Indian Journal of Fibre & Textile Research
Vol. 34, March 2009, pp. 76-81

Influence of softening treatments on hand value of woven fabrics produced from Indian wool and their blends

D B Shakyawar[a] & B K Behera

Department of Textile Technology, Indian Institute of Technology, New Delhi 110 016, India

Received 10 September 2007; revised received and accepted 7 March 2008

The effect of different softening treatments on low stress mechanical properties and hand values of fabrics produced from Indian wool and their blends has been studied. The extensibility, tensile resilience and coefficient of friction of the fabrics significantly (p>0.05) increase after softening treatments, whereas the bending and shear rigidities and their hysteresis, and compressional resilience reduce. The Koshi (stiffness) values of wool and wool blended fabrics decrease by 5-10% of that of untreated fabrics after softening treatments. However, the Numeri (smoothness) and Fukurami (fullness and softness) values increase by 10-40%. The fabrics treated with cationic and amino silicone softeners show total hand value (THV) higher than that of untreated fabrics; THV increases by 5-20% and 10-20% for winter suit and jacket application respectively. The amino silicone softener is more effective than cationic softener.

Keywords: Hand value, Low stress mechanical properties, Softening treatment, Wool, Woven fabric

1 Introduction

After weaving, the fabric tends to have hard and stiff hand due to residual tension, which gives rise to high level of pressure between the yarns. Various finishing treatments are given to loom state fabric to release residual tension. The finishing treatments, like application of steam, water, heat, tension, pressure and chemical, influence the mechanical interaction between interlacing yarns in the finished fabric, which, in turn, determines the fabric handle and making-up quality. The application of softeners considerably improves the quality of textile materials by modification of fibre surface which changes the physical and chemical nature of wool fibre surface.[1] The cationic and amino silicone softeners are most commonly used on wool products. The organic cationic softeners are usually alkyl quaternary ammonium derivatives which provide optimum performance at low production cost. Silicone softeners are more recent development in wool softening technology and there have been significant changes in the nature of the products used.

Attempts have already been made on exploratory study to utilize coarser Indian wool and their crossbred wool for the production of better quality fabrics by blending the wool with man-made fibres and other finer wool, and using various yarn and weave structures.[2-4] In continuation of same approach, the present study was carried out to improve the low stress mechanical properties and hand value of wool and wool blended fabrics by imparting cationic and amino silicone softening treatments.

2 Materials and Methods

2.1 Materials

Pure wool fabrics produced from different wool fibres, such as native, crossbred and exotic, and the fabrics produced from blends of Bharat merino (crossbred) wool with polyester and viscose fibres and also with coarser (native) wool were used for this study. The details of fabric are given in Table 1.

2.2 Methods

2.2.1 Softening Treatments

To improve the low stress mechanical properties and hand value, fabric samples were given two types of softening treatments, namely cationic and amino silicone softeners.

2.2.1.1 Cationic Softeners

The alkyl quaternary ammonium based cationic softener was used for softening the fabrics. The softening treatment was given using pad-dry-cure method. A 10 g/L of cationic softener solution was prepared, maintaining the pH of the solution at 6.0

[a]To whom all the correspondence should be addressed.
Present address: Division of Wool Technology, Central Sheep & Wool Research Institute, Avikanagar 304 501, Via –Jaipur (Raj.).
E-mail: dbshakya_67@yahoo.co.in

Table 1 — Detail of fabrics and softening treatment

[Yarn linear density – 88/2 tex, Twist – 515 turns / m, Type of spinning system – worsted, Weave structure – plain and fabric sett – 15 ends/cm × 15 picks/cm]

Fabric code	Fibre mix	Blend ratio %	Softening treatment
AM1	Australian merino wool	100:00	Control
AM2	Australian merino wool	100:00	Cationic
AM3	Australian merino wool	100:00	Amino silicone
BM1	Bharat merino wool	100:00	Control
BM2	Bharat merino wool	100:00	Cationic
BM3	Bharat merino wool	100:00	Amino silicone
CH1	Chokla wool	100:00	Control
CH2	Chokla wool	100:00	Cationic
CH3	Chokla wool	100:00	Amino silicone
BMP1	Bharat merino wool- polyester	50:50	Control
BMP2	Bharat merino wool - polyester	50:50	Cationic
BMP3	Bharat merino wool –polyester	50:50	Amino silicone
BMV1	Bharat merino wool –viscose	50:50	Control
BMV2	Bharat merino wool –viscose	50:50	Cationic
BMV3	Bharat merino wool –viscose	50:50	Amino silicone
BMCH1	Bharat merino – Chokla wool	50:50	Control
BMCH2	Bharat merino – Chokla wool	50:50	Cationic
BMCH3	Bharat merino – Chokla wool	50:50	Amino silicone

AM — Australian merino, BM — Bharat merino, CH — Chokla, P — Polyester and V — Viscose.

using small quantity of acetic acid. The temperature of the solution was brought to 40°C and then the fabrics were dipped into the solution for 15 min. The treated fabrics were padded at 1 kg/cm^2 pressure to achieve 80% expression in order to get optimum pick-up of 0.8% owm. Then the fabrics were dried at 100°C for 3 min and cured at 150°C for 4 min in drying and curing machine (Make: Ernst Benzag, Switzerland).

2.2.1.2 Silicone Softeners

The amino functional based polymethylsiloxanes silicone softener treatment was given using 7.5 g/L of amino silicone softener solution at *p*H 6.0 and temperature 40°C for 15 min. The padding, drying and curing of the fabric samples were carried out using the conditions similar to that used for cationic softener.

2.2.2 Fabric Evaluation

The low stress mechanical properties, such as tensile, shear, bending, compression and surface properties, were evaluated using KES set of equipments. Primary hand values (HV), i.e. Koshi (stiffness), Numeri (smoothness) and fukurami (fullness and softness), required for determination of total hand value of winter suit and jacket fabrics were evaluated on a scale of 0-5 by Kawabata hand evaluation equations using computer software.[5]

2.2.3 Statistical Analysis

To analyze the significant difference between low stress mechanical properties of untreated fabric and the fabrics treated with cationic and amino silicone softener, the critical difference (CD) at 95% probability level was calculated using the following formulae[6]:

$$\text{Critical difference (CD)} = r/\sqrt{n}$$

where r is the repeatability ($2^{3/2}\,\sigma_r$); n, the number of test for a sample ; and σ_r, the standard deviation.

The mean, standard deviation, coefficient of variation (CV), repeatability and critical difference are determined and shown in Table 2.

3 Results and Discussion

3.1 Low Stress Mechanical Properties of Fabrics

3.1.1 Tensile Properties

The fabric extensibility (EM) after softening treatment is shown in Fig. 1. It is found that the fabric extensibility increases after softening treatment, irrespective of the fibre mix and type of softening treatments. Bharat merino wool-polyester blended fabric shows highest increase in extensibility followed by pure wool and wool-viscose fabrics. The increase in extensibility is found to be significant at 95%

Table 2—Mean, standard deviation, repeatability and critical difference of low stress mechanical properties

Property	Mean (μ)	Standard deviation (σ)	Repeat-ability (r)	Critical difference (CD)
Tensile				
LT	0.7039	0.0229	0.0649	0.0324
WT	10.2	0.53	1.5	0.750
RT	51.0	2.24	6.35	3.17
EM	5.9	0.1886	0.5334	0.2667
Bending				
B	0.2919	0.0194	0.0549	0.0274
2HB	0.1759	0.0118	0.0335	0.0167
Shear				
G	1.88	0.0937	0.2652	0.1325
2HG	2.83	0.18	0.50	0.2549
Compression				
LC	0.2371	0.0237	0.0672	0.0237
RC	60.4	6.06	17.15	6.06
Surface				
MIU	0.1846	0.0082	0.0232	0.0082
MMD	0.0209	0.0019	0.0054	0.0019
SMD	10.3	0.84	2.38	0.84

confidence level; however, no significant change is found in Bharat merino –Chokla wool fabric. The increase in extensibility of fabric can be attributed to the decrease in inter-fibre and inter-yarn friction between warp and weft threads. The same may also be due to coating of elastic polymer film on the surface which improves elasticity of the yarn and results in higher extensibility of fabric.

The results of linearity to tensile (LT), tensile energy (WT) and tensile resilience (RT) of different fabrics before and after softening treatments are shown in Fig. 1. LT values of all fabrics decrease after softening treatments mainly due to increase in extensibility of the fabrics. The decrease in LT values of Australian merino, Chokla, Bharat merino-polyester and Bharat merino – Chokla fabrics is found to be significant; however, it is non-significant in case of Bharat merino and Bharat merino -viscose fabrics. The tensile energy of various fabrics does not show any trend because both extensibility and linearity of

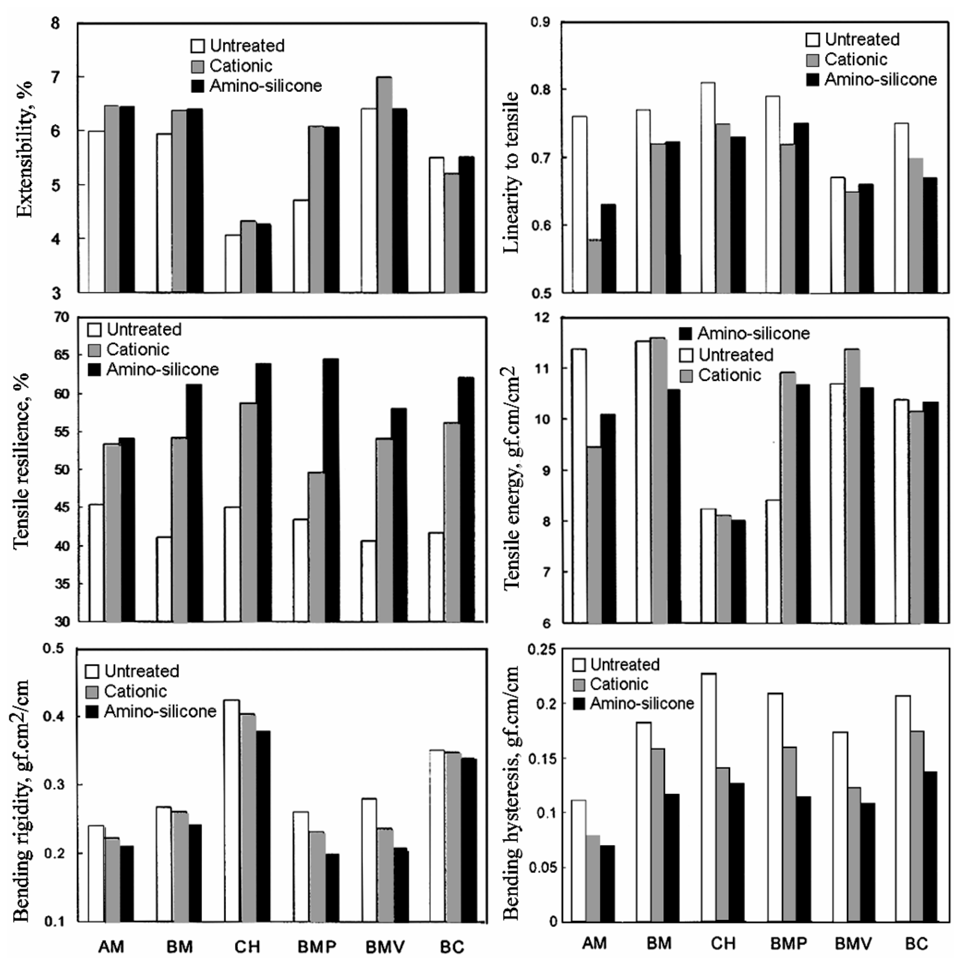

Fig. 1 — Tensile and bending properties of different fabrics

load elongation curve influence it. The tensile resilience increases significantly (p>0.05) after softening treatment for all the fabrics by 20-48% of the corresponding untreated fabrics, mainly due to lower inter-fibre as well as inter-yarn forces through modification of fibre surface by cationic and amino silicone softening treatments.

3.1.2 Bending Properties

The bending rigidity and its hysteresis of various wool and wool blended fabrics before and after softening treatments are shown in Fig. 1. Both bending rigidity and its hysteresis considerably reduce after softening treatments. The bending rigidity reduces by 3-10% for pure wool fabric, whereas it reduces significantly (p>0.05) by 11-26% for wool blended fabrics; the higher reduction in wool blended fabrics is attributed to heat setting effect at higher temperature of synthetic fibre which further reduces strain in the fibre in order to reach minimum energy level. The reduction in bending rigidity of various wool and wool blended fabrics is attributed to decrease in inter-fibre and inter-yarn forces due to formation of polymer film on the fibre surface. A significant (p>0.05) reduction (12-44%) in bending hysteresis is observed which is attributed to both the reduction in inter-yarn forces and enhancement of elastic property of the yarn due to formation of an elastic polymer layer on the surface of the fibre.

3.1.3 Shear Properties

The shear rigidity and its hysteresis of various wool and wool blended fabrics before and after softening treatments are shown in Fig. 2. There is a significant (p>0.05) reduction in both rigidity and hysteresis of shear after softening treatments, irrespective of fibre types and softeners. In general, the reduction in shear rigidity of different wool and wool blended fabric is

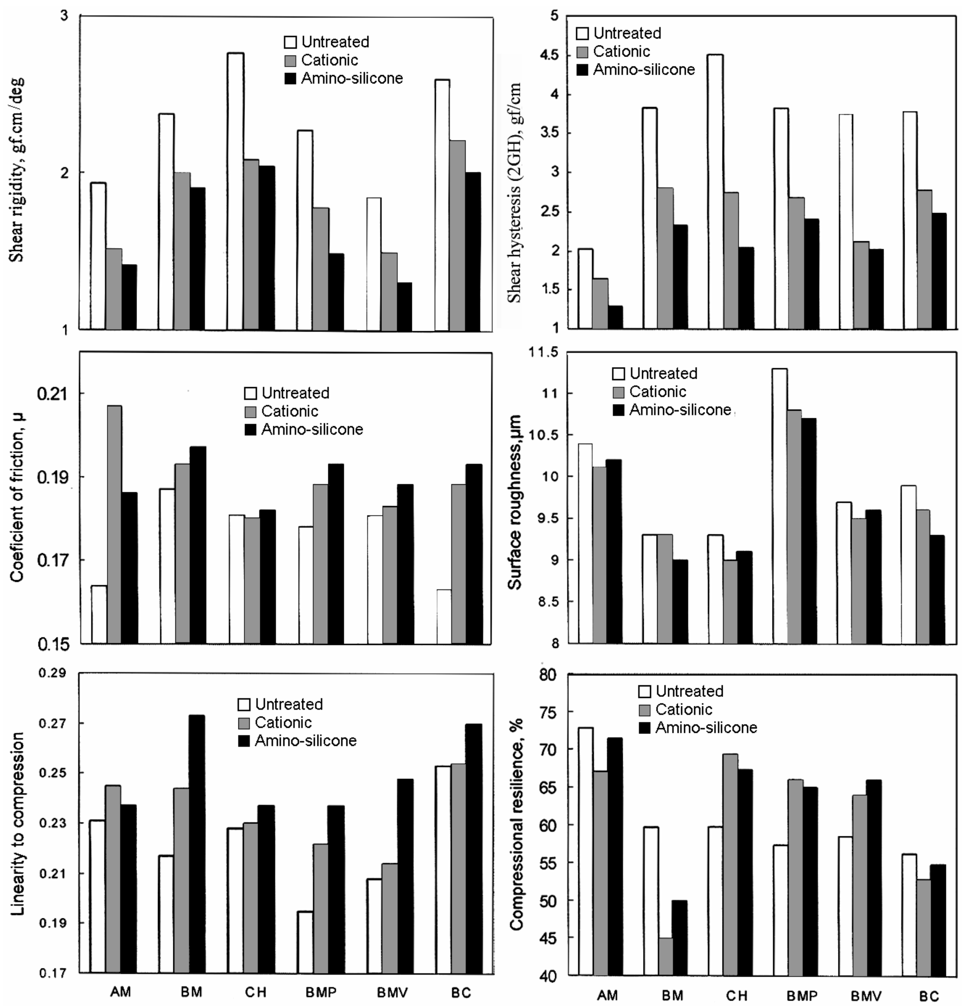

Fig. 2 — Shear, frictional and compressional properties of different fabrics

found in the range of 11-34% of their corresponding untreated fabrics; however, the reduction in shear hysteresis is observed in the range of 20-45%. The effect of amino silicone softener clearly shows an edge over the effect of cationic softener; former gives significantly higher reduction in shear rigidity and its hysteresis than later. These results are indicative of the greatly reduced inter-yarn pressure in both wool and wool blended fabrics after softening treatments because of coating of elastic polymer on the fibre surface. The coating of elastic polymer on the fibre surface improves smoothness and pliability of the yarn which makes the yarns easy to rotate at cross-over points.

3.1.4 Frictional Properties

The frictional properties in terms of coefficient of friction (MIU) and surface roughness (SMD) values of different wool and wool blended fabrics before and after softening treatments are shown in the Fig. 2. The results reveal that all the treated fabric samples irrespective of fibre mix exhibit a higher frictional coefficient (MIU) value as compared to untreated samples disregarding the type of softener used. The increase in MIU is accompanied by decrease in surface roughness (SMD). The increase in MIU of Australian merino, Bharat merino, Bharat merino-polyester and Bharat merino-Chokla wool fabrics after softening treatments is found to be significant at 95% confidence level; however, it is non-significant in case of Chokla and Bharat merino–viscose fabrics. The reduction in smoothness value is more clearly pronounced with silicone softener. The improvement in smoothness (SMD) increases the MIU value because of more number of asperities per unit area due to elastic polymer layer formation, which, in turn, increases area of contact and results in higher coefficient of friction.

3.1.5 Compressional Properties

The fabric compressional properties, i.e. linearity of load-thickness curve (LC) and compressional resilience (RC) values for different wool and wool blended fabrics before and after softening treatments are shown in Fig. 2. It is clearly observed from figures that LC values of Bharat merino, Bharat merino-polyester, Bharat merino-viscose and Bharat merino-Chokla fabrics increase after amino silicone softener treatment, whereas these are non-significant in case of Australian merino and Chokla fabrics. Compressional resilience values of fabrics also increase after softening treatments irrespective of fibre mix. The increase in LC is attributed to the increase in elasticity of constituent fibres because of elastic polymer layer formation on the fibre surface.[7] All wool and wool blended fabrics also show improvement in the recovery properties after softening treatment, which improves the compressional resilience (RC) value of the fabrics; the increment in RC value is found to be in the range of 5-10% of the untreated fabric samples.

3.2 Hand Value of Fabrics

3.2.1 Primary Hand Value

The changes in primary hand value of wool and wool blended fabrics before and after softening treatment are shown in Table 3. The Koshi value of a fabric, which is a measure of stiffness, is governed by flexural rigidity of constituent fibres and yarns, which also significantly changes after finishing treatments. The Koshi values of the fabric treated with cationic and amino silicone softeners are found to be lower than the corresponding untreated fabrics. The reduction in Koshi values of the fabrics is caused by substantial decrease in bending and shear rigidities and hysteresis. The reduction in Koshi values of amino silicone softener treated fabrics is found to be higher than the corresponding fabrics treated with cationic softener. It infers that the amino silicone softener is more effective for wool and wool blended fabrics than the cationic type softener because of flexible polymer backbone and low intermolecular

Table 3 — Primary and total hand values of fabrics with different softening treatments

Fabric code	Primary hand value			Total hand value	
	Koshi	Numeri	Fukurami	Suit	Slacks
AM1	7.68	3.54	4.75	2.78	3.24
AM2	7.36	3.15	5.27	2.87	2.92
AM3	7.13	4.05	5.81	3.06	3.14
BM1	7.65	3.15	4.97	2.73	3.00
BM2	7.64	3.55	5.47	2.87	3.05
BM3	7.60	3.44	5.66	2.86	2.94
CH1	9.38	2.42	4.58	2.27	2.55
CH2	8.95	2.82	5.50	2.54	2.59
CH3	9.30	2.93	5.12	2.36	2.42
BMP1	6.74	3.00	3.79	2.52	3.10
BMP2	7.09	3.52	5.37	2.89	3.05
BMP3	7.03	3.30	4.95	2.79	3.05
BMV1	7.95	2.94	4.43	2.58	2.91
BMV2	7.32	3.50	5.15	2.85	3.11
BMV3	6.73	4.09	5.56	3.07	3.20
BMCH1	8.51	2.82	5.06	2.57	2.78
BMCH2	8.66	2.86	5.11	2.54	2.66
BMCH3	8.71	2.87	5.76	2.61	2.58

forces of amino polydimethylsiloxane which increase the elasticity of constituent fibre.[8]

The Numeri (smoothness) value of fabric is a function of surface characteristics of fibres and yarns used for fabric manufacturing. It also depends on nature of chemical treatment. The Numeri values of the different wool and wool blended fabrics are shown in Table 3. It may be clearly observed that the Numeri values of the fabric treated with both cationic and amino silicone softeners are increased by 5-10% of the corresponding untreated fabrics. The effect of amino silicone softener is found to be more effective than the cationic type softener. The increase in Numeri value is caused by the substantial decrease in mean deviation of MIU (MMD) and surface roughness (SMD) of the treated fabrics due to formation of elastic polymer layer on the fibre surface.

The Fukurami value is a measure of fullness and softness of a fabric, and it mainly depends on compressional properties of the fabric. The Fukurami values of the treated fabrics are shown in Table 3. The results reveal that the Fukurami values of treated fabrics are increased by 10-25% of their corresponding untreated fabrics. The increase in Fukurami values is caused by the substantial changes in compressional energy (WC) and compressional resiliency (RC) of treated fabrics. This may also be due to the increase in fabric thickness. The amino silicone softener is again found to be more effective than the cationic softener, because of their flexible polymer backbone and low intermolecular forces.

3.2.2 Total Hand Value

The total hand values for winter suit and jacket applications of wool and wool blended fabrics are shown in Table 3. It is observed that the wool and wool blended fabrics treated with cationic and amino silicone softeners show higher total hand value than that of their corresponding untreated fabrics for winter suit and jacket applications. THV of wool and wool blended fabrics for winter suit and jacket applications increases by 5-20% and 10-20% respectively of the corresponding untreated fabrics. The increase in THV of wool and wool blended fabrics after both softening treatments for winter suit and jacket applications is mainly because of the increase in Numeri and Fukurami values and decrease in Koshi values of corresponding untreated fabrics. Overall effect of amino silicone softening treatment on primary hand values of different wool and wool blended fabrics is found higher as compared to cationic types of softener, which, in turn, gives higher THV value than cationic softener.

4 Conclusions

4.1 The extensibility, tensile resilience and linearity to compression of fabrics increase significantly after softening treatments, whereas the tensile linearity, tensile energy, bending and shear rigidities, and their hysteresis as well as compressional resilience reduce.

4.2 The Koshi value decreases, whereas the Numeri and Fukurami values of wool and wool blended fabrics increase significantly after softening treatments.

4.3 THV of wool and wool blended fabrics increases by 5-20 % of the corresponding parent fabrics for winter suit application, whereas for jacket fabrics, the THV increases by 10-20% of its control value after applying softeners.

4.4 The amino silicone softener is found to be more effective than cationic softener.

Industrial Importance: The study helps in enhancing the fabric quality in respect of soft feel and comfort. Crossbred wool produced in India can be utilized for suiting fabrics after giving softening treatment.

Acknowledgement

The authors are thankful to the Council of Scientific and Industrial Research, New Delhi, for financial support.

References

1 Jang K O & Yeh K, *Text Res J,* 63 (1993) 557.
2 Behera B K & Shakyawar D B, *Text Asia*, 20 (12) (2003) 40.
3 Behera B K, Shakyawar D B & Srinivasan S, *Text Asia*, 21 (1) (2004) 44.
4 Behera B K, Shakyawar D B & Rajesh Mishra, *Text Asia*, 23 (5) (2003) 17.
5 Kawabata S & Niwa M, *J Text Inst,* 80 (1989) 19.
6 Ly N G, *Text Res J,* 59 (1989) 17.
7 Tzanov T, Betcheva R, Hardalov I & Hes L, *Text Res J*, 68 (1998) 749.
8 Joynar M M, *Text Asia*, 6(1989) 55.