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Evaluation on the Sound Absorption and Mechanical Property of the Multi-layer Needle-punching Nonwoven

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Abstract. In this research, we used the special needle punching process to improve the disadvantages of the ordinary needle punching process. First, we manufactured the single-layer needle punching nonwoven by the ordinary needle punching process and then nonwovens were laminated followed by needle punching. We carried on this manufacturing processing until the multiple needle-punching nonwoven reached the certain thickness and area weight which were both limited in the ordinary needle punching process. The combination of two manufacture techniques as multiple thermal bonding and multiple needle-punching freed the single needle-punching from the limit of the expected thickness and area density. In this research, we tested the mechanical properties and sound absorption of the multi-layer needle-punching nonwoven and multi-layer thermal bonding nonwoven. According to the results, the tensile strength is higher than the multi-layer thermal bonding nonwoven; however, there was no distinct difference between the multi-layer needle-punching nonwoven and multi-layer thermal bonding nonwoven on the sound absorption performance.

Introduction

The global economy grows fast in recent years and people have higher standard for living environment relatively. The reduction of the pollutions becomes a critical issue; furthermore, pollutions most frequently seen in our daily life include noise pollution, water pollution, waste pollution, and air pollution. Noise pollution is different from the others because when its source stops, the noise pollution is solved and no wastes will remain. Moreover, the degree that pollution noise jeopardizes or influence each individual depends on the degree people accept the noise pollution. Furthermore, people are worn down with noise pollution thus noise pollution keeps people from concentration and efficiency, in particular, the repetitive works influence people more obviously. To develop the new type sound absorption material can solve these problems effectively. Basically, sound absorption materials can be divided into three types which are porous, vibratile, and fibrous; meanwhile, all of them turn the sound energy into heat energy to attain the sound absorption effect. Fibrous materials are endowed with excellent sound absorption properties therefore textile products have been expansively applied in the field of sound absorbing materials; furthermore, there is a great deal of literature indicating the usages of the textiles preventing the noise pollution [1-7].

However, fibrous sound absorbing materials have some defects, such as fiber fall-out or the irritation for human skin. The surface coverings could effectively solve these problems. The films [8, 9] and fabric coverings [10] are often applied to sound absorbing materials to protect the material from detrimental environments or to meet aesthetic requirements. Surface coverings usually contain high Surface coverings usually contain materials with higher sound reflection and obviously affect the properties of the sound absorbing materials. Average speaking, the surface covering can increase the sound absorption at low frequency but decrease the sound absorption at high and medium frequency.

Due to the nonwoven's mechanical structure and easy to apply, the thickness and the area weight of the nonwoven made by the ordinary needle-punch machine do not meet the requirement for good sound absorption. For overcoming such shortcomings, previous studies used the nonwoven which was laminated by thermal bonding instead of needle punching so the nonwoven was with high thickness and high area weight. Thermal bonding has the disadvantages as follows: when the laminated counts are too many, the middle of the nonwoven cannot be heated well, which results in insufficient thermal bonding. On the other hand, the over thick nonwoven consumes lots of energy and time during the thermal bonding process and disadvantages the industrialization.

Thus in this research, we referred to the special needle punching process used in nonwoven industry. First, the single layer needle punching nonwoven made according to the ordinary needle punching process underwent the first forming. And then the single layer needle punching nonwoven was laminated with another nonwoven, followed by the second needle punching process, and such procedure went on until the nonwoven reached the certain thickness and area weight and formed the multi-layers needle punching nonwoven. We overcame the disadvantages of the insufficient thickness and area weight of the single layer needle punching nonwoven by means of this special needle punching process.

Experimental

2.1 Material

The nonwoven used in this research was constituted with two polyesters which were hollow 3D crimp PET fibers and low melting point PET. The hollow 3D crimp PET fibers were used to be the main raw materials for nonwoven fabrics. The hollow 3D crimp PET fibers (Far Eastern Textile Co., Ltd., Taiwan) have the following characteristics: linear density, 7.78 dtex; single fiber strength, 3 g/d; fiber length, 51 mm; and, melting point, 240 ˚C. The low melting point PET (Huvis) was 51mm long, and its fineness was 4.0. It was of a core-layer structure. It was covered with a low melting PET skin. The surface' s melting point was at 110˚C while that of the core, the normal PET layer, was at 265 ˚ C.

2.2 Experimental Process

We combined two different manufacture techniques whose influences over the mechanical property and sound absorption of the sound absorbing nonwovens were explored. One sound absorbing nonwoven was multi-layers thermal bonding nonwoven which was made by the thermal bonding. The materials the single layer thermal bonding nonwoven were described as follows: the hollow 3D crimp PET fiber were blended with low melting PET fiber at a 70 wt% PET fibers and 30 wt% low melting point PET. The blended fibers were fed into a web fabricating system (Ta You Machinery Co. Ltd., Taiwan) to produce fibrous webs. Then, the fibrous webs with 200 g/m^2 in weight per unit area were pre-formed at 180 °C at a feeding speed of 0.5 m/min via a pair of thermal calenders (Chiefwell Engineering Co., Ltd., Taiwan).Afterward single layer thermal bonding nonwovens were laminated for 5 to 10 layers and then placed in the plate thermal compress for the second thermal bonding. The thickness of 30 mm was set for the multi-layer thermal bonding nonwoven. The other sound absorbing nonwoven underwent multiple needle-punching process and the materials we used were described as follows: the hollow 3D crimp PET fiber were blended with low melting PET fiber at a 70 wt% PET fibers and 30 wt% low melting point PET. The blended fibers were fed into a web fabricating system (Ta You Machinery Co. Ltd., Taiwan) to produce fibrous webs. Then, the fibrous webs with 200 g/m^2 in weight per unit area were pre-formed by needle puncher Afterward the single layer needle-punching nonwovens were laminated for multiple needle-punching. Furthermore, with the increase of the laminated counts, we adjusted the parameter by reducing the stab depth of 2mm to manufacture the multiple needle-punching nonwoven with 5 to 10 layers.

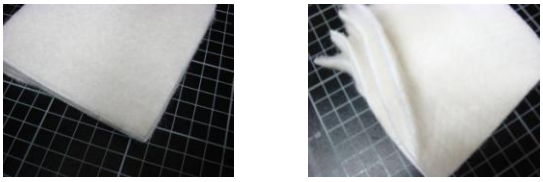

Fig.1 the multi-layers needle-punching nonwoven

2.3 measurements

In this research, we used two measurements to test the specimens. The maximum breaking strength and elongation measurement was performed to test the mechanical property of the strip specimens. Tensile Stress was conducted according to ASTM D5035-06 regulating fiber's tensile stress and elongation strength. An appropriate parameter was earned after testing and examining the tensile strength and elongation strength of the multi-layers needle-punching nonwoven and multi layers thermal bonding nonwoven. The sound absorption coefficient was measured according to ASTM E1050 by Two-microphone impedance tube.

Results and Discussion

Figs. 1 and 2 show that the Tensile strength of the multi-layers thermal nonwoven and multi-layer needle-punching nonwoven. It was obvious that the strength of the multi-layer needle-punching nonwoven was much higher than that of multi-layers thermal nonwoven. The result may be due to the following two reasons. First, multi-layer thermal nonwoven did not receive needle-punching and either the single layer thermal nonwoven or the multi-layer thermal nonwoven performed worse than the needle-punching nonwoven. Fine needle-punching process can shape the nonwoven effectively, entangle the staples inside the nonwoven by means of the physical property, and heighten the strength of the fiber web largely.Thus, such method reinforced the nonwoven from both the machine direction (MD) and the cross machine direction (CD). The other reason was multi-layer thermal bonding nonwoven only received the thermal process which maintained the defects of the fiber web and caused the weak reinforcement in the machine direction because the fibers could not connect well.

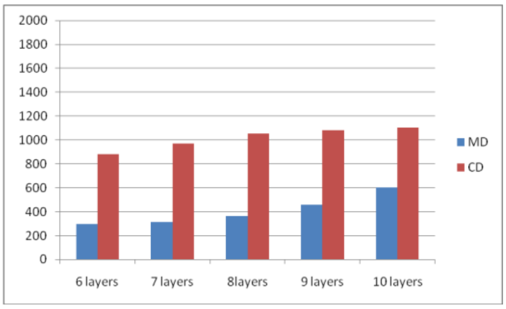

Figure. 1 Tensile strength of the multi-layers thermal bonding nonwoven the number of laminate is 6 to 10 thermal form temperature is 180 °C

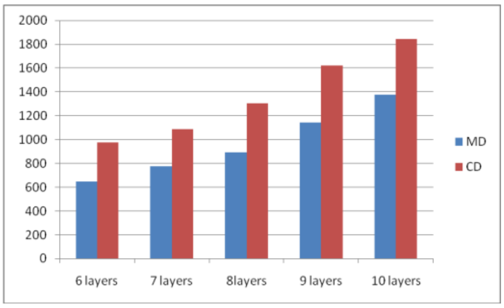

Figure. 2 Tensile strength of the multi-layers needle-punching nonwoven the number of laminate is 6 to 10 thermal process temperature is 180 °C

Fig. 2 displays that the maximum breaking strength increases by progression with the laminated counts in both MD and CD which proves that multi-layer needle-punching process reinforces the nonwoven efficiently. The sound absorption coefficient did not differ from each other in the two manufacturing process. The sound absorption rate of the multi-layers thermal nonwoven and multi-layer needle-punching nonwoven increased with the area weight. The only difference was when the laminated counts increased, the sound absorption of the multi-layers thermal bonding nonwoven was irregular. This may be because multi-layers thermal bonding nonwoven was not heated evenly in the plate thermal compress so the outer surface was overheated. Furthermore, the smooth surface was formed so as to influence the sound absorption.

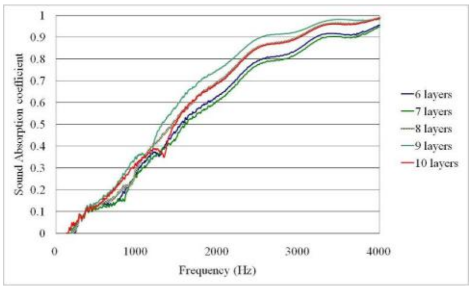

Figure3. the sound absorption of the multi-layers thermal bonding nonwoven the number of laminate is 6 to 10 thermal form temperature is 180 °C 15min

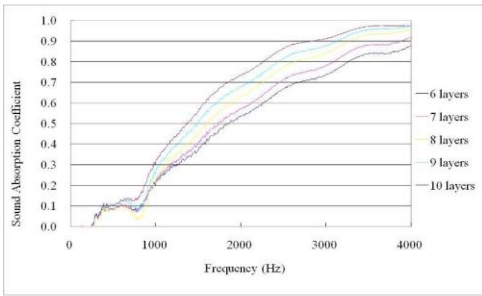

Figure4. the sound absorption of the multi-layers needle-punching nonwoven the number of laminate is 6 to 10 thermal form temperature is 180 °C 3min

Summary

In this research, the tensile strength of the multi-layers needle-punching nonwoven is higher than multi-layers thermal bonding nonwoven. When the number of laminate of multi-layers needle-punching nonwoven. The tensile strength in CD can reach 1835 N and in MD can reach 1387 N. The tensile strength of multi-layers thermal bonding nonwoven in CD is 1087N and MD is 601N. But in sound absorption character 2 different process have not distinction.

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