Development of Non-woven from Recycled Wool and Acrylic fibers and its Application in Footwear Industry

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ABSTRACT

This research focuses on developing an eco-friendly foot insole from recycled textile waste, particularly using wool and acrylic fibers, to provide warmth, comfort, and durability for adults, with a focus on elderly individuals vulnerable to winter-related foot discomfort. Cold floors in winter can aggravate foot issues like plantar fasciitis, chilblains, and frostbite, leading to pain and circulation issues. The insole aims to mitigate these problems through a sustainable design using natural and recycled materials. Used wool and acrylic blankets were broken down into fibers through garneting. Five non-woven samples were developed (100% wool , 60/40 , 50/50, 40/60 and 100% acrylic) using thermal bonding technique. The effect of blend ratio on the comfort properties of the non-woven samples was studied. As the wool fiber content increases, the thermal conductivity reduces in the non-woven samples. Non-woven sample made from100% wool fibres has shown lowest thermal conductivity of 0.0374 W/m.K.

Keywords: *wool, acrylic, recycling, thermal conductivity, air permeability*

1.INTRODUCTION

The fashion and footwear industries face an increasing demand for sustainable products, primarily driven by consumer preference and environmental concerns. Textile waste contributes significantly to global pollution, and researchers are now focusing on converting this waste into useful products [1]. Various types of insole materials used in current practice include leather, foam rubbers and cellular polymers, which are available in a wide range of hardness, densities, thicknesses, and thermal, physical and mechanical properties. This research aims to create a sustainable footwear insole using fabric waste, addressing the limitations of synthetic insoles in providing comfort, insulation, and support in colder climates. Especially elderly and women doing household in barefoot for long hours are susceptible to cold-related foot issues. The insole is designed with a multi-layered structure, combining wool and acrylic for thermal insulation and durability. The insole is designed with three primary layers: moisture absorption, thermal insulation, and silicon gel for durability and shock absorption [2]. The methodology involves garnetting and fusing to create usable fibers repurposing textile waste. The project aligns with environmental and health-related objectives, reducing textile waste and offering a product that enhances user comfort and reduces the risk of foot-related health issues during colder climates.

2. MATERIALS AND METHODS

2.1 Materials

Utilized woollen and acrylic blankets were collected; these blanket fabrics were cut into small pieces, and the pieces of fabrics were fed into a garneting machine to convert the fabrics into fibrous form. The garneting process was carried out at M/s Brown & Company, Coimbatore. The images of recycled fibers are shown in Figure 1 and Figure 2[3].

Figure 1. Recycled wool

Figure 2. Recycled acrylic

2.2 Non Woven preparation

The nonwoven samples were prepared using the Hand Lay Method [1]. Five nonwoven samples were prepared by changing the blend ratio (100, 60/40, 50/50, 40/60, 100) of wool and acrylic fibers which is depicted in Figure 3. Polypropylene nonwoven webs were also used to make a sandwich material.

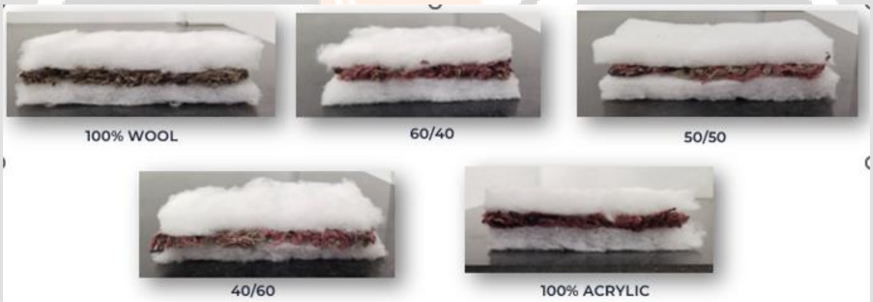

Figure 3. Non-woven samples with different blend ratio

2.3 Thermal bonding

The nonwoven sandwich material was thermally bonded using a Fulon Tech fusing machine at 200°C with 4 bar pressure. Five samples were developed at the same machine condition. Figure 4 depicts the thermal bonded non-woven samples.

Figure. 4 Thermal bonded non-woven samples

2.4 Testing

2.4.1 Air Permeability

The air permeability of the non-woven samples were evaluated as per (ASTM D 737) using MAG Solvics.

2.4.2 Thermal conductivity

The thermal conductivity of the non-woven samples was evaluated using Lees Disc method in terms of W/m/K [4-9]

3 RESULTS AND DISCUSSION

3.1 Effect of blend ratio on air permeability

The air permeability of the non-woven samples is shown in Figure 5. From Figure 5, it is identified that the air permeability increases with the increase in the amount of wool content in the sample. Highest air permeability of 10 $cm^3/sec/cm^2$ was noticed in 100% wool sample and 100% acrylic sample has given lowest value of 5.833 $cm^3/sec/cm^2$. It is found that an increase in the wool fiber content in the sample increases air permeability. The physical properties of the non-woven samples are given in Table 1.

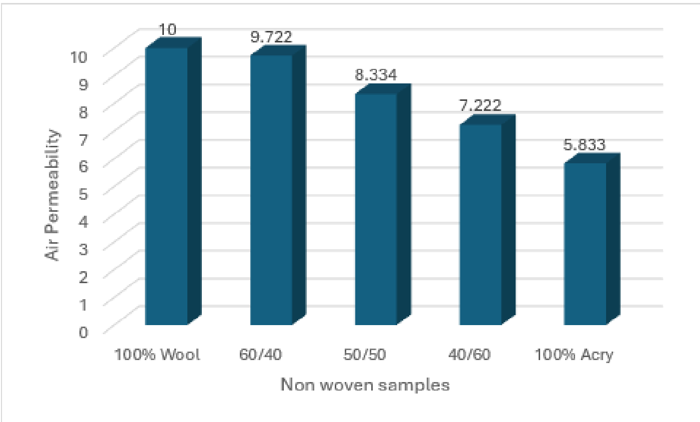

Figure 5. Air permeability of Nonwoven samples

Table 1. Physical properties of non-woven samples

S.NO	BLEND RATIOS	THICKNESS (mm)	GSM (g/m)
1	100% WOOL	3.74	670.4
2	60/40	3.62	661.6
3	50/50	3.412	650
4	40/60	3.38	622.4
5	100% ACRYLIC	3.31	540

3.2 Effect of blend ratio on thermal conductivity

The thermal conductivity of the non-woven samples is shown in Figure 6. As the wool fiber content increases in the nonwoven sample, the thermal conductivity reduces. 100% wool sample has given lowest thermal conductivity of 0.374 W/m.K. The thermal conductivity is gradually increasing with increase in acrylic fibers in the non-woven sample.

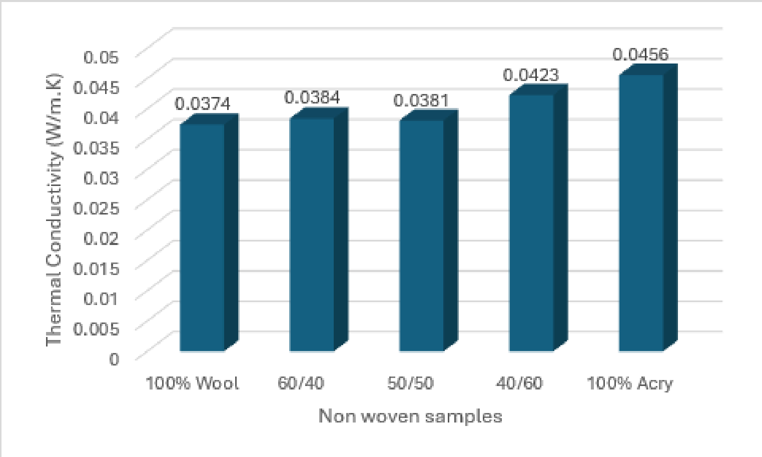

Figure 6. Thermal conductivity of non-woven samples

4. Conclusion

Non-woven samples were fabricated from recycled fibres of wool and acrylic blankets using thermal bonding technique. The effect of blend ratio of wool and acrylic fibres on the comfort properties such as air permeability and thermal conductivity were investigated. It is found that the lowest thermal conductivity and air permeability of 0.0374 W/m.K, 5.833 $cm^3/sec/cm^2$ was observed in the 100% wool and acrylic non-woven samples respectively. Further, the non- woven samples developed from this research work can be used as an insole material in foot wear industry.

5. REFERENCES

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