Manufacturing Technique and Property Evaluation of Sound Absorption Composite Planks

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Abstract

In this study, the basic material for sound absorption was porous nonwoven made of polyester nonwoven and low-melting polyester fiber. Nonwoven was then attached with foam polyurethane as composite plank for sound absorption and sound isolation. We used two microphone impedance tube for sound absorption test and INSTRON 5566 mechanical testing machine for tensile test. The optimum sound absorption coefficients as 0.67 ± 0.008 was obtained when density of foam polyurethane was 1.0 Kg/㎥ with thickness of 20 mm; Polyester (PET) nonwoven were laminated with 9 layers in a total thickness of 10 mm; and its low-melting polyester fiber was 30 wt%. The composite plank obtained the maximum fracture stress when it contained low-melting-point (low-Tm) PET fiber at 30~40 wt%. The results of this study could be applied in the partitions inside ships, vehicles or buildings.

Introduction

Industrialization improves the living standard, but the noise followed impacts the environment. Noise jeopardddizes workers' hearing, decreases the productivity and brings other negative influence. Noise pollution is colorless, tasteless and odorless and is not accumulate in the environment. Noise disappears when the resource of it is gone [1]. Morse, Blot and Brown (1940) studied about sound absorption of porous material [2]. In 1971, Attenborough researched on its microcosmic structure, such as the influence of the changing of fiber flexible, radius and fiber direction on sound wave propagation [3]. Furthermore, Mechel and Vér (1992) stated that sound pressure brought about the sound; if the sound waves touch sound absorption materials during its delivery, the air molecule would dangle in the voids inside the material; energy would be worn off with the abrasion [4]. Finally, Yang et al. used rice straw–wood particle composite to compare the fiber composite plank with other wooden plank for their sound absorption [5]. As a result, industrial-grade functional textile is one of the major manufacturing goals for the current textile industry in the scope of application [6-15]. Nevertheless, not until now, do some researchers take advantage of the properties of composite structure to improve the sound absorption. This research was with an attempt to attain this function with the least thickness.

Experimental

7D three-dimensional-crimp-hollow PET fiber (7D PET) and 4D low-Tm PET fiber were mixed with the weight ratio of 7：3, forming the nonwoven. 9 layers of the nonwoven were placed in the mold and thermal-treated for twenty minutes. Then it was cooled at the room temperature until it became the nonwoven plank with a thickness of 1 cm. Foam of reagent A and hardener of reagent B were mixed in volume ratio 1:1 and the mixture foamed for 2 days until it became the foam polyurethane plank. Then we adhered the nonwoven and foam polyurethane by thermal treatment for twenty minutes, after which it was left at the room temperature, forming the 30mm-thick-composite plank with sound absorption ability.

Results and Discussion

Tensile strength of the PET nonwoven plank

Figure 1 shows that when 7D PET/ low-Tm was 8:2, the tensile strength of the PET plank started increasing largely when the lamination number was 9 layer. The more layers the nonwoven had, the more fiber dispersed in each unit, resulting in a greater tensile strength.

Figure 2 shows the when the lamination number was 9 layer, the tensile strength of the PET nonwoven plank displayed an optimum tensile strength when the 7D PET/ low-Tm was 6:4. When 7D PET fiber and low-Tm fiber had physical cohesion, tensile strength of bulk nonwoven increased. However, the tensile strength started declined when the weight ratio was 5:5.

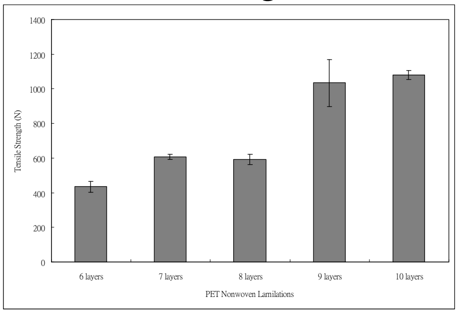

Figure 1 The tensile strength of PET nonwoven plank. (7D PET/ low-Tm ratio: 8:2; lamination number: 6 -10 layers; thickness: 10 mm)

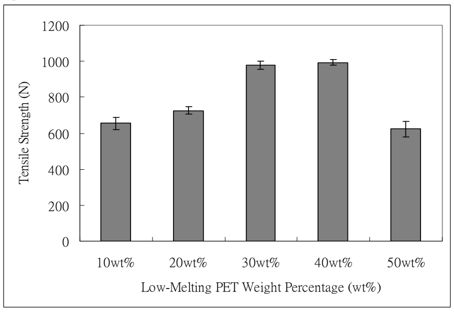

Figure 2 The influence of strength of PET nonwoven plank. (7D PET/ low-Tm ratio: 9:1, 8:2, 7:3, 6:4, 5:5; lamination number: 9; total thickness: 10 mm)

Sound absorption coefficient of the PET nonwoven plank

Figure 3 shows that when 7D PET/ low-Tm was 8:2, the PET nonwoven plank sound exhibits the optimum absorption coefficient on the frequencies of 800~4000 Hz when the lamination number was 9 layers. However, a lamination number of 6 to 8 layer contributed to sound absorption on frequencies below 800 Hz. With the same thickness, the greater the lamination number, the higher nonwoven plank's density, providing the plank with a greater sound absorption coefficient. The 10-layer nonwoven plank displayed a lower sound absorption than the 9-layer one.

Figure 4 reports that when the lamination number was 9 layer, the PET nonwoven plank exhibited an optimum sound absorption coefficient when the 7D PET/ low-Tm was 7:3. When low-melting polyester fiber received thermal treatment, it would melt thus have meshed cohesion with polyester fiber. It lifted the structural complexity because the difference in meshed structure would affect the sound absorption coefficients. When the weight ratio was 30 wt%, there were more junction point hence the meshed structure was more porous, and caused more sound power internal friction losses. However, with a weight ratio of 40 to 50 wt%, there were too many bonding points. Porous structures were blocked with molten material and deteriorated the air mobility and sound absorption. Figure 5 shows the sound absorption coefficients when the polyester fiber of fixed thickness of 10mm was mixed with low-melting polyester fiber at weight ratio of 30 wt%, and lamination was 9 layers. Because 7D polyester fiber was with three-dimensional crimp structure, the planks of polyester fiber nonwoven had more void allowing sound wave incidence to proceed with internal friction losses, and obtained better sound absorption than 12D polyester fiber.

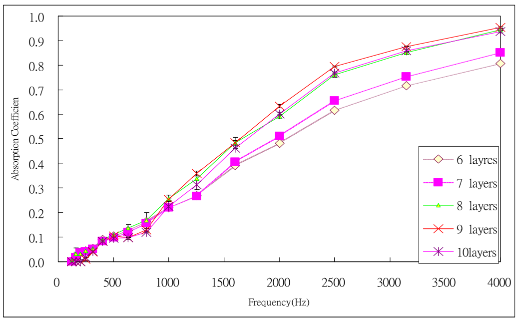

Figure 3 The sound absorption coefficient of PET nonwoven plank. (7D PET/ low-Tm ratio: 8:2; lamination number: 6 -10 layers; thickness: 10 mm)

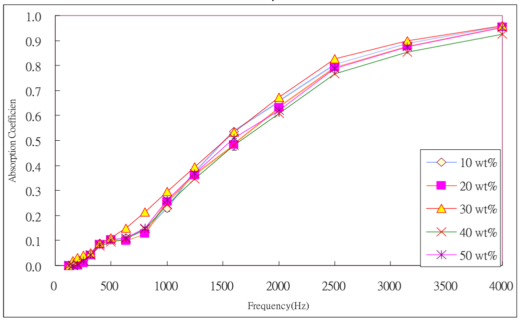

Figure 4 The sound absorption coefficient of PET nonwoven plank. (7D PET/ low-Tm ratio: 9:1, 8:2, 7:3, 6:4, 5:5; lamination number: 9; total thickness: 10 mm)

Sound absorption coefficient of the PET/ PU composite plank

Figure 6 shows the sound absorption coefficients at different densities of foam polyurethane when nonwoven was with a thickness at 10mm; the foam polyester was with a thickness at 20mm; the ratio of reagents A and B was 1:1. When foam polyurethane foamed to 1.0 Kg/㎥, the foam structure was the most complete. The sound wave incidence was within a closed cell wall, engendering compressed vibration of sound power loss, thus obtaining better sound isolation and absorption. When the density was less than 1.0 Kg/m^3 the structure was more uneven, resulting in the lower sound absorption coefficient. When it was higher than 1.0 Kg/㎥ the foam space was restrained by taking more stress. The material was close to rigid wall, the sound absorption would decrease. As a whole, the sound absorption increased, when frequencies was between 125 to 1500 Hz.

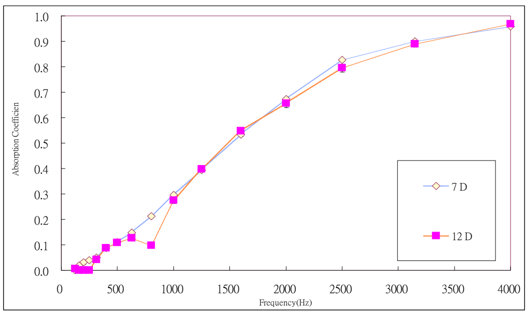

Figure 5 The sound absorption of PET nonwoven plank. (7D PET/ low-Tm ratio: 7:3; lamination number: 9; total thickness: 10 mm)

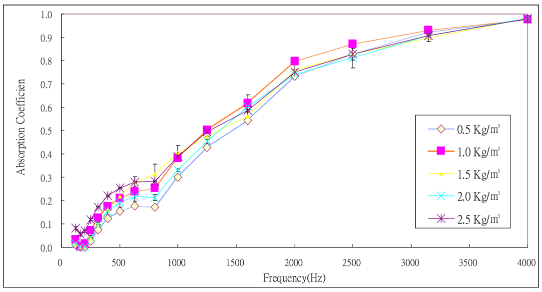

Fig.6. Figure 6 The sound absorption of PET/ PU composite plank. (For PET plank, 7D PET/ low-Tm ratio: 7:3; lamination number: 9; total thickness: 10 mm). (For PU plank, reagent A/B: 1:1; thickness: 20 mm; PU density: 0.5, 1.0, 1.5, 2.0, 2.5 Kg/m^3).

Conclusion

In this study, we successfully manufactured the PET/ PU composite planks with different PU density. The tensile strength of the PET planks was increased largely when 9 layers of nonwoven were used to laminate. In addition, the tensile strength of PET nonwoven plank increases obviously when the low-Tm fiber was added up to 30 %.. The optimum parameters of PET nonwoven plank were: 7D PET/ low-Tm ratio: 7:3; lamination number: 9; total thickness: 10 mm. Meanwhile, the optimum parameters of PU plank were: reagent A/B: 1:1; thickness: 20 mm; PU density: 1.0 Kg/m^3. Finally, the resulting PET/ TPU composite plank exhibited the optimum sound absorption when the density of foam polyurethane was 1.0 Kg/m^3, and the sound absorption coefficient was 0.67 ± 0.008, which meant the material can absorb 67 % of sound power.

Acknowledge

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