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A Study on the Air Permeability and Thermal Properties of Multi-layered Nonwoven Fabrics

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INTRODUCTION

One of the major applications of nonwoven fabrics is in their use as thermally insulating materials[1]. The laboratory methodology for characterizing the insulative properties of protective fabrics has been extensively studied in recent years[2-5]. This study was conducted to assess thermal resistance and air permeability of needle punched nonwoven fabrics with different levels of layer and punching density. The findings of the study provide an understanding of the insulation performance of fabric assemblies in a variety of applications, ranging from apparel to thermal insulation used in building.

EXPERIMENTAL

Single layer of fabric was made of polyester staple fibers with 2.5denier(70%) and 1.4denier(30%) and with 51mm fiber length. The web was parallel-laid and needle-reinforced after carding. Multi-layered fabric assemblies were needle reinforced by a different punching number in the range of 100~500 per cm^2 with the same depth of needle penetration of 51mm.

The weight of samples were measured according to ASTM D1910 and for thickness according to ASTM D1777-64. A Frazier Air Permeometer was used to determine air permeability of single fabric and multi-layered fabric assemblies according to ASTM D737-75. ASTM D1518-8 provided the working basis for the intrinsic thermal conductivity (k) and thermal resistance (R) measurements.

KES-F7 THERMO LABO II, consisting of a hot plate which includes a heat plate and guard plate with each electrically maintained at a constant temperature, was used. Average of four readings of wattage values per fabric type was used to calculate the intrinsic thermal conductivity and thermal resistance. The procedure was repeated for each of the fabric type.

RESULTS AND DISCUSSION

The results of thermal resistance and air permeability of needle punched nonwoven fabrics with different levels of number of layers and punching density are presented graphically in Figure 1 and 2, respectively. As can be seen from Figure 1, the thermal

resistance of nonwovens has the increasing trend with increasing number of fabric layers and decreasing with increasing punching density. Data presented in Figure 2 show that air permeability of multi-layered fabrics is directly related to number of layers, although the relationship between air permeability and punching density is independently shown.

Thermal resistance is the result of a complex combination of various factors, as is intuitively expected from a consideration of the heat-flow mechanism and of the fabric structure. Thus, the thermal resistance of the nonwoven fabrics has to discuss in terms of bulk density, specific volume and thickness of fabric to investigate the effectiveness of various factors.

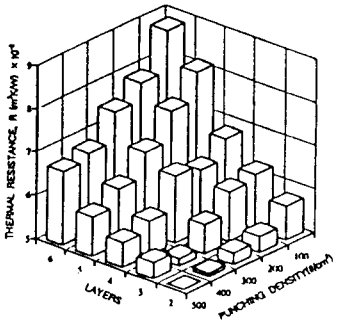

Fig. 1. Thermal resistance of needle punched nonwoven according to fabric layers and punching density

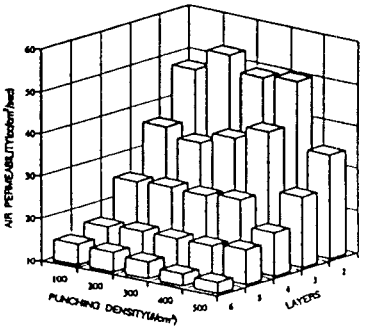

Fig. 2. Air permeability of needle punched nonwoven according to fabric layers and punching density

CONCLUSION

1. Thermal resistance of needle punched nonwoven fabrics is associated with the number of fabric layers and punching density.
2. Fabric structure has significantly contributed to both the thermal resistance and air permeability of the fabric assemblies.
3. Multi-layered nonwoven fabrics have high thermal resistance values, whereas single layer exhibits relatively high air permeability. So, the multi-layered nonwoven fabrics can be successfully utilized in thermal insulation materials.

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