FIBER WEIGHT FRACTION EFFECT TO ACOUSTIC PROPERTIES OF rHDPE CANTULA COMPOSITE

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Abstract:
In this study, composites made from recycled HDPE and Cantula fiber have been done and the absorption coefficient have been measured. Composites rHDPE-Cantula were made using hot press for approximately 60 minutes with 170^{o}C temperature while pressure exerted by 50 bar. In this study the weight ratio of Cantula fiber was varied 40%, 50%, 60%, and 70%. Impedance Tube Method was used to measure the sound absorption coefficient in accordance with ASTM E 1050. An increase weight ratio wasn't influence the sound absorption coefficient significantly, but the optimum sound absorption coefficient shifted to the higher frequencies from 80-200 Hz. An increase weight ratio showed better sound absorption coefficient from 500-1600 Hz, but the result from 60% weight ratio showed low sound absorption coefficient that may caused by it high density leading to the reduction of porosity. This result was supported by density measurement in accordance with ASTM D 792, which the result showed that the sound absorption coefficient increase with decreasing of the density..

INTRODUCTION

Global industry, science, and technology development improved the quality of human life but also posed some problems for the environment and human health for instance noise pollution (Jayamani, 2013). Sound-absorbing material application has become one of the main requirements for obtaining human convenience today, especially in the automotive industry (Ekici, 2012). Vehicle panel development has begun to shift in natural fibers utilization which cost less, lightweight, and environmental friendly (Abdullah, 2011). Generally, natural fibers have the ability to absorb sound, especially for noise controlling at vehicles, offices, and industrial (Eriningsih, 2009).

Pure thermoplastic composites production as a matrix has been done by society. However, plastic application was continuously increased which causes plastic waste existence overflowed. Therefore, it needs treatments which regarding environmental pollution problems. It count 40% of 19.2 million tons was polyethylene, Lei, (2007) performed a study using High Density Polyethylene desolation (HDPE). Generally, it properties are chemical processes, temperature resistant, and stable against air oxidation (Gunawan, 2012). This indicates that it can be used as a matrix in composites manufacturing as a sound absorber, which it will be used in this study.

Noise adverse effects on humans are emotional disturbance, discomfort feeling, unstable blood pressure, headache, and less concentration (Eriningsih, 2009). Those problems can be anticipated by taking action to reduce noises using acoustic absorbers (Kartikaratri, 2012). Sound waves energy will be absorbed by sound absorbing materials and turned it into the heat (Christian, 2014).

Recycle High Density Polyethylene (rHDPE) was used for a binder of cantula fiber which produces composites that are strong, lightweight, inexpensive, and environmental friendly. Fiber weight fraction optimization was this study main focus. It varied 40%, 50%, 60%, and 70% to determine the most excellent sound absorption performance.

RESEARCH METHODOLOGY

Materials and instruments:

Rincian peralatan yang digunakan dalam penelitian ini adalah

a. Hot Press Machine
b. Atomizer Machine
c. Crusher Machine
d. Scales
e. Digital Termometer
f. HDPE waste
g. Cantulafibers

RHDPE Fiber Productions

HDPE waste which still bottle shaped was chopped using a crushing machine until it forms a powder. RHDPE powder atomizer inserted on a machine with 200^{o}C of temperature ± 7 bar of pressure for 15 minutes to obtain a ready-made rHDPE fiber.

Spesimen Production Process

Cantula fibers which have been soaked with 2% of NaOH for 12 hours and then dried fibers mixed with rHDPE using a mixer. Weight fraction cantula fibers comparisons were 40%, 50%, 60%, and 70%. The final mixture was put into a mold 100 mm of diameter and 10 mm thick and then pressed using 170ºC of temperature for 60 minutes.

Noise Absorption Performance Testing Process

Acoustic properties testing is sound absorption performance test of material was performed by using two microphones of Impedance Tube Test in accordance with ASTM E 1050 as in Figure 1.

Gambar 1. Impedance Tube Test

Impedance tube that used was BSWA SW 422 500507 type for test specimen 100mm of diameter.

Density Testing Process

Density testing has been appropriately performed from ASTM D 792, where the testing was done by wrapping the specimens which had been cut into uniform size, using plasticine. Then, the samples were weighted in the air and fluid that has known its density.

Macroscopic Testing Process

Macroscopic testing was made by using a stereo microscope. A macroscopic is able to view the macro-structure of the specimen surface and to investigate the bond between matrix and fiber. The microscope used was Olympus Stereo Microscope SZX7 was exercised for 0.8 to 5.6 times bigger.

Data Processing Step

The first step of data processing was begun by noting the testing results into a table view on excel program. It demonstrated a graph that we were making the link between the sound absorption performance value and the frequency on various fractions. Furthermore, data obtained analysis was perfomed and supported by the density testing results and macroscopic photos.

RESULT AND DISCUSSION

Noise Absorption Performance Testing Result

The result was obtained from noise absorption performance testing at various weight fraction that can be seen on Figure 2.

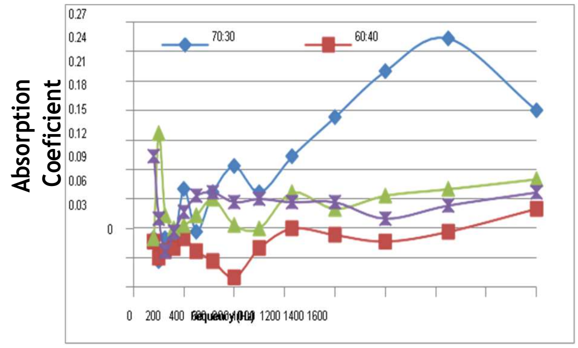

Figure 2. Noise absorption coefficient on various weight fractions

It produced 0.13 of α at 40% of composite fiber addicted on 80 Hz of frequency, whereas at 100 Hz of frequency of 50% of composite fiber addicted was 0.15 of α. At 200 Hz of frequency, 70% of composite fiber addicted was 0.1 of α. At 80-200 Hz of frequency, addicted fiber causes a frequency shift in the most optimum value of α. On 80-200 Hz of frequency data can be observed the sound absorption performance that was produced by rHDPE-Cantula composite was pretty good, it can be caused by short fibers a. As stated by Zainulabidin, et al., (2014) fiber is one kind of porous material which has a lightweight structure and fiber are cut short will have the absorption coefficient values which better than long fibers at low frequencies. The addition of fiber Cantula weight fraction did not significantly affect the value of α. However, the larger the addition of fiber optimum value α is increasingly shifted towards a greater frequency.

Greater frequency range of 500-1600 Hz graph shows the more fibers are added, the value of α will be greater. However, the composite with 60% of fibers addition are actually declined. Evenly, α is low value when compared with addition composite of 40% fiber. Basically, sound absorption phenomenon occurs when a sound wave frequency that comes together with the material natural frequency. Therefore, the sound waves energy will be absorbed and converted into heat energy through the vibrations of the material molecules (Xiaodan, et al., 2015). Each material will have a different sound absorption performance.

Density Testing Result

Density testing result is shown on Figure 3.

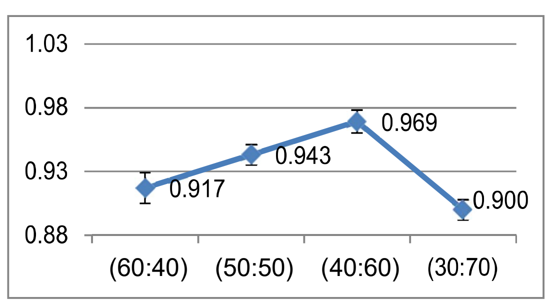

Figure 3. Density from weight fraction variation

The density testing results show fiber composites by 40%, 50%, and 60% of addition percentage increases with fiber addition. However, the density declining value in 70% fiber addition. It shows 40% and 50% of fiber addition shifts and changes α value which supported by the results of density testing that increased. Fiber addition causes greater density. It is also the friction possibility between fiber and the sound energy flow rate obstruction rose greater. Therefore, α is obtained also getting better.

Composite density in 60% of fibers addition was the greatest. It showed the best possible composition to exhibit a strong bond between fiber matrix to rHDPE cantula. The bond between the matrix and the strong fibers makes the composite becomes so dense that the material porosity is reduced which caused a material's ability to sound absorption is smaller where it is shown by the great density. Composites with 70% of fiber density addition measured value is the smallest compared to the other composites. It was possible because by the same thickness, 70% of fiber addition caused fibers presence in matrix composite become too large. Meanwhile, bond matrix less presence of fiber and matrix were caused many pores formation became weak and fragile. Therefore, it developed into the better sound absorption performance.

Macro Image Testing Result

The macro image testing was used to view the surface of each composite for each weight fraction variation as shown in Figure 4.

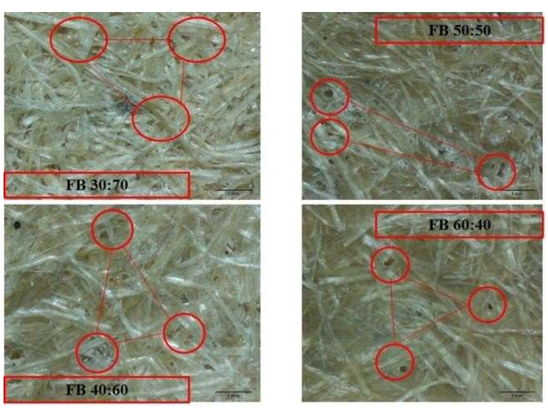

Figure 4. Macro image testing result of rHDPE:cantula composite

Composites with 70% of fibers addition by its surface was easy to investigate the cantula fiber as not coated by rHDPE matrix. It makes the composite surface which is uneven and has many gaps are formed which paved the sound waves to get into the material so that the material will be able to absorb sound better. Fiber composites with 60% of addition has a surface coated by rHDPE fiber and seen some pores on the surface so that the sound is not only absorbed on the surface but can get into the material however, solid material that causes pores was slightly formed. Therefore, the material ability to absorb sound is weak. Composite with 40% and 50% of fibers addition on the surface also seen on rHDPE coated by a matrix and contained pores so the sound waves can propagate into the material through the pores.

CONCLUSION

Based on data analysis and discussion can take several conclusions as follows:

1. In the 80-200 Hz frequency, the cantula fiber addition did not significantly affect to α, only caused a shift toward the optimum value of α greater frequency.
2. In the 500-1600 Hz frequency cantula fiber which was added then α is also getting increased. However, there were anomalies in 60% of fibers addition due to the greater density so that the material becomes more dense and the ability to absorb the sound becomes lower.

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