

Feltability of coarse wool and its application as technical felt

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In this study, attempts have been made to utilize the coarse wool for the production of felt for technical textile applications. The feltability of coarse wool is found to be very low due to larger fibre diameter, less number of scales per cross-section as compared to fine wools. Hence, it is blended with different proportion of fine wool for preparing the felt with acceptable norms. Effort has also been made to partially remove the kemp fibre by passing the coarse wool through a woolen breaker card. The blend level of such processed coarse wool and fine wool is optimized in terms of feltability behavior. Technical felts of three different qualities have been prepared using optimized blend of coarse and fine wools and their performance properties like thermal insulation, resilience and abrasion resistance are evaluated. The results show that coarse wool in blends with medium fine wool in the ratio of 60:40 can be utilized for the preparation of technical felts. The developed felts can be used as thermal insulation and sound absorption panels, and for oil and chemical absorption applications.

Keywords: Coarse wool, Felting, Kemp, Medullation, Technical felt, Thermal insulation

1 Introduction

India produces annually 43.22 million kg of wool annually, mainly consisting of carpet grade and coarse type of wool. The south Indian states including Karnataka, Andhra Pradesh and Tamilnadu contribute 25 % of total wool production. Deccani, Bellary and Kurumbai are the major wool producing sheep breeds in south India. These breeds are mainly reared for meat and not for wool. The wool produced by these animals is very coarse with greater than 50 μ fibre diameter and has a higher proportion of medullated kemp fibre. The wool is not suitable for making carpets and apparel and therefore attract very small price in the market. The preparation of woolen felt is one of the viable alternative value addition processes for these wools. Felt is formed when sheep wool or animal fur is subjected to heat, moisture and pressure or agitation. A unique property of wool fibre to produce an irreversible structure by rubbing under certain conditions is utilized to produce felt or nonwoven products. Woollen felts are used in different applications like namda, thermal insulation panels, temporary shelters in high altitude, etc. In general, felting is a form of tangling produced by the persistent rootward migration of the individual

fibres, which is caused by the directional frictional effect (DFE) of fibers¹. The felting behavior of wool mainly depends on the fibre scale, crimp, diameter and medullation. Generally, fine wool fibre has higher feltability due to its higher number of scales per unit area, higher crimp and lower diameter without any medullation². In this study, attempts have been made to remove kemp fibre through carding process, to study felting behavior of coarse wool and to find out the optimum proportion of fine wool to make felted products of different dimensions for technical application.

2 Materials and Methods

2.1 Fibre Properties

Two types of wools, viz. coarse wool and medium fine wool procured from the state of Karnataka were used in this study. The diameter, medullation percentage and staple length were measured as per standard procedure described elsewhere². The surface scale patterns of the fibres were elucidated using scanning electron microscope. The two lots of wool were then dusted in industrial dusting machine and scoured using non-ionic detergent in dolley type scouring machine. The fibre was then carded in woolen breaker carding machine. The effect of carding on the fibre properties was studied.

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2.2 Feltability Study

The coarse wool was mixed with fine wool in the ratios 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 to study its felting behaviour. The feltability or felting propensity of the mixed fibres was evaluated by the wool ball forming method. In this method, 1g of fibre was taken and soaked with 1g/L anionic detergent paste (Lissapol D) for one minute. Then the fibres were rubbed in hand into ball form for 5 min. The balls were then dried in hot air oven. Finally, the diameter of the developed felt balls was measured using digital vernier caliper in nine different places of the ball and the average diameter for each ball was used to calculate the ball density in g/cm^3 . The felt ball density is used as an indication of the feltability. The smaller the ball, the greater is the felting propensity. In other words, the higher the value of the ball density, the greater is the feltability of the fibres^{3,4}.

2.3 Technical Felt Preparation

The coarse wool was mixed with medium fine wool in different proportions, viz. 80:20, 60:40 and 40:60 (Sample codes A, B & C respectively) and converted into 6×4 feet size felt. Three different felts were produced from each blend by varying the amount of fibre weight, viz. 2, 3 and 4kg respectively. The felts were given sample code light weight (L), medium weight (M) and heavy weight (H). Thus, in total nine technical felts namely AL, AM, AH, BL, BM, BH, CL, CM and CH were produced using three different blends. The felts were produced from a number of processes, viz. web formation, web laying, milling and hardening. Firstly, the fibres were passed through woollen breaker card and the carded web was laid on grey cotton fabric in a required size. The milling was done by sprinkling soap solution on the web followed by manual rolling of the web in cylindrical direction repeatedly. Finally, the pre-milled webs were hardened using roller fulling machine into felts.

2.4 Testing Methods

The thickness, compressibility and resiliency of the felt were measured using a thickness gauge. The aerial density (g/m^2) of the felt was measured by the weighing method. The abrasion loss % of the felt was calculated at 1000 cycles of rubbing using WIRA abrasion test. The thermal insulation value was measured with SASMIRA thermal conductivity tester¹.

3 Results and Discussion

3.1 Fibre Characteristics

The fibre characteristics of coarse and medium fine wool are given in Table. 1. The fibre diameter of the coarse wool is found to be $60.39\mu\text{m}$ with 62% medullation as compared to $27\mu\text{m}$ diameter with 12% medullation of medium fine wool. The coarse wool has 40% of pure fibres with the diameter ranging from $20\mu\text{m}$ to $30\mu\text{m}$. No significant variation is observed in staple length between the fibres. The SEM pictures of coarse and medium fine wool fibres are given in Fig.1. The results show that both coarse and medium fine wools have 9-10 scales per $100\mu\text{m}$ length. However, the calculated numbers of scales/ $10000\mu\text{m}^2$ area of the coarse wool and medium fine wool are 0.66 and 2.65 units respectively. The coarse wool fibre shows 75% lesser scale frequency/ $10000\mu\text{m}^2$ area as compared to medium fine wool. There is significant difference found in the scale pattern and scale height between these wool fibres. The coarse wool exhibits flat scale pattern with very less scale height in the order of $0.1\mu\text{m}$ as compared to serrated scale pattern of medium fine wool with approximately $1\mu\text{m}$ scale height. The lower scale height and lesser scale frequency for coarse wool fibres can lead to lower directional friction effect (DFE) value.

3.2 Effect of Carding

The change in wool fibre characteristics due to carding is given in Table 1. The results show a significant difference in fibre parameters before and after carding in the case of coarse wool. This may be due to the presence of higher proportion of hair and kemp fibre in that wool. During carding, the hair and kemp fibres are removed due to their low strength

Table 1—Fibre characteristics of coarse wool and medium fine wool

Parameter	Coarse wool		Medium fine wool
	Before carding	After carding	
Staple length, cm	5.15	-	4.19
Fibre diameter, μ	60.39	50.82	27.03
Hetero fibre, %	22.14	16.83	3.84
Hair fibre, %	13.03	8.5	8
Kemp fibre, %	27.03	20.79	-
Total medullation	62.54	46.20	11.84
Scale frequency/ $1000\mu\text{m}^2$	0.64	-	2.65
Scale height, μm	0.1	-	1.0

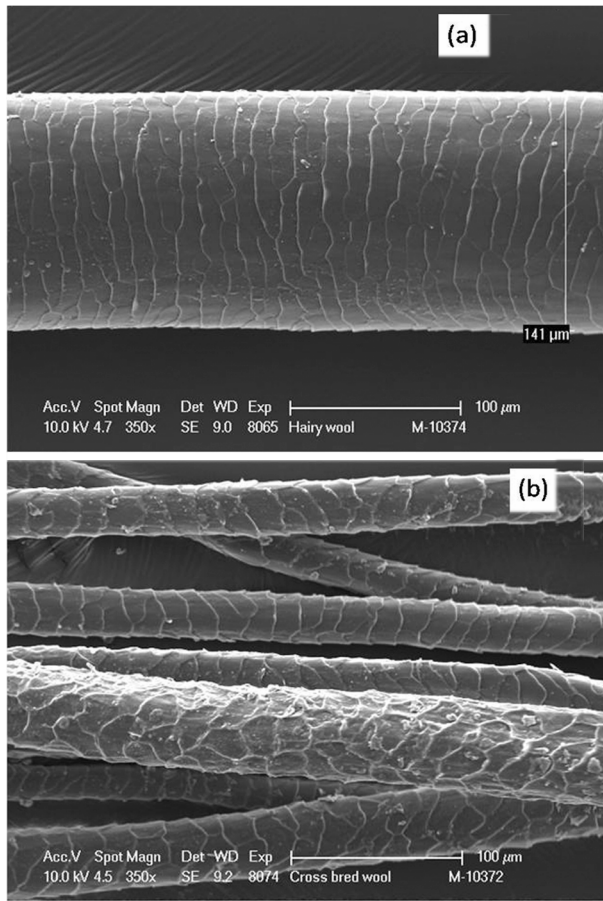


Fig. 1—SEM of coarse (a), and medium fine (b) wools

and low density. The hetero, hair and kemp fibres proportions of coarse wool are reduced to 24, 35 and 23% respectively due to carding action. The reduction in total medullation percentage is found to be 26% due to carding action. Based on the result, it is observed that the woolen breaker card can be used to remove the kemp wool present in the coarse wool.

3.3 Felting Behavior

The fibre composition of wool blends and results of feltability test carried out with coarse wool, medium fine wool and their blends in terms of diameter, volume and density of the respective wool felt balls are given in Table 2. The diameter and density of the balls are the good indicators of the felting property. The results show that coarse wool has 61% lower feltability as compared to medium fine cross bred wool. The fibre diameter, total medullation, scale frequency and scale height are the important fibre characteristics affecting the felting behavior. Though the coarse wool has similar scale frequency as that of medium fine wool, the scale height is very

Table 2—Blend composition and felt ball characteristics of coarse and medium wool and their blends

Blend, % (CW:FW)	Av. fibre diameter μm	Av. total medullation %	Felt ball diameter cm	Felt ball density g/cm ³
100:0	50.82	46.20	2.03	0.2281
80:20	42.74	41.59	1.97	0.2497
60:40	37.9	32.23	1.89	0.2828
40:60	33.72	27.62	1.88	0.2873
20:80	29.72	21.43	1.82	0.3167
0:100	27.03	11.84	1.73	0.3687

CW— Coarse wool, FW— Medium fine wool.

Table 3—Technical felt dimensional properties

Wool blend (CW:FW)	Sample code	Fibre taken for felting/m ²	Aerial density g/ m ²	Weight loss due to felting, %
Blend-A (80:20)	AL	892	801	10.21
	AM	1339	1160	13.37
	AH	1785	1566	12.27
Blend-B (60:40)	BL	892	848	4.93
	BM	1339	1294	3.36
	BH	1785	1730	3.08
Blend-C (40:60)	CL	892	860	3.59
	CM	1339	1305	2.54
	CH	1785	1741	2.46

low compared to medium fine wool. This could be the reason for lower feltability of coarse wool. The medium fine wool with higher scale height and higher scale frequency/unit area has good felting behavior. Hence, it is inevitable to mix coarse wool with medium fine wool to achieve optimum feltability. The results indicate that the blending of medium fine wool improves the feltability of coarse wool by reducing the total medullation percentage. Among the different proposition of coarse and medium fine wool blends, the 60:40 proposition of wool mix shows optimum feltability. By mixing 40% medium fine wool fibre, the feltability of coarse wool is increased by 24%.

3.4 Dimensional Properties of Felt

Based on the feltability study by the felt ball method, industrial grade technical felts were produced out of coarse wool by blending with medium fine wool. The dimensional characteristics of the developed felts are given in Table 3. The fibre loss during the felt manufacturing process is found to be higher in felts made from 80:20 coarse wool: fine wool blend compared to others. This is mainly due to the higher proportion of hair and kemp fibres in the blend. The felts made of blend A show 12% average

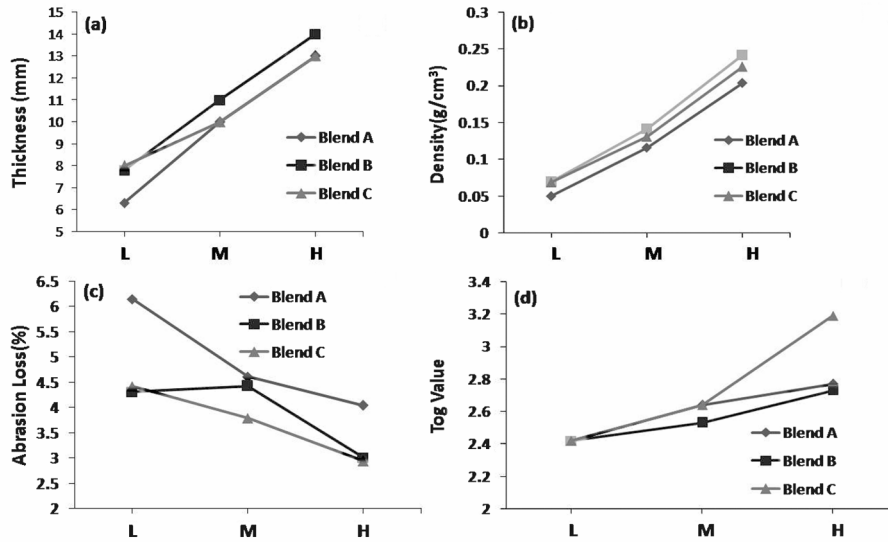


Fig. 2—Thickness (a), density (b), abrasion loss (c) and thermal insulation (d) of technical felt samples

loss compared to 3.8% and 2.9% in felts made with blends B and C. There is no significant difference in the aerial density between the blends B and C made felts. The thickness values of the produced felts are given in Fig. 2(a). The thickness of the AL felt is significantly lower due to the large amount of fibre shedding of kemp fibres. The wool felts made from blend B are slightly thicker than felts made from blend C. This is due to the optimum blend proportion of coarse wool and medium fine wool in those felts. The percentage of medullation fibre in the blend significantly influences the thickness of the felt. The density values of the developed felts are shown in Fig 2(b). The density of the felts is found to be in the range 0.05 – 0.226 g/cm³. The felts made from blends B and C show higher density as compared to blend A. However, no significant difference is observed between felts made from blends B and C. The results confirm that optimum blend proportion for coarse wool and fine wool is 60:40 for making technical felts and this is in good agreement with the results obtained for feltability using ball forming method.

3.5 Performance Properties of Felts

Results of weight loss due to abrasion of the felts which determines the wear life of the felts are shown in Fig. 2(c). The results show that the felts made of blend A exhibit higher abrasion loss followed by felts made of blends B and C, which contain higher proportion of medium fine wool. The abrasion loss % decreases with the increase in the medium fine wool content due to its higher felting tendency as compared

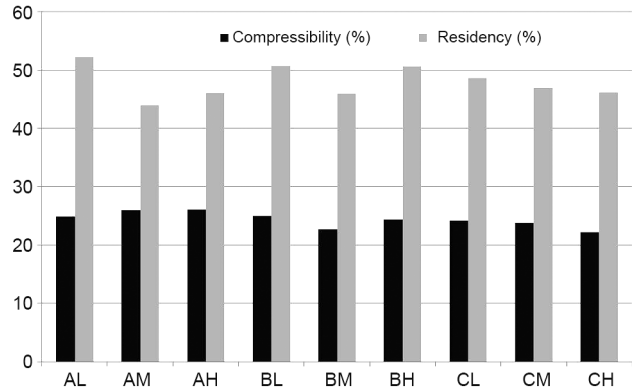


Fig. 3—Compressibility and resilience of technical felt samples

to the coarse wool. The thermal insulation value in terms of tog units is shown in Fig. 2(d). It is observed that the thermal insulation value of the felts depends on the thickness and fine wool content, and ranges from 2.5 tog unit to 3.19 tog unit. The increase in thickness and fine wool content in the felt results in increase in their thermal insulation value.

The compressibility and resilience of the felts are shown in Fig. 3. Compressibility of different blends is found in the range of 42-52%. It does not show any specific trend with change in blend and thickness. In general, lighter felt shows higher compression than heavier felts. The resiliency values of the different felts are found in the range of 22-28%. They do not show any specific trend due to change in blend proportion and thickness. In general, the compressibility and resiliency of the felts made from

blend B is found better than their counterparts due to the effective blend ratio of coarse and medium fine wool.

Based on the results, it is observed that the light weight felts (AL, BL and CL) are not suitable for technical textile application due to their low density. However they are suitable for the use as floor covering. The other felts with the density more than 0.116 g/ cm³ can be used for technical textile application.

4 Conclusion

The coarse wool has lower felting tendency due to higher proportion of hair and kempy fibres and hence is not suitable for felt production as such. The kemp fibres can be removed partially by processing the wool on a woollen breaker card. The proportion of medium fine wool to be blended with coarse wool is optimized at 40% level for the production of felt with acceptable limits. By this way, the coarse wool can be utilized for the production of felts with application in

the field of floor covering and technical purpose like thermal insulation and sound panels depending upon their density. Thus, the coarse wool which is discarded as waste can be utilized for these value-added products.

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