Thermal comfort properties of nonwoven fabrics used in surgical gowns

S H Eryuruk[1], B Karaguzel Kayaoglu[1] and P Altay[1]
[1]Istanbul Technical University, Textile Technologies and Design Faculty, Textile Engineering Department, 34437, Istanbul, Turkey

eryuruk@itu.edu.tr

Abstract. Nonwoven fabrics are used for surgical gown applications due to their low cost, lightweight, durability, breathability, low hairiness and disposability. Multi-layered nonwovens with membranes are used in disposable surgical gowns to enhance protection against fluids, aerosol, toxins and microorganisms to meet the needs of surgical applications. In this study, we have analysed thermal comfort properties of SMS (spunbond-meltblown-spunbond) fabrics with three different weights (35 g/m^2, 50 g/m^2 and 80 g/m^2) and also evaluated the layered nonwoven structures with a breathable and water impermeable membrane. As a result of the study, fabric weight and layered structure had been found to have an important effect on the comfort properties of nonwoven fabrics.

1. Introduction

Multi-layered nonwovens with membranes are used in disposable surgical gowns to enhance protection against fluids, aerosol, toxins and microorganisms to meet the needs of surgical applications. Nonwoven fabrics are used for surgical gown applications due to their low cost, lightweight, durability, breathability, low hairiness and disposability. Clothing comfort is another aspect that need to be considered besides protection.

There are limited number of studies concerning the thermal comfort properties of nonwoven surgical gowns [1-6]. Pamuk et. al. evaluated the thermal comfort properties of different disposable surgical gowns (Spunlace-normal, Spunlace-reinforced, and SMS-normal) by using the thermal manikin [1]. Woo et. al. developed a theoretical model providing a reliable prediction of thermal transmission through nonwoven structures. They measured the thermal conductivity of various nonwoven barrier fabrics for the validity the model. The model explains fiber and fabric variables in determining the thermal insulation values of nonwoven barrier materials [2]. Issa et. al. evaluated the effects of the sterilisation process on their thermal comfort so they analysed some of the thermal properties of disposable surgical gowns before and after different sterilisation methods [3]. They concluded that the disposable materials used in the hospital sector (laminate,nonwoven, PE) are affected by the sterilisation process. Bogdan et. al. analysed thermal insulation of the modern materials used in medical clothing in the context of thermal comfort experienced by surgeons wearing a full clothing ensemble [4]. They stated that medical clothing ensembles made of modern materials bring about the risk of thermal stress. Aslan et. al. investigated comfort and microbial protection performances of two reusable and two disposable surgical gowns by subjective wear trials [5]. They found that thermal comfort performance of the microfiber polyester woven gown was the best according to subjective wear trial and microbial resistance test results. Disposable nonwoven gowns

had lower comfort performances despite their higher permeability and lower resistance values. Zwolinska and Bogdan studied the thermal stress of surgeons using medical coverings [6].

In this study, we have analysed thermal comfort properties of SMS (spunbond-meltblown-spunbond) fabrics with three different weights (35 g/m^2, 50 g/m^2 and 80 g/m^2) and also evaluated the layered nonwoven structures with a breathable and water impermeable membrane.

2. Materials and Methods

35, 50 and 80 g/m^2 SMS (spunbond-meltblown-spunbond) fabrics were supplied from Mogul Textile Ltd., Turkey which were the most commercially used fabric types for surgical gowns. An elastic nonporous PU membrane with a weight of 80 g/m^2 were used that is pre-laminated on to a polyester raschel knitted fabric.

Alambeta test instrument was used to test thermal conductivity, thermal absorptivity, and thermal resistance of the fabrics [7]. Permetest instrument was used to measure water vapour resistance and water vapour permeability according to the ISO 11092:2014 (sweating guarded-hotplate test) standard [8]. The air permeability of the samples was measured by using Pro-white test apparatus according to standard EN ISO 9237:199519 by applying 100 Pa constant air pressure and 20 cm^2 sample size [9].

3. Results

Comfort properties of the surgical gowns are very important in determining the overall preference. Thermal conductivity values of fabrics are presented in Figure 1. As it is seen from the figure, as the fabric weight increases, thermal conductivity of fabrics increased due to the increased amount of fibres inside the nonwoven fabrics. Membrane has not a significant effect on thermal conductivity. All three fabric structures with membrane had nearly the same thermal conductivity values which is greater than the thermal conductivity of nonwoven fabrics.

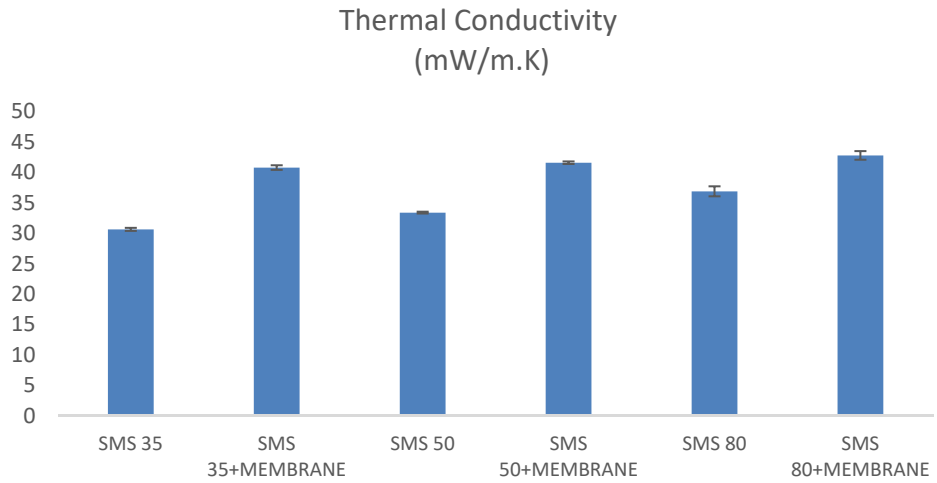

Figure 1. Thermal conductivity results

Thermal diffusion is related to the heat flow through the air in the fabric structure, higher thermal diffusion value is mainly related to bulky fabric structure and large amount of air inside the fabric. As the fabric weight increased, thermal diffusion of nonwoven fabrics decreased because of more compact structure and less air inside the fabric structure (Figure 2). Membrane increased the thermal diffusion because of more air inside the layered fabric structure.

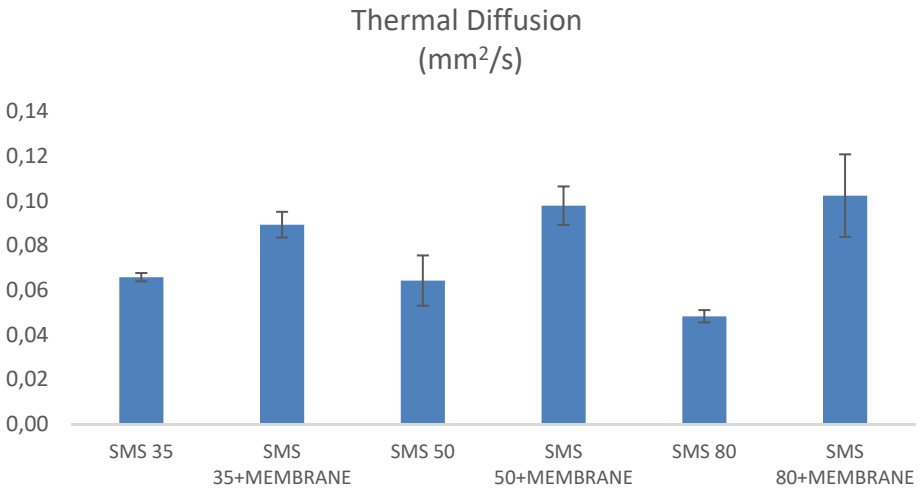

Figure 2. Thermal diffusion results

Thermal resistance represents the thermal insulation property of a fabric. According to the results, the highest thermal resistance values were obtained fabrics with membrane. Fabric weight has also an increasing effect on thermal resistance values of fabrics.

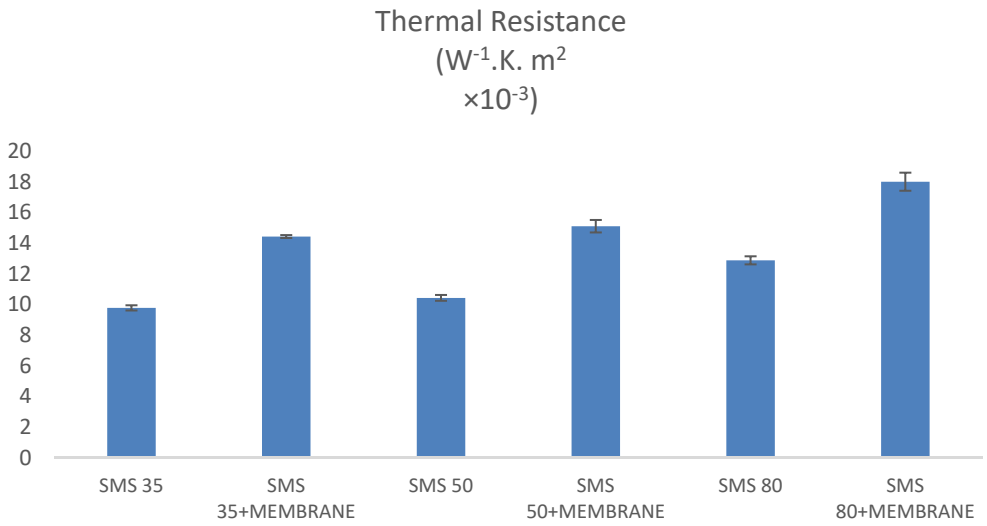

Figure 3. Thermal resistance results

Thermal absorptivity depends on the contact area between the skin and fabric surface. As it is seen from the Figure 4, thermal absorptivity increased as the fabric weight increased. Especially fabric weight 80 g/m^2 had the greatest value for thermal absorptivity because more contact area is obtained between the fabric and skin resulting to a cooler feeling. Membrane had no significant effect on the thermal absorptivity values of fabrics.

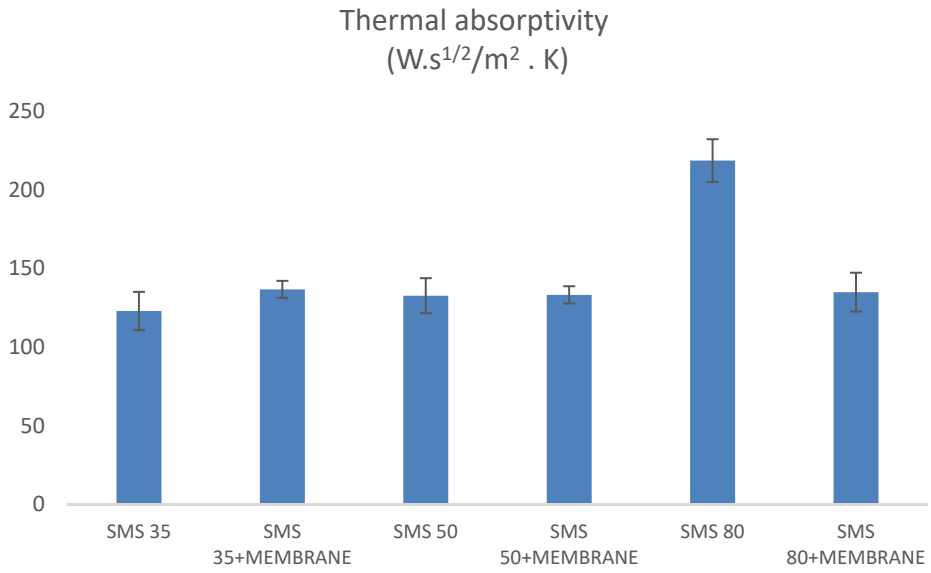

Figure 4. Thermal absorptivity results

Water vapor resistance is the ability of a fabric to allow moisture vapor to be transmitted through it. Water vapor resistance (R_{et}) values has increased as the fabric weight increased (Figure 5). Membrane had a significant effect on the R_{et} values which increased significantly. Relative water vapor permeability index of nonwoven fabrics with membrane has decreased for the nonwoven fabrics with membrane (Figure 6). Moreover, air permeability of nonwoven fabrics decreased as the fabric weight increased (Figure 7).

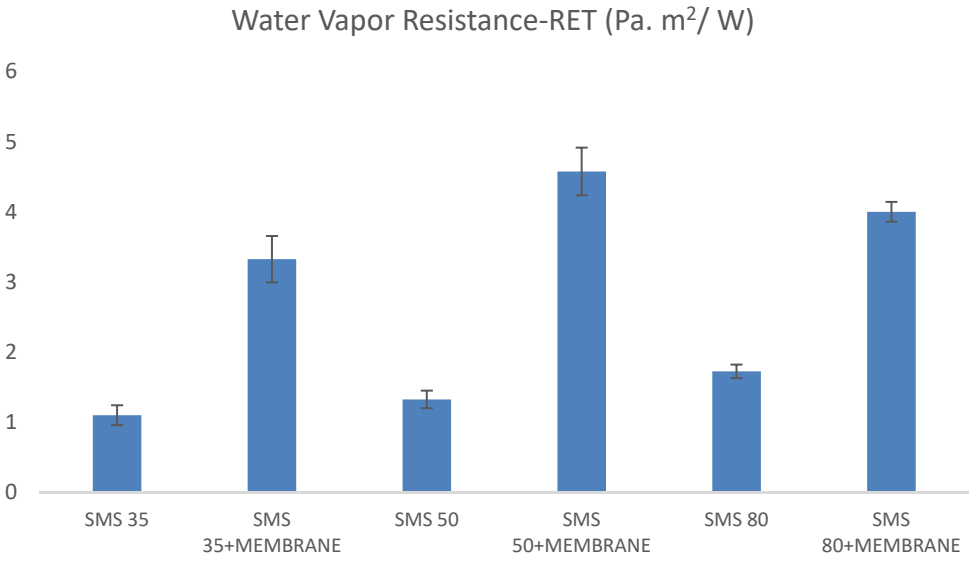

Figure 5. Water vapour resistance (Ret) results

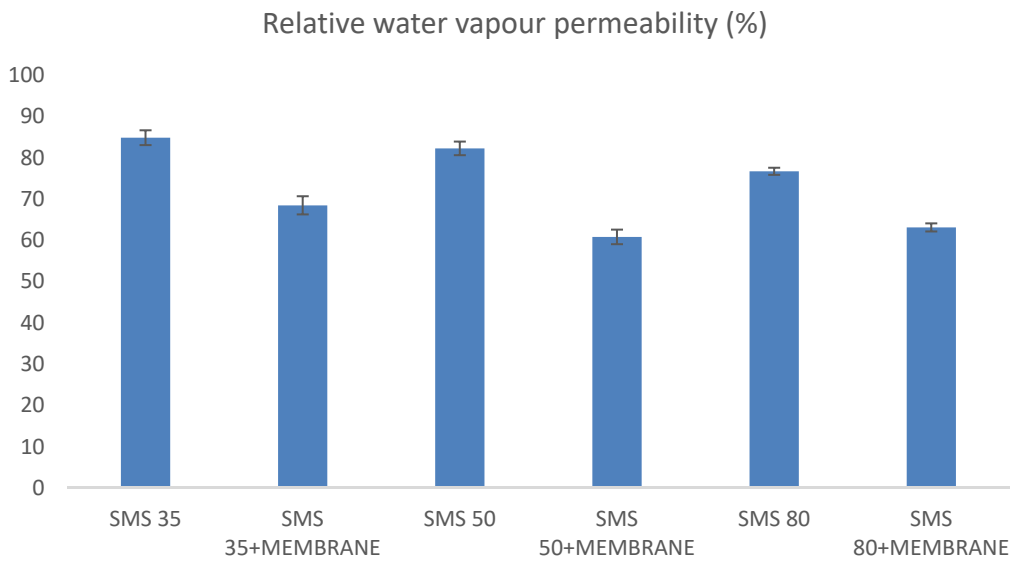

Figure 6. Relative water vapour permeability results

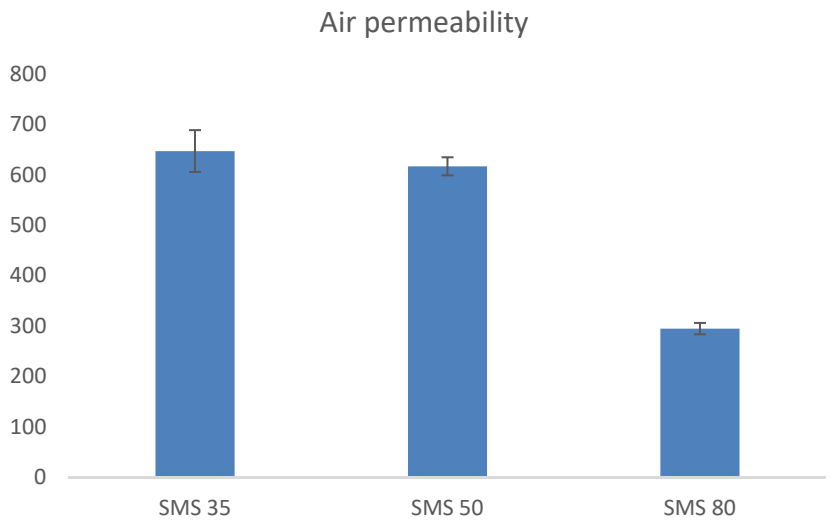

Figure 7. Air permeability results

4. Conclusions

It is very important for a surgical clothing to protect the health personnel and patient from infecting each other. Moreover, it has to meet the thermal comfort requirements to minimise physiological stress on the wearer so thermal comfort properties are needed to be evaluated like thermal conductivity, thermal resistance, air permeability, water vapour resistance and water vapour permeability values. Results of this study showed that as the fabric weight increased, thermal conductivity, thermal resistance, thermal absorptivity and water vapour resistance values of nonwoven fabrics increased whereas air permeability and water vapour permeability values decreased. The layered nonwoven structures with a breathable and water impermeable membrane had greater thermal conductivity, thermal resistance, thermal, diffusion, water vapour resistance values and lower relative water vapour permeability results. Especially membrane had a significant effect on the thermal resistance and R_{et} values. Results of this study showed that thermal comfort performances of nonwoven disposable gowns had decreased as the fabric weight increased and membrane added.

Acknowledgments
The present work is supported by ITU BAP (Istanbul Technical University Scientific Research Projects) with project number MGA-2018-41026 for the period 06.03.2018-06.03.2019.

References

[1] Pamuk O, Abreu M J, Ondogan Z, 2008 An Investigation on The Comfort Properties for Different Disposable Surgical Gowns by Using Thermal Manikin Tekstil ve Konfeksiyon **3** pp 236-239
[2] Woo S S, Shalev I and Barker R L, 1994 Heat and Moisture Transfer Through Nonwoven Fabrics
Part I: Heat Transfer Textile Research Journal **64 (3)** pp 149-162
[3] Issa M, Abreu M J, Schacher L, Adolphe D, Silva M E C, 2004 The Influence of The Sterilisation Process on Certain Thermal Properties Eur J Appl Physiol **92** pp 673–678
[4] Bogdan A, Sudoł-Szopińska I, Szopiński T, 2011 Assessment of Textiles for Use in Operating Theatres with Respect to the Thermal Comfort of Surgeons Fibres & Textiles in Eastern Europe **19** 2 (85) pp 65-69
[5] Aslan S, Kaplan S & Cetin C, 2013 An Investigation About Comfort And Protection Performances Of Disposable And Reusable Surgical Gowns By Objective And Subjective Measurements The Journal of The Textile Institute **104** 8 pp 870–882
[6] Zwolinska M and Bogdan A 2012 Impact of The Medical Clothing on The Thermal Stress of Surgeons Applied Ergonomics **43** pp 1096-1104
[7] Hes L, De Araujo M, Djulay V, 1996 Effect of Mutual Bonding of Textile Layers on Thermal Insulation and Thermal Contact Properties of Fabric Assemblies Textile Research Journal **66** pp 245–250
[8] ISO 11092:2014 Textiles -- Physiological effects -- Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test)
[9] ISO 9237:1995. Textiles-determination of permeability of fabrics to air