INVESTIGATION OF SINGLE AND MULTI-LAYER NONWOVENS THERMAL INSULATION AND AIR PERMEABILITY BEHAVIORS

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Abstract: Textile materials have potential importance for an alternative use on thermal insulation as their porous and fibrous structure. In this study, thermal insulation and air permeability of multi-layer nonwovens with 120, 180 and 500 g/m^2 forming single and double layer were investigated. Moreover, thermal insulation and air permeability of triple-layer and four-layer nonwovens with the weight of 180 g/m^2 were analyzed. It was found that the single layer nonwovens give better thermal insulation properties than the multi-layer nonwovens. Furthermore, the increase of weight of nonwovens causes to increase in thermal conductivity coefficients. According to the air permeability measurements, the results show that the air permeability of samples decreases with the increase of weight of samples and number of layer.

Keywords: Nonwoven, Multi-layer, Thermal Conductivity, Air Permeability.

Introduction

It is very important to have thermal insulation on daily and special habitats. The thermal insulation defined as absorbing (not reflecting) the thermal energy within the material. The textile materials being fibrous and porous have potential applications where thermal insulation is necessary.
The properties of insulation and absorption of the nonwovens differ by fiber geometry and fiber regularity within the texture. It is rather difficult to identify the microstructure of the nonwovens for their complex texture. Nonwoven structure contains not only fiber as well as air gaps. Different fiber composition within the nonwovens leads to change the total surface area (Seddeg, 2009). The sound absorption properties of the textiles having porous structure (Tascan and Vaughn, 2008; Tascan and Vaughn, 2008; Shoshani and Yakubov, 2000), different fiber blends (Nick et al. 2002; Seddeq et al., 2013), stratified composition (Lin et al., 2011; Kucuk and Korkmaz, 2015), standard and hollow polyester with different weight (Abdelfattah et al., 2011). Furthermore, the effect of the acoustic characteristic of nonwovens containing polyester, viscose, glass fiber and basalt fibers on the material thickness, weight, air permeability and porosity have been studied (Yang et al., 2001). There are also more studies on the effect acoustic properties of jute, polypropylene and polyester containing nonwovens on the bases of weight, fabric type, fiber density, number of ply, the distance between the origin of sound and material, and also fiber types (Sengupta 2010).
The energy sources are running out rapidly. This situation, leads activities on especially in developed and other countries to take control of their energy needs, and lead them to search for new energy sources. The major part of the energy saving is natural thermal energy.
Nowadays it became common to use thermal insulation materials on habitants in order to reduce the energy consumption. There are a number of researches on thermal insulation behavior of waste woven fabrics (Briga-Sa et al., 2013), waste wool and regenerated polyester fibers (Patnaik et al., 2015), nonwovens (Woo et al., 1994), stratified nonwovens (Mohammadi et al., 2003), the effect of fiber diameter and porosity dimensions (Zhu and Li, 2003), nonwovens produced by pinning methods (Saleh, 2011), glass, wool, rook wool and mineral wool (Abdou and Budaiwi, 2013).
In order to use polyester nonwovens is a various applications the behavior of air permeability behavior of the weightand pinning density of the polyester viscose blend nonwovens (Zu et al., 2015; Cincik and Koc, 2012), theoretical and experimental as well as artificial neural networks of multi-ply nonwovens (Mohammadi et al., 2002; Debnath et al., 2000), the relations, the pore size effect (Epps and Leonas, 2000), the effect of thermal insulation (Debnath and Madhusoothanan, 2010), and also the relations between air permeability and sound absorption was studied (Thilagavathi et al., 2010).
In this study, the thermal insulation and air permeability properties of nonwoven fabrics with different weight were investigated. The purpose for chosen nonwovens is for being lightweight materials, making them preferable on thermal insulation. In this context, thermal insulation and air permeability of multi-layer nonwovens with 120, 180 and 500 g/m^2 forming single and double layer were investigated. Moreover, thermal insulation and air permeability of triple-layer and four-layer nonwovens with the weight of 180 g/m^2 were analyzed. The thermal insulation and

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air permeability properties of samples increase with the decrease of weight and layer numbers of samples.

Materials and Methods

Fabric

Polyester nonwovens with 45 µm fiber diameter of 120, 180 and 500 g/m^2 were used.

Preparation of Multi-Ply Nonwovens

From the polyester nonwovens having 120 and 500 g/m^2 weight of the prepared samples of single and double layer, and 180 g/m^2 polyester nonwovens single, double, triple and fourfold samples were prepared.

Measurements of the Thermal Conductivity Coefficient

Thermal conductivity coefficients of the samples were evaluated in accordance with TS 4512 Standard (TS EN ISO 10534-2) via using P.A.HILTON LTD.H940 instrument. In order to measure thermal conductivity coefficients of the samples prepared, the samples with the diameter of 25 mm was primarily experimented. The heat value (Q) in watt was determined from the digital screen of the instrument. The measurements of the thickness and area of the tested fabrics as well as heat difference between them were replaced in the following equation (Kılıc and Yigit, 2008).

$$Q = -k.A.\frac{dT}{dx}$$

In this equation, Q is the heat flow (W), A is the surface field (m^2), x is the thickness of sample (m), ΔT is the temperature difference (K) and k is thermal conductivity coefficient (W/m K). The measurements of thermal conductivity coefficient were iterated three times.

Measurements of the Air Permeability

The measurements was carried out by using 20 cm^2 circular fabric with 100 Pa pressure difference for 1 second and the results was expressed in mm/s by taken the average of five different measurement. The test was performed according to TS 391 EN ISO 923 (TS 391 EN ISO 9237) test method.

Results and Discussion

Results of Thermal Conductivity Coefficient Measurements

The thermal conductivity coefficient results of the samples with different weights and number of layers are given on Figure 1.

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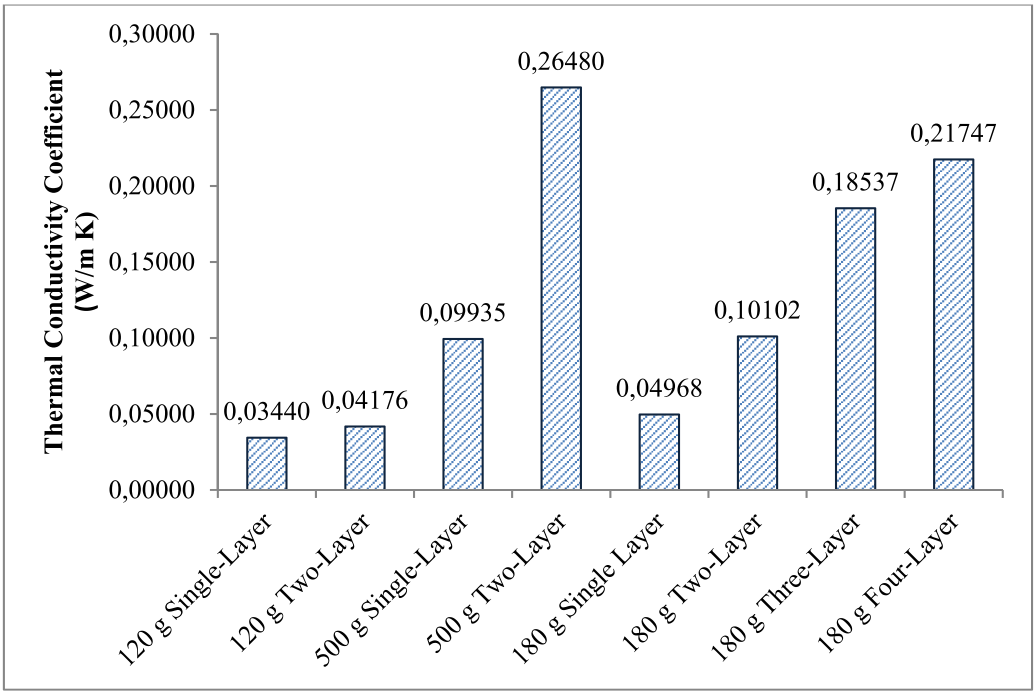

Figure 1. Thermal conductivity coefficient of samples.

Figure 1 shows that, the increased nonwoven weight increases the thermal conductivity coefficient, as a result of increased weight leads to increasing the thickness of the materials. According to the Fourier Law, the increased sample thickness and number of layers causes increasing the thermal conductivity coefficient.

The increased number of layers causes increased thickness, and as a result of this leads to increases the thermal conductivity coefficient. These results were also correlated with the air permeability of the samples decreases by increasing the number of layers and weights.

Results of Air Permeability Measurements

The air permeability results of the samples with different weights and number of layers are given on Figure 2.

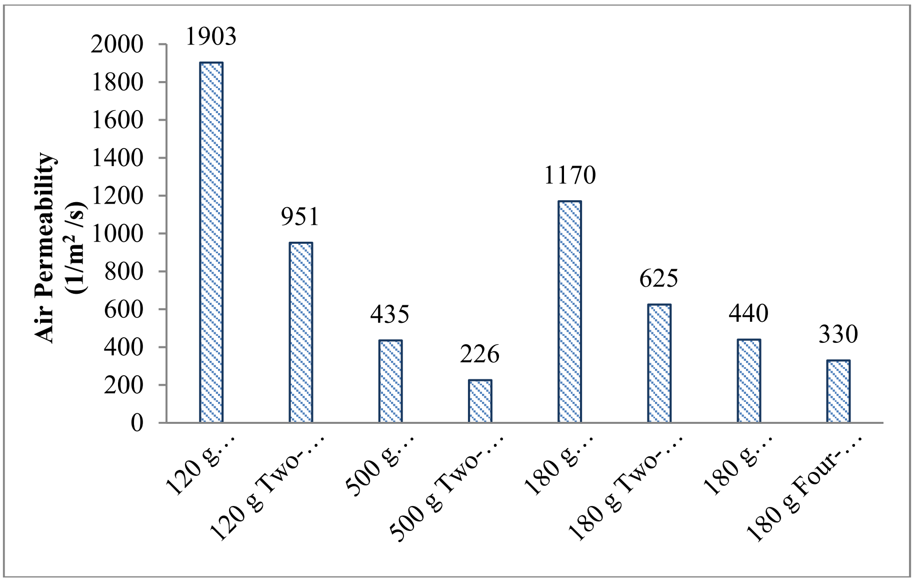

Figure 2. Air permeability measurements of samples.

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The air permeability results show that, the increased sample weight decreases the air permeability. This can be explained by the weight increasing causing to density decrease. The density increase leads to decrease the air permeability. The increased number of layers of the samples causes decrease on air permeability. This can be explained by increased number of layers causing increase on the sample thickness. The increased sample thickness causes increased air flow distance during the test and this results decrease on air permeability. Besides, the increased number of layers leads density increase.

Conclusion

In this study, the thermal conductivity coefficient and air permeability of the nonwovens with different weight and number of layers was investigated. In this context, the thermal conductivity and air permeability coefficient of polyester nonwoven fabrics with 120, 180 and 500 g/m^2 weights and also their 2,3 and 4 layers samples was investigated. As a result, the increased weight and number of layers of the nonwovens leads to increase on thermal conductivity and decrease on air permeability. The prepared nonwovens found very suitable materials as having light, cheap, high air permeability and thermal insulation properties.

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