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Evaluating performance characteristics of different fusible intertinings

K Phebe[a], K Krishnaraj & B Chandrasekaran

Centre for Leather Apparel & Accessories Development
CSIR-Central Leather Research Institute, Adyar, Chennai 600 020, India

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An attempt has been made to evaluate the performance characteristics of three different fusible interlinings used in apparel industries with sheep nappa leathers in terms of bending, softness, bond strength, shrinkage, tensile strength and double hole stitch tear strength. Of all aspects of performance investigated, it is found that among the three interlinings, the fusible interlining which is warp knitted with a combination of strong nylon yarn woven with the cotton yarn performs well as compared to the other two interlining materials. The results not only facilitate the basic understanding of the fusing behavior of interlining materials with nappa leathers but also are useful for apparel design and construction.

Keywords: Bond strength, Leather, Sheep nappa, Fabric shrinkage, Tensile strength, Woven interlining

1 Introduction

Fusing technology such as a thermoplastic adhesive bond between face fabric and interlining is well known in clothing industry[1]. It is not merely used in garments, but also used substantially in collars, cuffs, waistbands, pocket flaps and plackets[2]. Fusible interlining is a kind of material whose base cloth is applied with thermoplastic macromolecular compound and has a strong binding power. Through the action of certain temperature, time and pressure, it can bind with fabrics directly. These variables have a great influence on the bond strength and the properties of the composite material obtained [3]. Interlinings are also used to support the outer fabrics so as to create and maintain three dimensional shape and drape of a garment[4]. Use of interlinings can help to overcome some of the negative features of shell fabric and provide attractive and stylish appearance in the final garment[5]. A fused panel as a joined composite has specific properties with respect to shell and interlining. To the best of our knowledge, in literature there is no research available related to performance characteristics of fusible interlinings with leather. Since sheep nappa leathers are widely used for apparel applications. the present study is aimed at investigating the effect of fusible interlinings on selected characteristics of sheep nappa leathers with reference to their ability to impart a favorable appearance during wear.

[a]Corresponding author.
E-mail: kphebejohn@yahoo.co.in

2 Materials and Methods

Commercially available sheep nappa leathers (ABC grade) were procured with an average size of 5±0.5ft^2. They were chosen such that they had a fairly uniform substance and size. Samples were cut from the butt portion of leather adjacent to each other to evaluate bending length, softness, bond strength, % shrinkage, tensile strength and double hole stitch tear. Samples cut parallel to the backbone are designated as S1, S2, S3 and S4 and those cut perpendicular to the backbone are designated as L1, L2, L3 and L4. Three types of woven interlinings F1, F2 and F3 are chosen having the specifications as given in Table 1. Fibre content test is measured according to AATCC 20 (2007).

Fusing was carried out using a roller press machine (WIN Make–NHG 600 Shangai WEIJIE Clothing Machine Co. Ltd.). Fusing conditions were standardized after preliminary experiments, such as temperature of 120°C, pressure of 2 bar and time of one revolution per min. They are fused to leather samples and subjected to standard testing procedure to evaluate fusing effects on the fabrics in terms of

Table 1—Specification of fusing material

Parameter	F1	F2	F3
Weave	Plain	Plain	Warp knit
Weight, g/m^2	95.4	59.6	83.7
Thickness, mm	0.24	0.19	0.26
Picks/in	38	26	32
Fibre content	100% Cotton	100% Cotton	59.6% Rayon + 40.4% Polyester

stiffness, softness, bond strength, shrinkage, tensile strength and double hole stitch tear. Additionally the effect of stitch on the above-mentioned properties of fused composites has also been studied. A stitch was made along the length of the specimens using the following sewing conditions:

Sewing machine	:	Pfaff flat bed single needle machine
Stitch type	:	Lock stitch
Thread type	:	Core spun polyester
Thread tkt no	:	50
Stitch density	:	3 Stitches/cm
Needle size	:	90
Needle model	:	134-35-LR point

2.1 Softness

Softness is one of the most important physical properties to be considered when assessing the quality of leather[6]. For this study, softness of leather was measured by IUP36 test method[7] using a ST 300 digital softness tester, supplied by M/s MSA Engineering Systems Ltd., UK.

2.2 Bending Length

Bending ability of a material is considered as potentially important to stiffness. For evaluating the bending length, eight sets of samples of size 25 × 120mm were cut along and across the backbone direction. Each set comprises four samples, of which one represents the control sample which is not fused with the interlining and the other three samples are fused with the three types of interlinings. Bending length was measured using a SASMIRA bending tester according to the Indian standard IS: 6490 (1971). Low value of bending length means low stiffness and hence better drape ability. However, a high value of bending length indicates high stiffness or poor drape ability. Stitches were made along the length of the specimen and the same procedure was repeated to measure the bending length values in stitched samples.

2.3 Tensile Strength and Elongation

After evaluating bending length, dumbell shaped specimens were cut from these samples for determining tensile strength according to IS: 5914(1970). The test was carried out using an Instron 4501 universal testing machine with a load cell capacity of 1 kN.

2.4 Bond Strength, Shrinkage and Tear Strength

Bond strength is the sturdiness of the seal between the fusible interlining and the fabric which is evaluated after fusing. It was measured as per the standard SATRA TM 401(1992).

Per cent shrinkage was calculated according to ASTMD 2724(1968) standard as shown in the following equation:

$$\%\ \text{Shrinkage} = \frac{(A\text{-}B)\times 100}{A} \qquad \ldots (1)$$

where A is the average original distance between the bench marks; and B, the average final distance between bench marks. Double hole stitch tear strength was determined according to Indian standard IS: 5914(1970).

3 Results and Discussion

Evaluation of properties of a fused composite often presents a difficult task because its properties depend upon various shell fabrics, choice of fusible interlinings and fusing parameters. The results of this study present useful information in garment manufacturing as well as garment appearance.

3.1 Bending

Bending behavior is one of the most important attribute used to assess the quality of leather and that of fusible interlinings for determining their suitability to the end use. High values of bending length indicate greater resistance to flexing while lower values indicate easier flexing and hence better drapability. The mean values of bending length of sheep nappa leathers for both plain and fused with interlinings are given in Table 2.

A comparison of the results for samples cut along the backbone clearly proves the bending length increases considerably for all samples fused with different materials as compared to that of plain samples (control). The increase in bending length ranges from 1.1 cm to 1.7 cm. The reason being, during fusing the melt adhesive interlining is mainly attached to leather by a resin that penetrates. During the resin transfer process, the resin would melt, spread uniformly over the leather and form a close link structure, making it rigid. Such fabrics will be stiff and flexible. Among the fused composites, leather fused with material F3 and F1 shows comparably lowest bending length than that fused with F2 and therefore is more flexible with better drape. Introducing a stitch on the fused sample further enhances the bending length. The increase in bending length ranges from 1.1 cm to 2.3cm. A cursory look at the results show that the stitch on the leather with fused interlining provides a good grip and adequate

Table 2—Bending length (cm) of sheep nappa leathers[a]

Leather sample	Plain leather	Leather with fusing			Fused leather with single stitch along the length		
		FI	F2	F3	FI	F2	F3
				Along the backbone			
S1	3.0±0.4	4.3±0.3	4.7±0.3	4.4±0.1	5.2±0.7	5.3±0.3	4.6±0.3
S2	2.9±0.2	4.1±0.4	4.4±0.20	4.1±0.2	4.8±0.2	4.5±0.3	4.1±0.2
S3	2.9±0.1	4.0±0.2	4.2±0.3	4.0±0.2	4.7±0.1	4.7±0.2	4.0±0.1
S4	2.7±0.2	4.1±0.3	4.4±0.3	4.0±0.2	5.0±0.3	5.0±0.4	4.3±0.2
				Across the backbone			
L1	3.1±0.1	4.8± 0.2	4.5±0.40	4.9±0.2	4.3±0.1	4.1±0.1	4.5±0.2
L2	3.1±0.1	5.2±0.2	4.6±0.38	5.2±0.1	4.3±0.6	4.2±0.1	4.7±0.4
L3	2.9±0.1	4.5±0.1	3.8±0.17	4.5±0.1	4.5±0.2	4.2±0.3	4.6±0.1
L4	2.7±0.2	4.7±0.3	3.86±0.2	5.0±0.2	4.4±0.3	4.2±0.2	4.7±0.2

[a]Values are given as the average of six measurements taken along with standard deviation values.

Table 3—Softness (mm) of sheep nappa leathers[a]

Leather sample	Plain leather	Leather with fusing			Fused leather with single stitch along the length		
		FI	F2	F3	FI	F2	F3
				Along the backbone			
S1	6.13±0.27	4.31±0.2	4.43±0.2	4.22±0.2	4.11±0.23	4.12±0.33	3.60±0.15
S2	6.40±0.25	4.50±0.4	3.9±0.05	5.14±0.4	4.50±0.03	4.58±0.11	3.73±0.13
S3	6.23±0.20	3.70±0.2	4.9±0.20	3.7±0.08	3.51±0.12	4.55±0.27	3.61±0.38
S4	6.38±0.10	4.10±0.4	4.8±0.20	3.9±0.03	3.93±0.44	4.63±0.16	3.65±0.19
				Across the backbone			
L1	6.71±0.05	6.54±0.22	6.47±0.35	6.51±0.08	4.16±0.32	5.13±0.68	3.98±0.19
L2	5.15±0.08	4.68±0.18	5.05±0.17	3.67±0.36	4.50±0.25	3.60±0.11	3.47±0.26
L3	6.37±0.80	5.61±0.35	5.40±0.53	4.34±0.34	4.54±0.18	4.49±0.14	3.76±0.30
L4	6.50±0.22	5.27±0.28	6.20±0.14	5.15±0.77	4.04±0.11	5.50±0.28	3.86±0.12

[a]Values are given as the average of six measurements taken along with standard deviation values.

resistance to the composite, thereby increasing the rigidity. Leather fused with interlining F3 followed by stitching has the highest flexibility and hence better drape behavior.

For across backbone samples, there is a significant increase in the bending length of fused samples compared to that of plain samples, as also in the case of samples cut along the backbone. However, there is an increase in the bending length of fused stitched interlinings as compared to that of plain samples; but it is not so pronounced as in the case of fused composites. This may also be attributed to the disorder of yarns created in the woven interlining on stitching.

3.2 Softness

Softness is one of the most important properties by which a tanner can judge leather quality. Recent developments in non-destructive testing of leather softness are a notable achievement in this area. The softness values of sheep nappa leathers along and across the backbone fused with three types of fusing materials are given in Table 3. The fusing material is mainly used to reinforce and stiffen some parts of the garments, like cuffs and collars. When leathers are fused with these interlinings, there is a tendency for softness to decrease. It is evident from the results that softness is decreased significantly upon fusing. For samples cut along the backbone, the extent of decrease ranges from 1.26 mm to 2.53 mm in fused composites. The reason being, during fusion of leather with interlining the adhesive melts and then permeates into the leather, causing the adhesion of the leather and interlining. Since the fused composite constitution comprises the adhesive, the softness decreases. When a simple plain stitch is made on the fused sample and then subjected to softness tests, it is found that there is a further decrease in softness because of the added component of thread in the fused composite, making it hard and rigid. It is also observed that leathers fused with F2 possess better softness in most of the cases followed by F1 and F3. From the softness values across the backbone for plain leathers and leathers fused with different fusing materials, it is noted that softness decreases on fusing and varies in the range from 0.9cm to 2.3cm. When sewn, the softness further decreases as in the case of samples cut along backbone samples and ranges from 1.0cm to 2cm. The decrease in softness is found to be less for samples fused with F2.

3.3 Bond Strength

The bond strength of fused systems is also one of the most important parameters which influence, the quality of the garment. The main aim of this test is to study the mechanical stability of the adhesive layer between leather and fusing fabric. During fusing, temperature, pressure and duration of operation are the key factors determining the bond strength apart from the material properties. Bond strength values of the composites made of leather and different types of fusing material are given in Table 4. The minimum requirement for bond strength of a fused composite of leather is 0.5N/mm as per SATRA TM 401. It is observed that the interlining F3 has the highest bond strength of the order of 0.7 - 0.8 N/mm followed by F1 with bond strength ranging from 0.4 N/mm to 0.6 N/mm. The bond strength of fused composite with F2 interlining is the least of all the three interlinings. The reason being, the degree of penetration of the adhesive into the structure of the material is more in F3 interlining, thus enabling a deeper and a bigger contact area. Therefore, more energy is required in the breaking of bonds and hence the bond strength is high. A less variation in bond strength is observed for samples fused with interlining F1, which is mainly because of abrading interlining surface. A very large variation in the bond strength is observed for samples fused with F2 and it may be due to the appearance of shear phenomenon between layers. The shear forces may cause rippling or localized delamination in fused composites. Thus, the bond strength is very important in terms of non – occurrence and severity of rippling. The higher the bond strength, the lower is the potential to buckle or ripple.

Table 4—Bond strength (N/mm) of sheep nappa leathers with interlining[a]

Leather sample	F1	F2	F3
Along the backbone			
S1	0.38±0.03	0.20±0.08	0.64±0.03
S2	0.43±0.09	0.12±0.05	0.72±0.09
S3	0.29±0.02	0.13±0.02	0.64±0.04
S4	0.24±0.11	0.17±0.04	0.64±0.03
Across the backbone			
L1	0.6±0.10	0.19±0.10	0.7±0.10
L2	0.4±0.10	0.30±0.08	0.8±0.10
L3	0.5±0.10	0.14±0.10	0.8±0.01
L4	0.5 ±0.03	0.14±0.04	0.8±0.10

[a]Values are given as the average of six measurements taken along with standard deviation values.

3.4 Shrinkage

Shrinkage of fused garment parts is a very common and serious problem. This problem could arise from improper fusing press settings, non-uniform pressure, temperature and defects in interlining. Excess shrinkage may cause sizing problems as the finished garment will be smaller than it was planned. It also leads to formation of puckered seams. The differential shrinkage induces shearing forces on the points of fusing which can separate the bond if the bond strength is not high enough and once the bond is separated, the potential to buckle or ripple would be high. Excess mechanical action during garment fabrication can cause excessive shrinkage of fused composites and weakening of bond strength. Therefore, based on the understanding of the causes of shrinkage, in order to prevent shrinkage the outer shell and the fusible interlining must be compatible. Shrinkage values of the composites of sheep nappa leathers with different fusing materials are given in Table 5.

It is shown that specimens fused with F2 exhibit the maximum shrinkage which may be because of the incompatibility between shell and fusible interlining, whereas with F1 and F3 the % shrinkage is almost negligible and in many cases, no shrinkage has been observed at all. For samples cut across the backbone, leathers fused with F2 shrunk to a greater extent compared to those of F1 and F2.

3.5 Tensile Strength

Tensile strength of a material is the maximum amount of tensile load it can be subjected to before it leads to failure. Tensile characteristic is an important property as it relates to strength and performance of

Table 5—Shrinkage (%) of sheep nappa leathers along the backbone[a]

Leather sample	Along length of fused sample			Along width of fused sample		
	F1	F2	F3	F1	F2	F
			Along the backbone			
S1	–	2.3±1.5	–	–	1.8±1.0	0.13±0.2
S2	0.2±0.3	1.3±1.2	–	–	1.3±1.5	–
S3	–	2.3±0.6	–	–	2.3±0.6	–
S4	–	2.0±1.8	–	–	1.5±2.1	–
			Across the backbone			
L1	0.33±0.3	2.2±0.70	–	–	1.2±1.00	–
L2	–	1.2±0.80	2.0±1.4	–	1.3±0.30	0.5±0.7
L3	0.2±0.2	1.6±0.28	–	0.3±0.5	1.2±0.28	–
L4	–	2.0±0.50	–	–	1.0±0.30	–

[a]Values are given as the average of six measurements taken along with standard deviation values.

Table 6—Tensile strength (Mpa) of sheep nappa leathers along backbone[a]

Leather sample	Plain leather	Leather with fusing			Fused leather with single stitch along the length		
		F1	F2	F3	F1	F2	F3
				Along the backbone			
S1	16.2±2.7	12.9±2.6	12.3±2.4	14.3±4.0	10.3±3.2	12.3±4.7	17.0±6.2
S2	9.3±1.5	7.1±1.2	8.2±2.0	9.3±2.3	8.9±2.6	8.8±3.5	10.7±2.5
S3	11.5±3.5	11.0±3.8	15.0±4.7	18.3±4.7	12.4±4.2	10.9±3.8	13.9±3.2
S4	5.7±2.1	3.7±0.5	5.3±2.1	5.4±0.8	8.1±1.2	7.4±0.7	10.0±1.1
				Across the backbone			
L1	14.2±2.6	12.6±1.8	14.1±2.0	13.9±1.8	8.6±2.8	9.1±1.9	9.03±0.5
L2	9.1±1.3	8.5±1.5	8.6±0.8	9.3±0.7	7.8±0.1	6.5±0.3	8.7±0.9
L3	13.4±2.1	11.2±0.4	11.4±0.6	12.1±1.3	14.5±2.2	12.6±3.1	16.03±2.5
L4	8.5±0.6	7.9±1.1	9.0±1.2	7.9±0.9	6.6±0.2	7.01±0.5	8.2±0.7

[a]Values are given as the average of six measurements taken along with standard deviation values.

the material. The results of the measurements of tensile strength of plain, fused composites and stitched fused composites are given in Table 6. The strength decreases for almost all samples on fusing and on sewing. It is obvious that the low tensile strength is due the arrangement of fibres in the woven/ skin matrix. Among the fused composites leather fused with interlining F3 has the highest tensile strength because F3 is a composite material having rayon in the warp direction and polyester in the weft direction. This combination of a strong rayon yarn woven with the polyester yarn leads to higher tensile strength compared to the other two fusing composites. The presence of only cotton yarns in F2 and F3 have led to the decrease in tensile strength.

3.6 Double Hole Stitch Tear

This test has become quite popular because only a small amount of leather is required to make this test and the procedure is simple. During this test, the force exerted is essentially perpendicular to the specimen and fibres. The double hole stitch tear strength of plain sheep nappa samples and fused samples when tested along and across the backbone is given in Table 7.

There is a significant increase in stitch tear strength for samples fused with F3 followed by F1 along the backbone. A consistent trend is not seen for samples fused with F2. A look at the specimens tested across the backbone prove, that on fusing, there is a very good increase in tear strength values for all the three types of fusing and the samples fused with F3

Table 7—Double hole stitch tear (N) of sheep nappa leathers along backbone[a]

Leather sample	Plain leather	Leather with fusing		
		F1	F2	F3
		Along the backbone		
S1	35.2 ±4.7	44.04±3.3	35.6±6.1	57.76±1.2
S2	40.9±7.9	44.3±4.3	39.16±2.7	65.2±9.4
S3	30.1±8.5	42.5±11.0	28.59±1.7	62.62±4.3
S4	36.6±3.5	48.3±2.7	45.58±9.0	61.79±9.1
		Across the backbone		
L1	37.50±6.6	65.07±13.1	52.73±10.6	75.17±5.6
L2	23.7±2.6	57.74±5.0	46.0±9.1	69.05±12.1
L3	35.64±7.2	49.8±3.04	63.32±5.7	68.93±5.6
L4	39.0 ± 8.0	63.3± 4.8	60.3 ± 8.5	72.0± 13.7

[a]Values are given as the average of six measurements taken along with standard deviation values.

dominates the most as shown for the samples cut along the backbone with a percentage increase ranging from 87 to 100, while there is a 40 -143% increase for F1 and 40 - 94% for F2.

4 Conclusion

It is evident that fusible interlinings F3 followed by F1 perform well in the areas of bond strength, shrinkage, tensile strength, bending and double hole stitch tear strength both along and across the backbone. The reason being, F3 is a composite material containing both rayon and polyester. The combined effect of both the fibres has led to an enhanced and outstanding performance which outbeat manufacturer's recommendation for selection of interlining which is not a reliable predictor of performance. These tests are one of the most important in determining satisfactory performance of fusible interlinings. Further research using other types of skins and interlinings will be carried out to determine whether the obtained results can be generalized to specific structures of fusible interfacings.

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