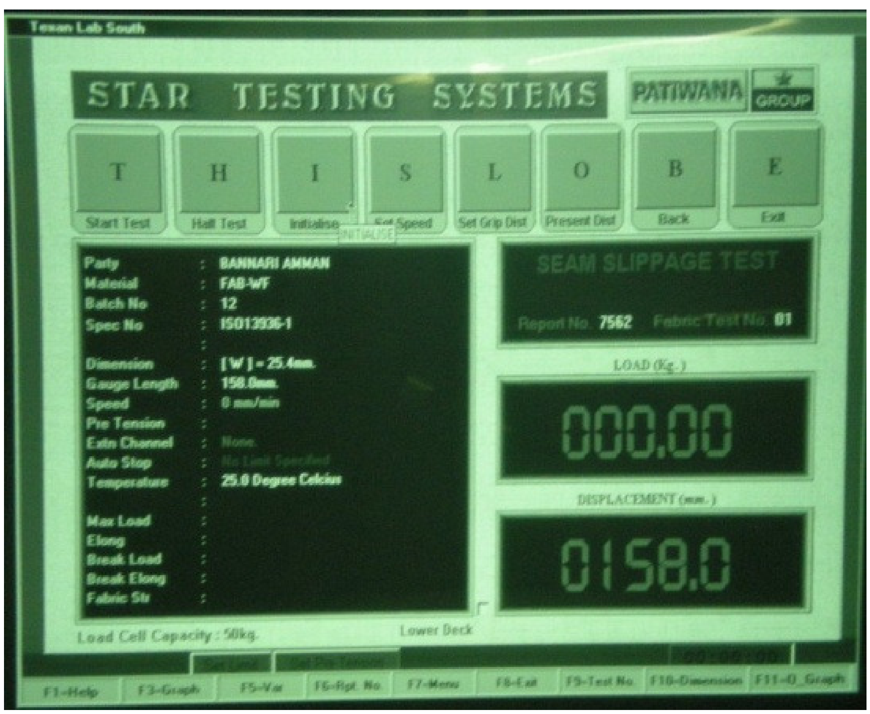


Figure-2
Parameter Setting Screen for Fabric Testing

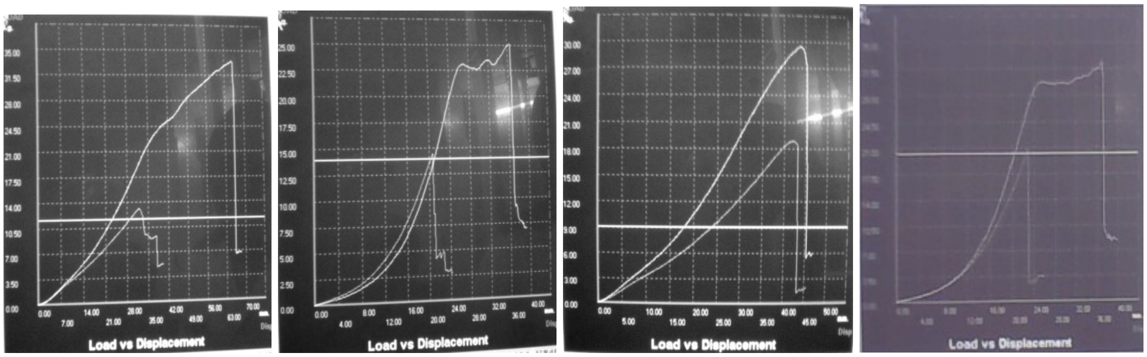


Figure-3
Load-Displacement curve for polyester-cotton plain unfinished and finished fabric at warp and weft direction

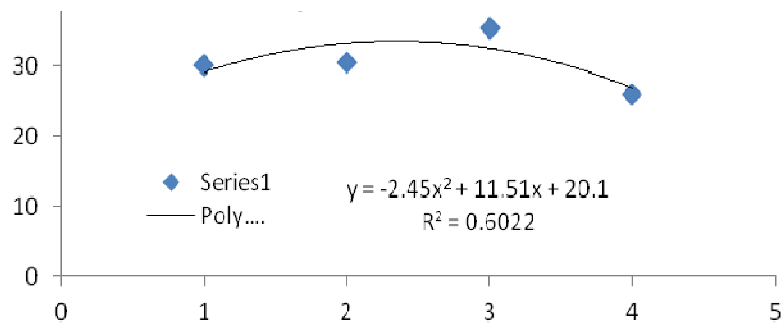


Figure-4
Breaking Load of PC Blended Plain Fabric

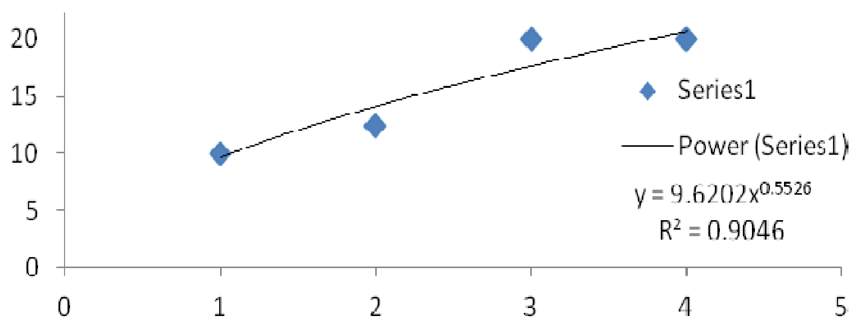


Figure-5
Seam Slippage of PC Blended Plain Fabric

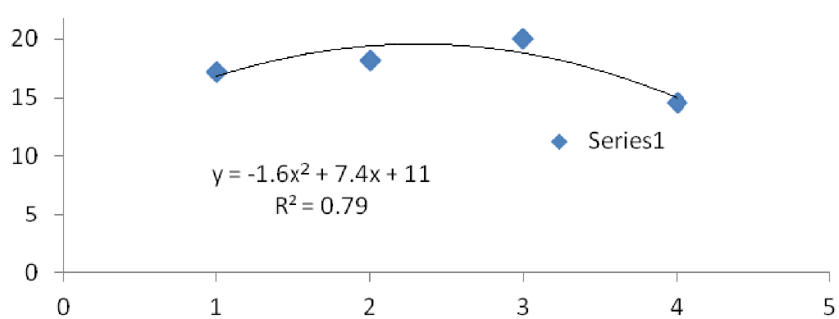


Figure-6
Seam Strength of PC Blended Plain Fabric

It is known that when the fabric is tested for breaking load it depicts higher breaking load compared to the finished and unfinished warp way direction of tested fabrics. But in case of the satin fabric the finish has lesser influence on the fabric seam performance. The seam strength of the PC blend satin fabric is tested to understand its behavior. The coefficient of determination of the model represents that breaking load, seam slippage and seam opening follows a R^2 value of 0.60, 0.91, 0.79 respectively which means that the remaining value of the R^2 is influenced by the factors like the yarn count, EPI, PPI, cover factor and process parameters.

Conclusion

The following conclusions are drawn from this present work. From the study it is clear that the resistance to breakage at the application of load is more for polyester/cotton blend than the cotton fabric. While taking a detailed look at the comparison of breaking load required for the finished and unfinished fabric, it is clear that the application of finish has some distinct effects. The fabric construction (EPI, PPI, count, weave type) proves to be playing a major role in the performance of seam. The cover factor increases with the increase in EPI and PPI, thus resulting in greater fabric strength, the greater is the resistance to fabric and seam breakage. The present study gives a clear understanding about the variation in the requirement of load for various types of weave structures, say plain, twill and satin. From the study it is concluded that the plain fabric has higher seam performance than the other weave types. Some of the other parameter which was found to influence the seam performance is sewing thread type and the fibre content in the sewing thread.Some of the test results explained that there were no seam opening observed at 6.0mm (seam slippage) in the comparative graph. Instead, the fabric tears at the seam or in most of the cases the sewing threads were broken due to the application of load. To maintain good seam and garment quality, seam performance is the essential parameter that should be taken into account.

References

1. Lindberg J., Westerberg L. and Svenson R., Wool fabrics as garment construction material, *Journal of the Textile Institute*, **51,** T1475-T1492 **(1960)**
2. Booth J.E., Principles of textile testing: an introduction to physical methods of testing textile fibres, yarns and fabrics, London: Heywood Books **(1968)**
3. Gersak J. and Knez B., Reduction in thread strength as a cause of Loading in the sewing Process, *International Journal of Clothing Science and Technology*, **3(4),** 6-12 **(1991)**
4. Glock R.E. and Kunz G.I., Apparel Manufacturing: Sewn Product Analysis, New Jersey: Englewood Cliffs **(1995)**
5. Rosenblad W.E. and Cednas M., The influence of fabric properties on seam puckering, *Clothing Research Journal,* **1(3),** 20-26 **(1973)**
6. Stylos G. and Lloyd D.W., Prediction of seam pucker in garments by measuring fabric mechanical properties and geometric relationship, *International Journal of Clothing Science and Technology*, **2(1),** 6-15 **(1990)**
7. Shimazai K., Studies on seam strength- tensile strength of seam sewed by hand, *Japanese Resource Association of Textile End-Uses*, **20**, 317-327 **(1976)**
8. Bhalerao S., Budge A.S. and Borkar S.P., Seam performance in suiting's, *Indian Textile Journal*, **107(11),** 78-81 **(1997)**
9. Behera B.K., Chand S., Singh T.G. and Rathee P., Sewability of denim, *International Journal of Clothing Science and Technology*, **9(2),** 128-140 **(1997a)**
10. Behera B.K. and Sharma S., Low stress behaviour and sewability of suiting and shirting fabrics, *Indian Journal of Fiber and Textile Research*, **23(4),** 233-241 **(1998)**
11. Choudhury P.K., Improvement in Sewing performance of jute bags, *Indian Journal of Fiber and Textile Research*, **25(3),** 206-210 **(2000)**
12. Lin T.H., Construction of predictive model on fabric and sewing thread Optimization, *Journal of Textile Engineering*, **50(1),** 6-11**, (2004)**
13. Mohanta R., A study on the influence of various factors on seam performance, *Asian Textile Journal*, **15(10),** 57-62 **(2006)**
14. Mehta P.V., An introduction to quality control for apparel Industry, Japan: ISN international **(I985)**
15. Solinger J., Apparel Manufacturing Handbook, Columbia: Bobbin Blenheim, **(1989)**
16. Carr H. and Latham B., The Technology of Clothing Manufacturing. Oxford: Blackwell Scientific Publications, **(1995)**
17. Chmielowice R., Seam strength factors, *Textile Asia*, **18(3),** 94-97 **(1987)**
18. Tarafdar N., Kannakar R. and Mondol M., The effect of stitch density on seam performance of garments stitched from plain and twill fabrics, *Man-made Textiles in India*, **50(8),** 298-302 **(2007)**
19. Choudhry K., Sewability of suiting fabrics, M.Sc Thesis. University of Delhi, **(1995)**
20. Kawabata S. and Niwa M., Fabric performance in clothing and clothing manufacture, *Journal of the Textile Institute*, **80(1),** T40-T52 **(1989)**
21. Kawabata S. and Niwa M., Objective measure of fabric mechanical property and quality, *International Journal of Clothing Science and Technology*, **3(1),** 7-4 **(1991)**
22. Minazio P.G., The fabric processing performance and its role in predicting the appearance of men's wool suit jackets, *International Journal of Clothing Science and Technology*, **10(3/4),** 182-190 **(1998)**

23. Bhatnagar S., Cotton sewing thread and Siro system, *Indian Textile Journal*, **102(2)**, 30-31 **(1991)**

24. West D., Sewing threads-how to choose, *Textile Asia*, **24(5),** 82-87 **(1993)**

25. Behera B.K., Shakun S., Snrabhi S. and Choudhary S., Comparative assessment of low stress mechanical properties and sewability of cotton and cotton banana union fabric, *Asian Textile Journal*, **9(5),** 49-56 **(2000)**

26. Mukhopadhyay A., Sikka M. and Karmakar A.K., Impact of laundering on the seam tensile properties of suiting fabric, *International Journal of Clothing Science and Technology*, **16(4)**, 394-103 **(2004)**

27. Rengasamy R.S., Kothari V.K.,. Alagirusamy R. and Modi S., Studies on air-jet textured sewing threads, *Indian Journal of Fiber and Textile Research*, **28(3),** 281-287 **(2003)**

28. Gribaa S., Amar S.B. and Dogui A., Influence of sewing parameters, upon the Tensile behavior of textile assembly, *International Journal of Clothing Science and Technology*, **18(4),** 235-246 **(2006)**

29. Gupta B.S., Leek F.J., Baker R.L., Buchanan D.R. and Little T., Directional variations in fabric properties and Seam quality, *International Journal of Clothing Science: and Technology*, **4(2/3),** 71-78 **(1992)**

30. Krasteva D.G. and Petrov H., Investigation on the seam's quality by sewing of light fabrics, *International Journal of Clothing Science and Technology*, **20(1),** 57-64 **(2008)**

31. Ukpanmwan J., Mukhopadhvay A. and Chatterjee K.N., Sewing threads, *Textile progress*, **30(3/4),** 1-91,**(2000)**

32. Sandow K. and Hixon D., Thread selection made simple, Bobbin, August, 46-49 **(1999)**

33. Kadolph S.J., Langfoid A.L., Hollen N. and Saddler J., Textiles, New York: Macmillan **(1998)**

34. Salhotra K.R., Hari P.K. and Sundaresan G., Sewing thread properties, Textile Asia, **25(9),** 46-49 **(1994)**

35. Ito K., Problems in recently]manufactured worsted Men's suiting from the point of View of suit quality, *International Journal of Clothing Science and Technology*, **9(3),** 200-202 **(1997)**

36. Behera B.K., Evaluation and selection of sewing thread, Textile Trends, **39(12),** 33-42 **(1997b)**

37. Gurarda A., Investigation of the seam performance of PET/Nylon-elastane woven fabrics, *Textile Research Journal*, **78(1),** 21-27 **(2008)**

38. Kothari V.K. ed., Testing and quality management, New Delhi: IAFL publications **(1999)**

39. Sundaresan C., Salhotra K.R. and Hari P.K., Strength reduction in sewing threads during high speed sewing in industrial Lockstitch machine part II: Effect of thread and fabric properties, *International Journal of Clothing Science and Technology*, **10(1),** 64-79 **(1998)**

40. Miguel R.A.L., Lucas J.M., Carvalhe M.D.L. and Manich A.M., Fabric design considering the optimization of seam slippage, *International Journal of Clothing Science and Technology*, **17(3/4),** 225-231 **(2005)**

41. Nergis B.U., Performance of seams in garments, *African Textiles*, Dec/Jan. 29-31 (1997/1998) **(1998)**