THE INFLUENCE OF WATER JET PRESSURE ON ABSORBENCY OF SPUNLSCE NONWOVEN

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Abstract
Nowadays, the use of nonwovens as absorbent products such as wet handkerchiefs, disposable infant diaper, feminine sanitary napkin and surgical pads is increasing. One of the most important methods for the nonwoven production is spunlace. This research evaluates the effect of spunlace nonwoven structures in water retention and water vapor permeability of nonwoven. Carded webs from polyester fibers and viscous fibers of four different basis weights (35, 40, 45 and 50g/m2) were hydroentangled using three different water jet pressures (50, 60 and 70 bar). To study the effect of these variables on the structure of nonwovens and absorbency related properties, sample's characteristics such as thickness and mass density were measured. The absorptive capacity method was carried out by an arrangement. This method consists of measuring the capability of liquid holding by the sample after specific floating time and dripping the excessive liquid in certain time. Water vapor permeability of the samples was measured by cup method. The results showed that with increasing water jet pressure, mass density increased and other parameters like thickness, water retention and water vapor permeability decreased. Also, it was observed with increasing basis weight, the sample thickness increased. On the other hand, with increasing weight, the amount of water retention and water vapor permeability of nonwoven were reduced.
Key words: Nonwoven, Spunlace, Water retention, Water jet pressure, Weight.

1. Interdiction

Textile products have a wide application range in different industries such as clothing, medicine, liquid filtration, ventilation systems and liquid absorption. Moisture may be transferred through textile materials in vapor and in liquid form that is related to comfort [1], which is very important in usage, and it is related to wet processing, which is an important step in textiles production [2]. Wetting is the displacement of a fiber-air interface with a fiber-liquid interface [3]. One of the most significant products in textile technology is the nonwoven that have a great deal of development and growth potentiality. Almost all of these products are produced by spun-bonding, spun-lacing, melt-blown or thermal calendaring technologies. Fibers of cotton, polyester, polypropylene, viscose and other diverse mixtures are used in medical and hygienic nonwoven products [4]. Considering the wide usage of these fabrics such as wipers, feminine hygienic products, wet kerchiefs, medical and hospital products, baby diapers, surgical gowns, etc., the subject of wetting, wicking (capillary flow), liquid retention and absorbency in these products is greatly important.

In the case of fibrous materials such as woven or nonwoven structures, the fiber surface properties and pore structure of the material are the main determinants of its absorbency properties and liquid retention [5,6]. On the other hand, in fibrous structures, the liquid can wick into the inter-fiber spaces and hold by them [7,8].

The objective of the present study was to investigate the effect of setting the water jet pressure in spunlace production technology and basis weight of samples on the nonwoven structure. The changes of jet pressure and weight were effective parameters on the size of pores, so the influence of these variables on water retention, and water vapor permeability was considered.

2. Experimental

2.1 Spunlace Nonwoven Samples and Testing Condition

Characteristics of spunlace web, which were the same in all samples, are described in Table 1. The twelve spunlace nonwoven samples were produced using Rieter Perfojet's hydroentanglement machine with two jet manifolds. Carded webs from polyester fibers and viscous fibers of four different basis weights (35, 40, 45 and 50g/m2) were hydroentangled using three different water jet pressures (50, 60 and 70 bar). All samples were produced at 32-34°C and 30-32% relative humidity. The liquid used for all tests was single distilled water with 7.26×10-5 surface tension and 0.895×10-9 viscosity. All the tests were performed at 23-25 oC and 33-35% relative humidity

Table 1.Characteristics of spunlace web of nonwoven samples

	Fiber	(%)	Fineness(den)	Length(mm)
Spunlace web	Viscose	70	1/5	38
	Polyester	30	1/4	38

2.2 Measurement of Thickness and Mass Density of Samples

Sample thickness was measured according to ASTM D 5729-97 test method, with a Shirley digital thickness tester. Ten samples for each nonwoven were tested and the mean value was reported. Mass density of the samples was calculated using the following equation:

$$\rho = M/d \tag{1}$$

where ρ , M and d are the mass density (kg/m^3), weight (g/m^2) and mean of the sample thickness (mm), respectively.

2.3 Water Vapor Permeability Measurement

Water vapor permeability was measured by cup method according to BS 7209 in which eight samples were measured and the mean value was recorded. The weight loss was converted to water vapor permeability according to Eq. (2) and Eq. (3).

$$WVP(gr.m^{-2}.day^{-1}) = \frac{24M_0}{At} \tag{2}$$

$$A = \frac{\pi d_0{}^2 \times 10^{-6}}{4} \tag{3}$$

where M_0 is loss in mass (g), t is time between weighing (hr), A is internal area of dish (m^2) and d_0 is internal diameter of dish.

2.4 Water Retention Measurement

This experiment with a little difference is based on ISO9073-6:2000. This method consists of measuring the capability of liquid holding by the sample after specific floating time and dripping the excessive liquid in certain time. In order to remove the excessive water an arrangement shown in Fig. 1 is used. By means of an iron clip with 10 (cm) width, the sample was hanged vertically to the upper jaw and distilled water reservoir was on the bottom of this device. The upper jaw was moved down to immerse the sample into the water. The sample left into the water for 60±1 seconds. Then, the jaw was moved up and the sample removed from water bath. The sample was remained for 120±1 seconds so the excessive water would drop out. During This time, the weight of the sample was measured and recorded by the measuring head and the recorder. By means of Eq. (5), the percentage of water retention for each sample was measured.

$$WR = \frac{M_2 - M_1}{M_1} \times 100 \tag{5}$$

where WR is the percentage of water retention in sample, $M_1(g)$ is the first weight of sample, $M_2(g)$ is weight of sample plus retained water at the end of the experiment.

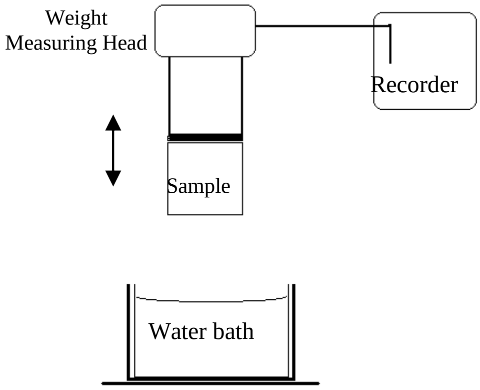

Figure 1. . The mechanism of measurement method for water retention

3. Results and Discussion

3.1 Nonwoven Thickness and Mass Density

The changes of mass density and thickness of different samples are illustrated in Fig. 2,3 respectively. It can be found that with increasing water jet pressure, the mass density has been increased, while the thickness is decreased with increasing water jet pressure. These results indicate using higher pressure the nonwoven has structure that is more compact due to entangled fibers.

Moreover, with increasing the basis weight, the thickness and mass density are increased. In spunlacing process if production parameters of nonwoven samples remain the same and the difference was just the amount of fibers per unit area, in equal water jet pressure, the sample that contained more fibers, showed greater mass density and thickness as well.

3.2 Effect of Water Jet Pressure and Basis Weight on Water Vapor Permeability

Water vapor permeability (WVP) is an important parameter in evaluating comfort characteristics of a fabric, as it represents the ability of transferring perspiration. According to Weiner [9], knowing the density and fabric thickness for predicting the ability of humidity steam transfer in a certain temperature is enough. It can be concluded from Fig. 4 that the increasing water jet pressure and weight of sample leads to the sample's WVP decreases. This could be the result of variations in thickness and mass density of samples. The WVP of the thinner samples are higher than that of thicker samples. Two mechanisms can be considered for water vapor transfer through the fabric: one is through absorption by fabric and then evaporation from fabric surface and the second is through fabric pores [10]. The increase of water jet pressure and weight can affect the second mechanism. The mass density increases with increase of water jet pressure and weight, i.e. there was a reduction in the effective radius of capillaries or pore size. Hence, vapor transfer from samples with the same quality decreases with increasing the mass density.

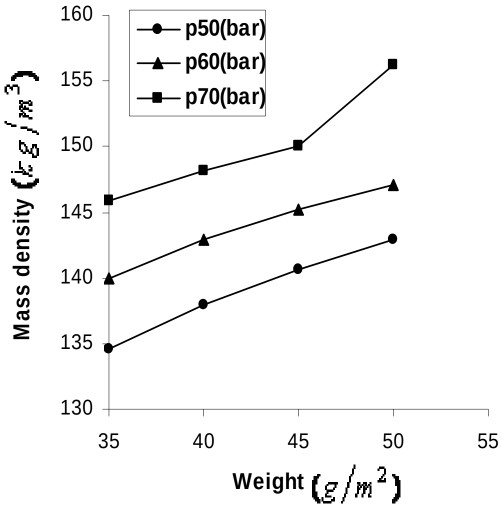

Figure 3. Changes in mass density with increasing of basis weight and water jet pressure

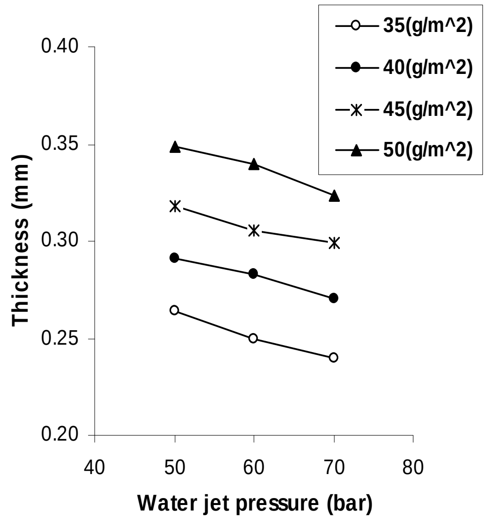

Figure 4. Changes in thickness with increasing of basis weight and water jet pressure

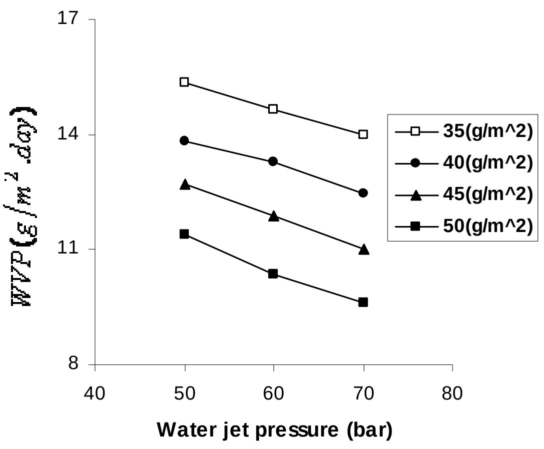

Figure 5. Effect of water jet pressure and basis weight on WVP of samples

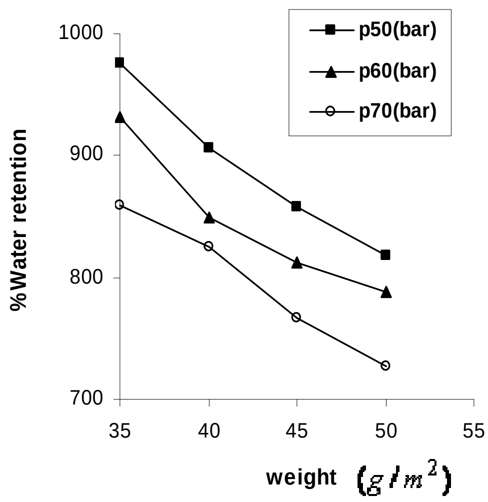

Figure 6. Changes of water retention percent with increasing of basis weight and water jet pressure

3.3 Effect of Water Jet Pressure and Basis Weight on Water Retention

The results from measuring percentage of water retention for each sample are shown in Fig. 6. It can be stated that with increasing weight of sample and water jet pressure, the water retention decreases. It can be attributed to increase mass density of samples and decrease in the size of pores, which is resulted by the increase water jet pressure, and weight of sample. Hence, the compact structure of fibers in nonwoven leads to decrease the amount of water retained among inter-fiber spaces. Water retention is governed by the fiber arrangement factors in nonwoven, which control pore size and inter-fiber spaces. Water jet pressure is a crucial factor influencing the fabric structure and properties, since it affects fiber entanglement completeness. Completeness is a term that is defined [11] as the portion of fibers that are tied together. This is a parameter related to fabric energy intake.

Another basic factor having influence on the nonwoven is the basis weight. If a constant amount of energy is being delivered to a fabric, the basis weight determines how much energy is going to be absorbed per fabric unit area. Logically, the higher weight, the less energy that is absorbed by the fabric and the lower entangling or mass density is achieved [11].

Eq. (6) shows the theoretical formula for hydroentangling energy, $E(kj/kg)$ applied to the fiber web by water jets in a manifold [12]:

$$E = Q\frac{CD^2NP^{2/3}}{\upsilon^{1/2}WS} \qquad (6)$$

Where Q is a constant, C is the orifice discharge coefficient (assumed 0.64), D is the diameter of jet orifice (m), N is the number of jets/m per manifold, P is the water pressure (N/m^2) in the manifold, υ is water density (g/m3), W is the basis weight of the web (g/m^2), and S is the line speed in $m/\min$.

According to Eq. (6), while the other parameters are held constant, hydroentangling energy is increased by increasing water pressure [12]. Therefore, the mass density of nonwoven increases and leads to effective radius of capillaries decreases. It has also been shown that an increase of hydroentangling energy results in decrease of liquid retention capacity and wicking rate [13].

4. Conclusions

The study shows the water jet pressure and basis weight by changing hydroeantangling energy, are effective parameters on entangling of fibers and nonwoven structure and properties such as mass density, thickness and capillary pore size. It is observed that increasing weight leads to the increase of thickness and mass density. Moreover, it causes a decreasing trend in water vapor permeability and water retention. On the other hand, by increasing water jet pressure, the thickness, water retention and water vapor permeability decrease whereas the mass density increases.

6. References

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