European Journal of
Engineering and Applied Sciences

ISSN: 2651-3412 **Journal homepage:** dergipark.gov.tr/EJEAS

Published by Çorlu Faculty of Engineering, Namık Kemal University

Original Research Article

The Effect of Laying Direction on the Characteristics of Nonwoven Fabrics

Pelin Gürkan Ünal[1,*]

[1] **Department of Textile Engineering, Çorlu Faculty of Engineering, Tekirdağ Namık Kemal University, Tekirdağ, Turkey**

Received: 10.10.2018 *Accepted: 14.12.2018*

Abstract: In this study, the effect of laying directions (cross or cross/parallel) on the mechanical and permeability properties of nonwoven fabrics produced with polyester/viscose blends was investigated. For this purpose, nonwoven fabrics made of 70% viscose/30% polyester were produced with card line and these webs were overlaid in cross-wise or cross/parallel directions to obtain the final fabric. Then, mechanical properties such as breaking strength and elongation, air permeability properties, water absorption percentages were measured in order to determine the effect of laying direction on the properties of the fabrics. Increasing the parallel web ratio in the cross direction decreased the breaking strength values, on the contrary, increasing the parallel webs ratio in the machine direction increased the breaking strength values of the final product based on the fibre orientation.

Keywords: *Nonwoven, Parallel, Cross, Mechanical, Permeability, Spunlace*

Dokusuz Kumaşların Özelliklerine Serim Yönünün Etkisi

Özet: Bu çalışmada, polyester/viskon karışımlı üretilen dokusuz kumaşların mekanik ve geçirgenlik özelliklerine serme yönlerinin (çapraz veya çapraz/paralel) etkisi araştırılmıştır. Bu amaçla, % 70 viskon /% 30 polyester karışımı içeren dokusuz kumaşlar tarak hattı kullanılarak üretilmiş ve bu tülbentler nihai kumaşı elde etmek için çapraz veya çapraz/paralel yönlerde serilmiştir. Daha sonra, kumaşın özelliklerine serme yönünün etkisini belirlemek için kopma mukavemeti ve uzama, hava geçirgenlik özellikleri, su emme yüzdeleri gibi mekanik özellikler ölçülmüştür. Enine yönde paralel serimli tülbent oranının arttırılması, kopma mukavemeti değerlerini azaltmış, aksine, makine doğrultusundaki paralel serimli tülbent oranının arttırılması, elyaf oryantasyonuna dayanan nihai ürünün kopma mukavemet değerlerini arttırmıştır.

Anahtar Kelimeler: *Dokusuz, Paralel, Çapraz, Mekanik, Geçirgenlik, Spunlace*

Geliş: 10.10.2018 *Kabul: 14.12.2018*

[*] Corresponding author.
E-mail address: pgunal@nku.edu.tr (P. G. Ünal)

1. Introduction

Nonwoven fabric production dates back to 1854 to August Belford. August Belford evaluated the card noil and bonded the short cotton fibres with starch. Even though the past of the nonwovens went long way back, until 1960's there was no increase in the production at an industrial scale. In the period of 190-1970, the nonwoven industry has grown commercially in America, and this was followed by West Europe, Japan, and Asian countries [1].

Nowadays, nonwoven products are often used in daily lives based on the single-use as cleaning-wipes, personal care products, medical and hygiene products and mostly in technical textiles etc. The industry has approximately 20% of the textile industry and it has been growing up since 1970's. Nonwovens can be produced with different techniques and in addition to limitless of production possibilities, the produced product has its own unique properties. For the web production, dry, wet and polymer laid methods are used. After web production, the fibres must be consolidated in order to form cohesion forces. Mechanical, thermal and chemical methods can be used to bind the fibres. Finally, based on the end use of the product, different finishing treatments can be applied. Moreover, there are sub-processes like cross-lapping which is a continuous web transfer machine that normally follows a card or Garnett machine as a part of an integrated dry-laid web formation system. In order to obtain the desired web weight, many layers of webs are feed from side to side onto a lower conveyor which runs perpendicular to the in-feed web. With cross lapping and parallel lapping processes, the final web formation is performed. However, there is a big distinction in these two processes in terms of fibre orientation in the final web [1].

To the best of author's knowledge, many studies and researches were done in the field of needle punched nonwovens. Midha and Mukhopadyay prepared a literature review of bulk and physical properties of needle-punched nonwoven fabrics [2]. Bulk and physical properties of needle-punched nonwoven fabric depend on the nature of component fibre, the manner in which the fibres are arranged in the structure and the degree of consolidation. In the literature review of Maity and Singha, the influence of structural parameters such as fibre orientations, packing density, specific surface area, thickness etc. on various mechanical and functional properties of needle punched nonwoven fabrics was studied [3]. In another study, different nonwoven fabrics were produced from reclaimed fibres by analytically changing the machine variables and measurements of the air permeability, mechanical properties, pore size distribution, and filtration efficiency of the nonwoven fabrics were examined. The outcome of this study reflected an overall development in all filtration characteristics due to the calendaring operation [4]. Ray and Ghosh studied the fibre cross laying as well as fibre orientation angle in cross-laid needle-punched nonwoven fabric and its relationship with tensile properties of fabric. It was found that maximum tenacity was obtained in case of cross-direction (CD) and then the tenacity gradually reduces towards machine-direction (MD) and based on statistical analysis it was found that cross-laid needle-punched nonwoven fabrics possessed reasonable isotropy in respect of both fibre orientation and tenacity in all fabrics [5]. Ahmad and his colleagues studied the use of comber noil in the production of hydroentangled nonwovens at varying water jet pressures and conveyor speeds. The results showed that these variables can help to manufacture fibrous assemblies with engineered properties, according to required application area [6]. The effect of laying directions on the mechanical and comfort properties of nonwoven fabrics produced with 100% polyester, and polyester/viscose blended was investigated [7].

In this study, the effect of laying directions (cross or cross/parallel) on the mechanical and permeability properties of nonwoven fabrics produced with polyester/viscose blends was investigated. For this purpose, nonwoven fabrics made of 70% viscose/30% polyester were produced with card line and these webs were overlaid in cross-wise or cross/parallel directions to obtain the final fabric. Then, mechanical properties such as breaking strength and elongation, air permeability properties, water absorption percentages were measured in order to determine the effect of laying direction on the properties of the fabrics.

2. Materials and Method

All the specimens were produced in cross and cross/parallel directions. The blend ratios of the webs laid in two directions were the same. All the specimens had the same gram per square meter 60 g/m^2, and the same pattern of honeycomb. The blend ratio was 70% viscose/30% polyester. Viscose fibres had fibre fineness of 1.7 dtex and 40 mm fibre length, whereas polyester fibres had 1.6 dtex fibre fineness and 51 mm fibre length. The laying ratios and gsm values of the cross/parallel webs were 75%/25% 45-15 g/m^2 cross and parallel webs, 50%/50% 30-30 g/m^2cross and parallel webs, 25%/75% 15-45 g/m^2 cross and parallel webs, respectively. The specifications of the webs used in the study were given in Table 1.

Table 1. Materials used within the study

Pattern	LD*	Laying Ratio (%)	GSM of webs (g/m^2)	TW** (g/m^2)
Honeycomb	C[1]	100	C 60	60
Honeycomb	C/P[2]	75-25	C 45/P 15	60
Honeycomb	C/P	50-50	C 30/P 30	60
Honeycomb	C/P	25-75	C 15/P 45	60
*Laying Direction, [1] Cross, [2] Cross/Parallel **Total Weight				

Table 2. The settings of the water jet needling machine

	Sizes of the Jet Strips	Pressures of the Jet strips
HP1*	0.12-40-2	30 bar
HP2	0.12-40-1	55 bar
HP3	0.12-51-2	100 bar
HP4	0.11-60-1	135 bar
***High Pressured Pumps**		

The nonwoven fabrics were produced in the parallel and cross production lines and were bonded with hydroentaglement method. All webs were consolidated under the same conditions on water jet needling machine. The settings of the water jet needling machine was summarised in Table 2.

All specimens were conditioned under laboratory conditions (20ºC ± 2 and 65±2% Relative humidity) for 24 hours and all the tests were performed with ten repetitions. Fabric weight measurements were performed according to ISO 9073-1 with Radwag Instrument. Thickness measurements were done based on the ISO 9073-2 with Karl Schröder. Breaking strength of the nonwoven fabrics were performed according to ISO 9073-3. Water absorption measurements of the fabrics were done according to EN 1644-1 standard. In this test, first dry weights of the specimens were measured, and then the specimens were wetted and stringed out for one minute in order to remove the extra water. After one minute, wet specimens were weighed again and with Eq.(1) absorption percentages of the fabrics were calculated.

$$Absorption\ (\%) = [(Wet\ weigth - Dry\ weight)/Dry\ weight] \times 100 \quad (1)$$

Air permeability measurements were carried out according to TS 391 standard with Prowhite Airtest II instrument.

3. Results and Discussions

Breaking strength results of the spunlace nonwoven fabrics were given in Fig. 1. Breaking strength tests were performed in two directions of the fabrics; cross direction and machine direction. Cross direction refers to the width wise of the machine while machine direction refers to the lengthwise direction of the produced fabric. Two striking outcomes from the breaking results were; increasing the amount of parallel webs in the final product caused a decrease in the breaking strength values of the spunlace fabrics in cross direction, while increasing the amount of parallel webs in the final product caused an increase in the breaking strength values of spunlace fabrics in machine direction. This is due to the fibre orientation in the web. While producing nonwoven webs, there are two ways of laying-in. Cross direction or parallel laying of webs in order to get final web weight. In cross direction of webs, the fibres are in more complicated orientation. Thus, the results of the breaking strength of the fabrics in cross direction was highest amongst. However, increasing the parallel web ratio in the cross direction decreased the breaking strength values, since the fibres were in the opposite direction. On the contrary, increasing the parallel webs ratio in the machine direction increased the breaking strength values of the final product due to similar reasons.

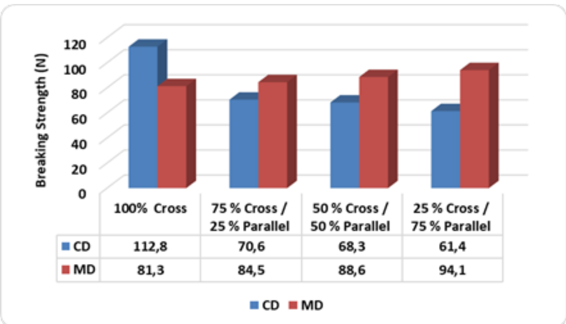

Figure 1. Breaking strength results of the nonwoven fabrics

Breaking elongation results of the spunlace nonwoven fabrics were given in Fig. 2. The elongation results was the opposite of the breaking strength results. Increasing the ratio of parallel webs in the final web caused an increase in the cross direction, whereas it caused a decrease in the elongation results of the fabrics in the machine direction.

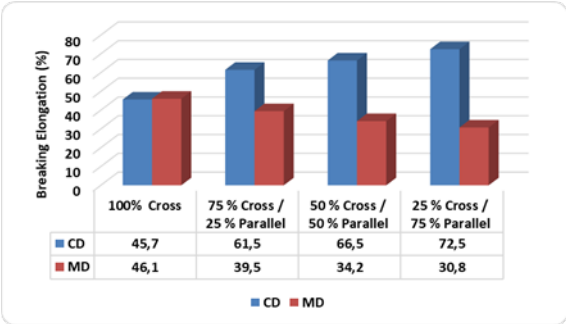

Figure 2. Breaking elongation results of the nonwoven fabrics

Water absorption percentages of the spunlace fabrics layed-in different percentages of cross-parallel directions were presented in Fig. 3. Water absorption percentages of the spunlace fabrics decreased with regard to the increase in the parallel web ratio in the final product. The reason of this was thought to be that the pore sizes in the 100 % cross layed fabrics were bigger than that of the ones in the cross/parallel layed fabrics. Thus, the fabrics with bigger pores had less water retention than the ones with smaller pores.

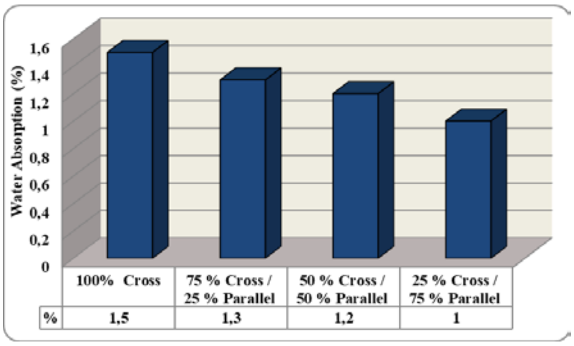

Figure 3. Water absorption percentages of the nonwoven fabrics

The air permeability of the spunlace fabrics were given in Fig. 4. As it can be seen from the Fig.4, increasing the ratio of parallel webs decreased the air permeability of the spunlace fabrics based on the parallel fibre orientation in the web. This result is also similar with the water absorption results. The correlation of air permeability and the water absorption percentages of the spunlace fabrics was %97,6. In cross layed webs, the pore sizes were bigger which caused more air penetration while on the hand, webs with the smaller sizes led less air penetration.

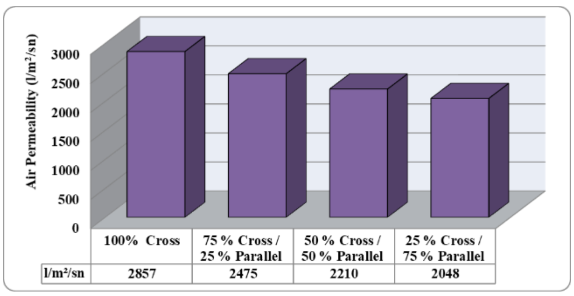

Figure 4. Air permeability results of the nonwoven fabrics

4. Conclusions

Increasing the parallel web ratio in the cross direction decreased the breaking strength values, on the contrary, increasing the parallel webs ratio in the machine direction increased the breaking strength values of the final product based on the fibre orientation.

The elongation results were the opposite of the breaking strength results.

The increase in cross laying ratio of spunlace fabrics caused an increase in water absorbency and air permeability results. The reason for this was due to the hollow (porous) structure and high surface area where the complex fibre placement in the cross-layed webs caused.

Fibres in the parallel layed web structures were parallel to the machine direction which caused fibre uniformity in terms of fibre orientation in the fabric. For this reason, the tensile strength in the machine direction (MD) was high and the elongation at break is low. On the contrary, in the fabric width direction (CD), the breaking strength was low and the elongation at break was high. Other tests, water absorption and air permeability results were also low due to parallel orientation of the fibres in the web structure.

As the fibres in the cross-direction direction were placed more homogeneously in the fabric than that in the parallel, the tensile strength in the machine direction (MD) was low and the elongation at break was high. In the fabric width direction (CD), the breaking strength was high and elongation at break was low. Air permeability and water absorption rates of the cross layed fabrics were high compared to the cross/parallel layed fabrics.

As a result, the production of spunlace fabrics having the same weight per m^2 and the same pattern in bonding but having different mechanical and permeability characteristics is possible by changing the laying ratio of webs in cross and/or parallel directions.

Acknowledgements

I would like to thank Gourkan Moustafa, Textile Engineering student at Namık Kemal University, who contributed to the fabric production and the realisation of experiments.

References

[1] Russell, S.J. (2007). *Handbook of Nonwovens*. CRC Press.

[2] Midha, V.K., & Mukhopadyay A. (2005). Bulk and physical properties of needle-punched nonwoven fabrics. *Indian Journal of Fibre & Textile Research*, 30, 218-229.

[3] Maity S., & Singha K. (2012). Structure-Property Relationships of Needle-Punched Nonwoven Fabric, *Frontiers in Science*, 2(6), 226-234.

[4] Sakthivel S., Ezhil Anban J.J., Ramachandran T. (2014). Development of needle-punched nonwoven fabrics from reclaimed fibers for air filtration applications. *Journal of Engineered Fibers and Fabrics*, 9, 149-154.

[5] Ray S.C., & Ghosh, P. (2017). Studies on nature of anisotrophy of tensile properties and fibre orientation in cross-laid needle-punched nonwoven fabrics. *Indian Journal of Fibre & Textile Research*, 42, 160-167.

[6] Ahmad F., Tausif M., Hassan M. Z., Ahmad S., Malik M. H. (2018). Mechanical and comfort properties of hydroentangled nonwovens from comber noil. *Journal of Industrial Textiles*, 47 (8). 2014-2028.

[7] Gürkan Ünal P. (2018). The Effect of Laying Direction on the Mechanical and Comfort Properties of Cross and Cross/Parallel Laid Nonwoven Fabrics, In I. Uluslararası Bilimsel Çalışmalarda Yenilikçi Yaklaşımlar Sempozyumu.