International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Performance of Blended Felts of Wool and Polypropylene Fibers

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Abstract: ***Impact of blending wool (W) with polypropylene (P) fibres on performance of felt has been studied. Blended Felts of three ratios; 70W: 30P, 50W: 50P and 30W: 70P were prepared in three thicknesses viz. 1-2mm, 2-3 mm and 3-4 mm. 100W felt was also prepared for base reference. Dimensional, mechanical and functional properties of felts were determined. It was found that thickness and blend ratio of felts influence their performance. Improvement in strength and abrasion resistance and compressibility of felts is observed after blending polypropylene fibre with wool fiber.***

Keywords: thickness, weight, strength, abrasion resistance, compressibility, recovery

1. Introduction

The irreversible fabric structure made of woolfibres under specific conditions is known as felt. Felt is counted in non-wovens as there are no threads in the composition of this fabric. They are based on webs of individual fibres. Wool becomes felt when it is subjected to moisture, heat and pressure.

Presently, the wool felt producing industry in India is facing various problems, including short supply of wool. It was pointed out by Batra (1998) in his study that industry needs 20-25 % more wool. This extra need can be met either by increasing production of wool fibre or by blending other fibres with wool to produce wool-blended felt. Thus there is need to study other fibres which can be easily blended with wool. Introduction of different fibres in felt making process will surely help in bringing out variety and versatility of products.

The present study has been planned to assess the utility and scope of polypropylene fibres for blending with wool to prepare wool-polypropylene felt. Polypropylene is a manmade fibre, which belongs to class of polyolefin fibre. Due to its easy availability and low cost, it is being extensively used for nonwoven textile manufacture. Its tenacity ranges from 4.5 to 6.0 gpd (Sekhari, 2011). Being a paraffinic hydrocarbon, polypropylene has negligible moisture regain and its tensile properties are not affected by water. It is resistant to insects and microorganisms. Acid and alkali has very little action on polypropylene fibre (Shenai, 1996).Wool suffers from drawbacks of sensitivity to alkali, insects, water and low tensile strength. It is expected that blending of these two fibres will improve shortcoming of wool felt. This paper reports properties of blended felts of wool and polypropylene fibers.

2. Methodology

2.1 Development of wool - polypropylene blended felt

Wool and polypropylene fibers were used to prepare blended felt. Wool fiber was obtained from Jodhpur and polypropylene fiber was purchased from Techno tech Textile LLP ,Valsad,Gujrat. Wool of Chokhla variety was used.

2.2 Blending of fibres

Blending of wool and polypropylene fibres were done in three ratios-

a) 70% wool: 30% polypropylene-70W : 30P
b) 50 %wool: 50% polypropylene- 50W : 50P
c) 30% wool: 70 Polypropylene- 30W : 70P
d) 100% wool felt was prepared for base reference. Felt of three different thicknesses were prepared-1-2mm, 2-3 mm and 3-4 mm

The size of felt was kept constant (6x4 feet).

2.3 Preparation of felt

Each experimental lot was carded on woollen card. Carded webs of blended fibers were laid down in the form of bed so as to prepare felts of appropriate thickness as mentioned above. The bed thus prepared was impregnated with an emulsion of soap in water by sprinkling. Gentle pressure by hand was given to the moist wool to remove extra soap solution. The material was then spread on a jute fabric and rolled into cylindrical form for hardening treatment in which cylinder was pushed to and rubbing with uniform pressure with the help of hands. After around 30 minute, the fibres become interlaced and matted give a coherent sheet. Simultaneously mending of thin places was done by putting extra tuft of carded web wherever needed and again rubbed till a compact strong structure was achieved. The prepared felts were then washed to remove extra alkali present in the felt samples.

2.4 Determination of physical properties of blended felt

Following properties of felt were tested by standard procedures:

2.4.1 Dimensional properties

Thickness: A pressure of 20g/cm² was applied on the felt sample to measure thickness. The thickness of the sample was taken at ten different places and average thickness in mm was calculated.

Weight: Weight in gm/sqmt was determined.

2.4.2 Mechanical properties

Tensile strength: The testing was done as directed inSection 12 of ASTM test method D461by InstronStrength Tester.

Abrasion resistance: The testing for abrasion resistance was done on the WIRA carpet abrasion machine which is designed for comparative testing for wear. The specimens were abraded at constant pressure. Per cent weight loss was calculated and rating was given to specimen.

2.4.3 Functional properties

Compression and Recovery: Shirley W.I.R.A. carpet thickness gauge designed to measure carpet thickness at pressure from 0.25 lb/inch² to 12lb/inch² was used. The compression and resiliency (recovery from compression) was measured during a complete loading and unloading cycle.

3. Results and Discussion

3.1 Properties of fibers

Table 1: Properties of selected fibers

Properties	Wool	Polypropylene
Length (mm)	86.56 (18.03%)	38.88 (2.66%)
Fineness	23.04 micron (24.09%)	1.55 denier (13.43%)
Strength (gpd)	1.25	3.5

Figure in parenthesis show CV%

It is clear from Table 1 that wool fiber is longer but coarser and weaker than polypropylene fiber. Moreover, being natural fiber, variation is higher in wool fiber than in polypropylene fiber.

3.2 Dimensional properties of experimental felts

Table 2: Influence of Blend ratio of Wool and Polypropylene on Thickness of Felt

Blend ratio	1-2 mm		2-3 mm		3-4 mm	
	Thickness (mm)	C.V. %	Thickness (mm)	C.V. %	Thickness (mm)	C.V. %
100 wool: 0 polypropylene	1.54	20.25	2.59	7.56	3.36	7.26
70 wool: 30 polypropylene	1.73	8.90	2.54	2.87	3.60	4.72
50 wool: 50 polypropylene	1.58	18.22	2.67	8.46	3.74	9.43
30 wool: 70 polypropylene	1.58	15.18	2.55	10.03	3.46	10.08

3.2.1 Thickness

It is evident from Table 2 that thickness of 1-2 mm felt ranges from 1.54 mm to1.73 mm while thickness of 2-3 mm felt ranges from 2.54 to 2.67 mm. Thickness of 3-4 mm felts varies from 3.36 mm to 3.74 mm. Study of effect of different blend ratio on thickness reveals no particular trend with the increase in ratio of polypropylene fiber. Overall it can be said that slight variation is found in thickness of pure and blended felts.

Various factors affect thickness of felt. One of which is fiber fineness. Another is fiber assembly. Felts produced by blending wool with other fibers has different structure especially fiber arrangement and interlocking. Thus variation in thickness of pure and blended felts might be due to difference in diameter of fibers as well as uneven distribution of fibers in felts which causes sampling fluctuation. Value of CV% also confirms this.

One way ANOVA has been calculated to find out effect of blend ratio on thickness of felt. Difference in thickness of felts of different blend ratio is not significant ($F = 2.02$, $p= 0.12$).

Table 3: Influence of Blend ratio and Thickness on Weight of Felt

Blend ratio	1-2 mm		2-3 mm		3-4 mm	
	Weight (g/m²)	C.V. %	Weight (g/m²)	C.V. %	Weight (g/m²)	C.V. %
100 wool: 0 polypropylene	4.12	8.90	5.64	2.48	6.30	3.33
70 wool: 30 polypropylene	2.40	9.87	4.78	4.72	5.95	10.06
50 wool: 50 polypropylene	2.67	4.68	5.43	8.23	8.77	16.64
30 wool: 70 polypropylene	2.80	24.46	4.51	3.94	6.35	5.63

3.2.2 Weight

It is clear from Table 3 that weight is increasing continuously as thickness of felt is increasing from 1-2 mm to 3-4 mm. Correlation coefficient has been determined between weight and thickness. Positive significant correlation ($r =0.62$) has been found between these two properties. As far as effect of blend ratio on weight is concerned, different trend is observed in felts of different thicknesses. Besides, no specific trend is seen with increasing ratio of polypropylene fiber in blend. It can be observed that weight of blended felts of 1-2 mm thickness decreases drastically compared to pure wool felt. Weight of blended felt of 2-3 mm thickness is slightly less than that of pure wool felt. The reason is that polypropylenewith density of 0.9 g/cm^{3}is lighter than wool fibre (density-1.32 g/cm^3).In case of 3-4 mm thick felt, weight decreases when 30% polypropylene fiber is included in the blend. On further increasing the percentage to 50, weight increases significantly and then again decreases in felt with 70% polypropylene. This may be due to uneven distribution of fibers in felt. In general, weight of felts decreases when polypropylene is mixed with wool.

Two way ANOVA has been calculated to find out effect of thickness and blend ratio on weight of felts. Difference in weight of felts of different thicknesses is found significant ($F = 243.87$, $p= 0.00$). Similarly effect of blend ratio is also found significant ($F = 18.24$, $p= 0.00$). Interaction between these two factors is significant ($F= 11.86$, $p=0.00$). Thus both the factors have influenced weight of the felt.

3.3 Mechanical properties of experimental felts

Table 4: Influence of Blend ratio on Tensile Strengthof 1-2 mm Thick Felt

Felt Samples	1-2 mm							
	Force (N)				Elongation (mm)			
	Weft	C.V. %	Warp	C.V. %	Weft	C.V. %	Warp	C.V. %
100 wool: 0 polypropylene	39.48	7.72	86.88	9.43	19.74	7.71	52.72	8.63
70 wool: 30 polypropylene	28.07	6.48	39.12	10.15	14.03	6.48	19.56	10.15
50 wool: 50 polypropylene	101.04	13.76	72.96	9.48	65.12	7.351	127.70	6.51
30 wool: 70 polypropylene	88.25	11.90	175.66	14.24	141.18	1.63	48.06	7.93

Table 5: Influence of Blend ratio on Tensile Strength of 2-3 mm Thick Felt

Felt Samples	2-3 mm							
	Force (N)				Elongation (mm)			
	Weft	C.V. %	Warp	C.V. %	Weft	C.V. %	Warp	C.V. %
100 wool: 0 polypropylene	71.16	7.20	152.46	.50	168.79	7.20	98.20	13.459
70 wool: 30 polypropylene	84.5	2.15	162.72	7.72	155.38	.73	31.09	12.876
50 wool: 50 polypropylene	112.58	13.80	107.02	12.85	54.24	24.09	55.36	2.12
30 wool: 70 polypropylene	180.07	16.12	297.43	6.46	66.20	21.75	34.31	12.25

Table 6: Influence of Blend ratio on Tensile Strengthof 3-4 mm Thick Felt

Felt Samples	3-4 mm							
	Force (N)				Elongation (mm)			
	Weft	C.V. %	Warp	C.V. %	Weft	C.V. %	Warp	C.V. %
100 wool: 0 polypropylene	100.55	.87	128.53	2.86	53.79	4.81	31.29	5.17
70 wool: 30 polypropylene	120.42	.41	169.03	8.15	48.19	5.39	30.215	10.32
50 wool: 50 polypropylene	205.58	17.46	162.85	11.86	50.74	25.86	56.27	20.59
30 wool: 70 polypropylene	378.76	16.18	481.60	7.96	19.83	21.73	19.54	7.52

3.3.1 Strength

Tables 4, 5 and 6 clearly show that strength of blended felt is higher than pure felt. It is evident that strength of felt increases continuously when ratio of polypropylene is increased from 30 to 70 in felts of 2-3 mm and 3-4 mm thickness. The tensile properties of felts depend on fiber strength to some extent specially fiber mix in the blend. The polypropylene fiber is stronger than wool fiber. However, trend is different in felt of 1-2 mm thickness. Blending of 30 % polypropylene reduces strength of felt. This may be due to low percentage of polypropylene fiber or due to uneven distribution of fibers in the felts. After that it increases drastically and then again decreases but is still higher than pure felt.

Data demonstrates that warp wise strength of felts is higher than weft wise strength. The reason may be the fact that while making felt, rubbing of fibers is done in warp direction. This makes the felt more compact in warp direction.

Tables also reveal that strength of felts is increasing as thickness of felts is increasing from 1-2 mm to 3-4 mm. The reason is thickness of felts. The tensile properties of felts also depend on thickness. Thick felts contain more fibers compared to thin felts so are able to bear higher tensile load.

Two way ANOVA calculated to find out effect of thickness and blend ratio on strength of felts shows significant effect of thickness of felts on strength ($F = 1022.36$, $p= 0.00$). Likewise effect of blend ratio on strength is also found significant ($F = 962.035$, $p= 0.00$). Interaction between these two factors is significant ($F=157.177$, $p=0.00$). Thus both the factors have influenced strength of the felts.

Table 7: Influence of Blend ratio and Thickness on Abrasion Resistanceof Felts

S. No.	Bend ratio	1-2 mm	2-3 mm	3-4 mm
1.	100 wool: 0 polypropylene	‹1	1	1
2.	70 wool: 30 polypropylene	‹1	1	1
3.	50 wool: 50 polypropylene	1	2	2
4.	30 wool: 70 polypropylene	3	3	4

Grade – 1 Poor, 2 Fair, 3 Good, 4 Very Good, 5 Excellent, ‹ mean – Hole formation observed

3.3.2 Abrasion resistance

Table 7 shows abrasion resistance of felts. Felt made of 100% wool fiber shows poor abrasion resistance. Besides, felt of 1-2 mm thickness also shows holes after 100 cycles whereas felts of 2-3mm and 3-4 mm thickness do not show hole. Thus abrasion resistance of thicker felt is better than that of thinner felt. Similar observation has been made by Agrawal (2006). Thicker fabric resists damage from abradants more than thinner fabric (Tortora, 1982).

When 30% polypropylene fiber is blended with wool, trend similar to pure wool felt is observed. However, when 50% polypropylene fiber is blended, poor abrasion resistance is found in 1-2 mm thick felt but felts of 2-3mm and 3-4 mm thickness show fair abrasion resistance. On further increasing the ratio of polypropylene to 70%, improvement in abrasion resistance is observed. Abrasion resistance is rated good in 1-2 and 2-3 mm thick felts and very good in 3-4 mm thick felt. Thus it can be said that abrasion resistance has improved after blending 50% to 70% polypropylene with wool fiber. The reason for improvement in abrasion resistance is inherent toughness of polypropylene fiber. Abrasion resistance of polypropylene is almost similar to nylon and is superior to that of other fibres (Sinclair,2015)..

According to Booth (1976), abrasion resistance of tough fiber is higher than that of weak fiber.

3.4 Functional performance properties of experimental felts

Functional performance of felts viz. compressibility and recovery of felt is affected by the choice of blend components. Compressibility and recovery of pure and blended felts have been tested and result is presented in Table 8.

Table 8: Effect of Thickness and Blend Ratio on Compressibility and Recovery of Felt

Thickness of felts	Blend ratio	Per cent Compressibility	CV %	Per cent Recovery	CV %
1-2 mm	100 wool: 0 polypropylene	4.63	33.55	94.53	5.93
	70 Wool: 30 Polypropylene	9.74	24.72	95.11	1.99
	50 Wool: 50 Polypropylene	7.77	32.14	96.56	2.52
	30 Wool:70 Polypropylene	9.34	11.38	90.70	3.16
2-3 mm	100 wool: 0 polypropylene	2.95	14.54	98.88	.37
	70 Wool: 30 Polypropylene	9.42	12.83	98.58	.45
	50 Wool: 50 Polypropylene	5.39	26.16	97.89	.59
	30 Wool: 70 Polypropylene	5.74	9.94	96.02	.67
3-4 mm	100 wool: 0 polypropylene	2.13	22.12	99.12	.42
	70 Wool: 30 Polypropylene	6.33	17.62	98.67	1.39
	50 Wool: 50 Polypropylene	5.06	41.592	98.71	.39
	30 Wool: 70 Polypropylene	4.12	12.846	97.18	.49

It is clear that compressibility of 1-2 mm thick felts is highest. This is followed by decreasing order of compressibility of felts of 2-3mm and 3-4 mm thickness respectively. Felting causes entanglement of wool fibers which makes felt dense and very compact. Increase in number of fibers in thicker felts further increases density and compactness. This makes thick felt less compressible. Negative correlation coefficient (r= -0.49) significant at 0.01 level is found between thickness and compressibility. This indicates that thickness has affected compressibility of felts.

Although influence of blend ratio on compressibility does not reveal any specific trend but it can be seen that compressibility of blended felts is higher than that of pure wool felts. Thus compressibility of felts enhances after blending polypropylene with wool fiber. The reason might be

So far as recovery is concerned, it is evident from Table 8 that recovery of 1-2 mm thick felt is slightly less than that of felts of 2-3 mm and 3-4 mm thickness. Positive correlation(r = 0.62) significant at 0.01 level is found between thickness and recovery property. This shows that thickness has affected recovery of felts.

Influence of blend ratio on recovery shows that slight variation is found in recovery of felts of different thickness. In blends of 2-3 mm and 3-4 mm thickness, recovery decreases marginally continuously as blend ratio increases. But in felt of 1-2 mm thickness, trend is different. It increases on inclusion of polypropylene fiber up to 50% and then decreases on further increasing the ratio to 70%. It is also found that recovery decreases after blending 70% polypropylene with wool fiber in felts of all the three thicknesses. Overall it can be said that presence of polypropylene fiber in blended felts affects recovery of felts marginally.

Difference in recovery of felts of different thicknesses is found significant (F = 23.385, p= 0.00). Similarly difference in recovery of felts of different blend ratio is also found significant (F = 7.310, p= 0.00). Butinteraction between these two factors is not significant (F= 1.212, p=0.00).

4. Conclusions

It can be concluded after analyzing the properties of felts that blending of polypropylene fiber with wool fiber has improved strength and abrasion resistance of felts. Compressibility of felts enhances after blending polypropylene with wool fiber. Besides, presence of polypropylene fiber in blended felts affects recovery of felts marginally.

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