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Speaker Box Made of Composite Particle Board Based on Mushroom Growing Media Waste

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Abstract. This research aimed to use mushroom growing media waste (MGMW) that was added by urea, starch and polyvinyl chloride (PVC) glue as a composite particle board to be used as the material of speaker box manufacture. Physical and mechanical testing of particle board including density, moisture content, thickness swelling after immersion in water, strength in water absorption, internal bonding, modulus of elasticity, modulus of rupture and screw holding power, were carried out in accordance with the *Stándar Nasional Indonesia* (SNI) 03-2105-2006 and Japanese International Standard (JIS) A 5908-2003. The optimum composition of composite particle boards was 60% MGMW + 39% (50% urea +50% starch) + 1% PVC glue. Furthermore, the optimum composition to create speaker box with hardness values of 14.9 Brinnel Hardness Number and results of vibration test obtained amplitude values of the Z-axis, minimum of 0.032007 and maximum of 0.151575. For the acoustic test, results showed good sound absorption coefficients at frequencies of 500 Hz and it has better damping absorption.

INTRODUCTION

Particle board is one of composite products or wood panel made of wood particles or other lignocellulose materials unified with synthetic adhesives or other binders, which then are hot-pressed [1]. Speaker box is a piece of electronic equipment that is associated with the audio system. Speaker box can bring a high quality sound in the living room, home theater/ home audio at home or in places associated with the audio that brings a sense of satisfaction and pride. A beautiful design of speaker box will make it not only ideal as an audio system that is tunable, but also as a sweetener in the interior of the room. The design of speaker box is greatly affected by the quality of the tone. Currently, speaker box with minimalist design is widely preferred and many brands are offered ranging from low-end to high-end quality, all of which have the particularity in terms of models, finishing, sound and price. However, in Indonesia, the branded speaker boxes are always imported, instead of producing by our nation [2].

However, the supply of timber obtained from the forest as the main material of speaker box, has limited availability. In the last eight years, the number of timber from natural forests as raw materials in the timber industry is declined. In 2005-2013, the raw material from natural forests dropped from 20.5 million m3 to 5.54 million m^3. Meanwhile, the need for timber as raw material from plantations, including those from industrial plantations and private forests increased from 11.22 million m^3 to 39.8 million m^3 [3].

The condition requires a solution, therefore an alternative material to replace the position of timber as speaker box material, is required. Selection of alternative materials is done by utilizing wastes, one of them is agricultural waste. One of agricultural wastes is mushroom growing media waste (MGMW), where the waste is abundant in

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number, because in a few months after the mushroom is harvested, MGMW will be discharged and generally used for solids in the cliff to widen an area.

In this research, mushrooms growing media waste used as reinforcement for polymer-based composite material to be formed as composite particle board for speaker box manufacture. Essentially, the raw materials in the speaker box production are not necessarily obtained from high-quality materials. Moreover, they can be from natural waste that supports the emergence of environmental issues and the scarcity of raw material resources. However, speaker box can be made in accordance with the desired product based on the density of composite particle boards [4].

Composite particle board is composed of MGMW added with polyester resin and catalyst mekpo with optimum composition of 75% MGMW + 24% polyester resin + 1% catalyst Mekpo (methyl ethyl ketone peroxides), in accordance to the physical and mechanical tests and with SNI 03-2105-2006 and JIS A 5908-2003 [5].

EXPERIMENTAL STUDIES

The production of speaker box made of composite particle board that is based on MGMW added with PVC glue, urea and starch is accompanied by acoustic, hardness and vibration testing. Samples were prepared for acoustic testing and hardness test are shown in Table 1. Furthermore, to generate the best results, speaker box would be tested by the vibration test. The complete flowchart for this research was shown in Fig. 1.

Table 1. Composition of MGMW with PVC glue, urea and starch.

No.	Particle board	MGMW (%)	Starch (%)	Urea (%)	PVC glue (%)
			39		
1	1	60	50	50	1
2	2	60	40	60	1
3	3	60	30	70	1

Acoustic Testing

Acoustic testing was done to determine the extent of noise reduction that can be absorbed by the composite particle board based on mushroom growing media waste. Acoustic testing used the impedance tube method. Sample size for acoustic testing with size (10 x 10 x 1.5) cm^3 is suitable with standards ASTM C384/ISO 10534. Sample was mounted on the tip of the tube so that there was no loophole and five different frequencies of 125, 250, 500, 1000 and 2000 hertz, were examined. Furthermore, these values determined the value of sound absorption.

Hardness Testing

Hardness testing used the *universal hardness tester* CV-700. The Brinnel hardness test was conducted at three points of each material tested, using a ball *identor* of 5 mm and 306 N for 12 seconds.

Speaker Box Design and Production

The design of speaker box made of MGMW + PVC + glue (starch + urea) is shown in Fig. 2 for front and back images and Fig. 3 for an image to the right and above.

Materials required to produce speaker box made of composite particle board from MGMW + PVC + glue (starch + urea) were G glue, *Rajawali* glue, nails, carpet rubber, and egg containers.

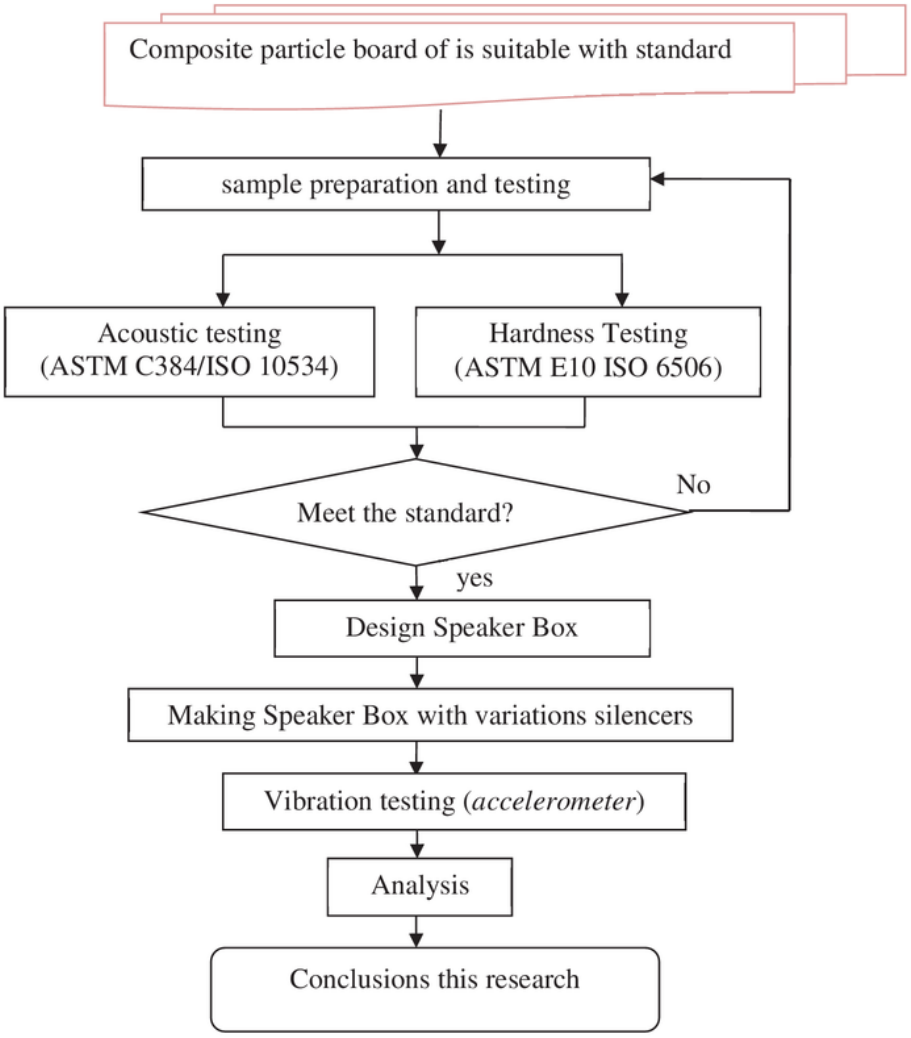


Figure 1. Research Flowchart.

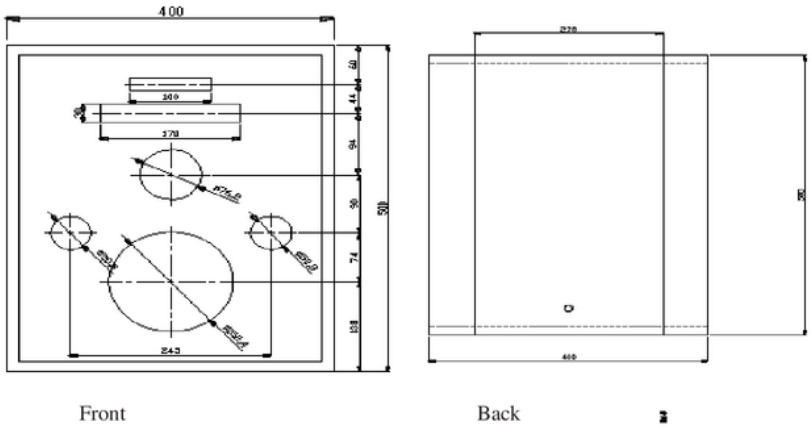


Figure 2. Front and back images of speaker box design.

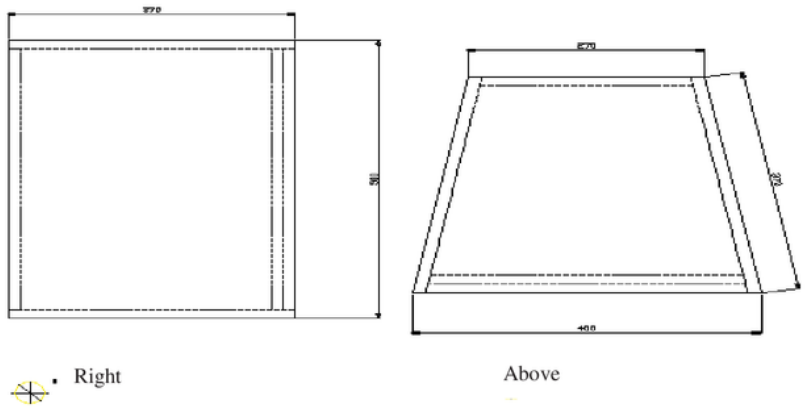


Figure 3. Right and above image of speaker box design.

Vibration (Accelerometer) Testing

After the assembly was complete, the last step was to perform the vibration test. The vibration testing scheme is presented in Fig. 4. The vibration test equipment in sets and test equipment placed on the workpiece and then the active speaker box was set to generate maximal bass sound. Active speaker box switched on track for two minutes, and the results will be read on a computer that was connected with test equipment. The second treatment was to determine the frequency of speaker box to find out whether the speaker box vibrates and this treatment will be able to chart a neutral frequency.

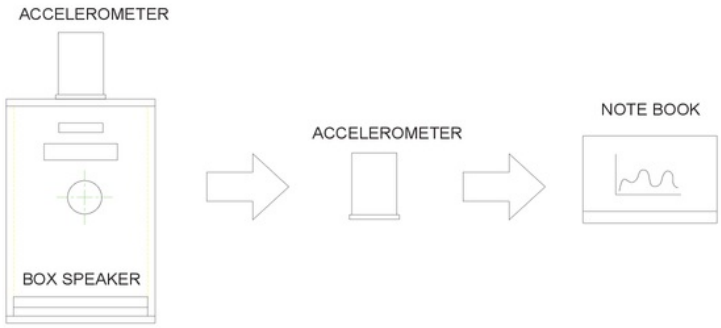


Figure 4. The vibration testing scheme.

RESULT AND DISCUSSION

Acoustic Testing

The quality of the sound damping material indicated by the value α (absorption coefficient of the material), the bigger the better α is used as a silencer, where α value ranges from 0 to 1. If α is 0, it means no sound is absorbed whereas if α is 1, it means that 100% sound that comes is absorbed by the material. Fig. 5 shows the correlation between the frequencies and absorption.

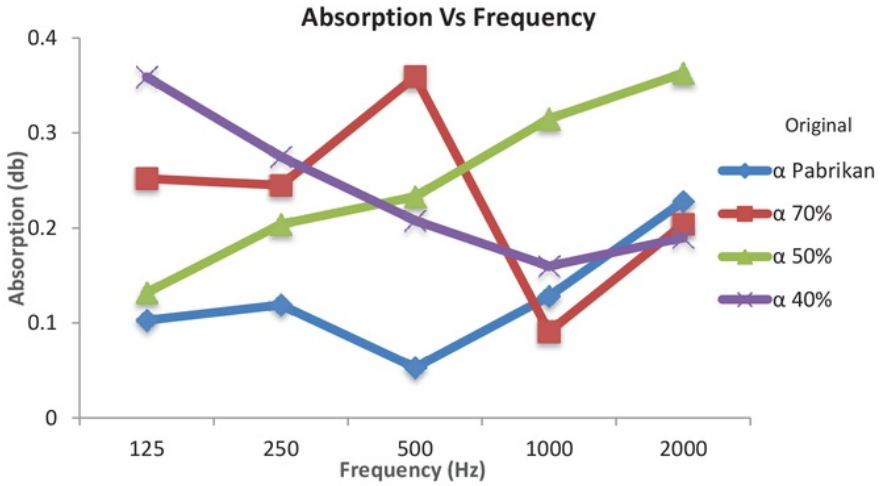


Figure 5. The correlation between the frequencies and absorption.

Composition of 60% MGMW + 1% PVC glue + 39% (50% starch + 50% urea) at a frequency of 125 Hz has a low value of coefficient of sound absorption and at high frequencies of 2000 Hz, it can absorb sound appropriately. Results of acoustic testing is based on the value of the NRC (Noise Reduction Coefficient), subsequently, the composition of 60% MGMW + 1% PVC glue + 39% (50% starch + 50% urea) can absorb the sound well at high frequencies in compared with others.

Hardness Testing

Composition of 60% MGMW + 1% PVC glue + 39% (50% starch + 50% urea) has the highest hardness value, which was 14.9 BHN. The hardness level is shown in Fig. 6.

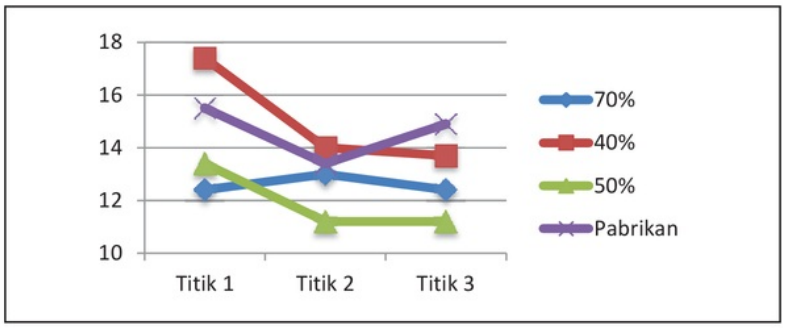


Figure 6. The results of hardness testing.

Speaker Box Production

Speaker box was made of from the composition of 60% MGMW + 1% PVC glue + 39% (50% starch + 50% urea), because it was evidenced to have the highest value of absorption and hardness (Fig. 7).

Front image Top image

Figure 7. Speaker box with composition 60% MGMW + 1% PVC glue + 39% (50% starch + 50% urea).

Vibration (Accelerometer) Testing

The results of vibration/accelerometer test of speaker box with composition 60% MGMW + 1% PVC glue + 39% (50% starch + 50% urea) in compared with common speaker box, shown in Figure 8, 9, 10, 11, 12, 13, 14 and 15. Speaker box made of MGMW had maximum vibration amplitude value X axis of 0.1073 and a minimum value of -0.119934, Y axis experience the thrill of maximum and minimum values of 0.102356 -0.112244, whereas

in the Z-axis vibration maximum values obtained by 1.051575 - 0.9 = 0.151575 and minimum 0.932007 - 0.9 = 0.032007.

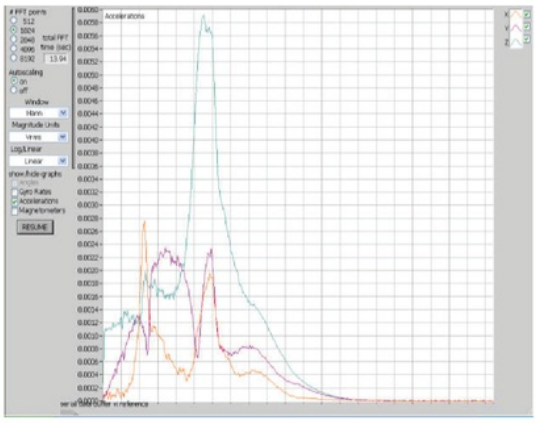


Figure 8. Graph of natural frequency of speaker box MGMW.

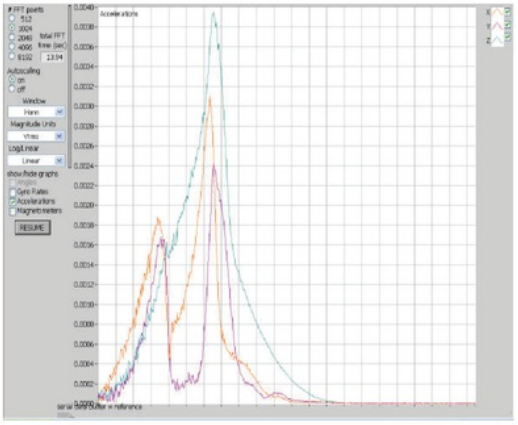


Figure 9. Graph of natural frequency of commercial speaker box.

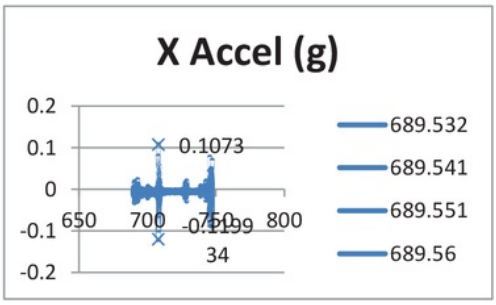


Figure 10. Graph of vibration X direction of speaker box MGMW

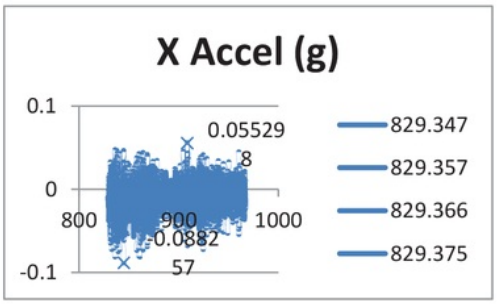


Figure 11. Graph of vibration X direction of original speaker box

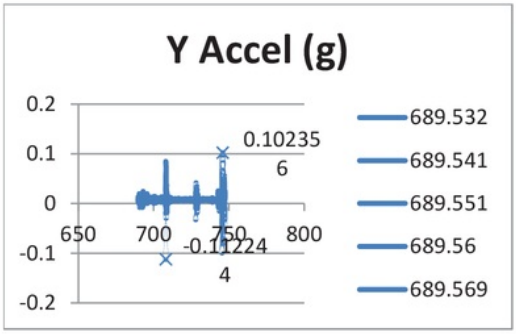


Figure 12. Graph of vibration Y direction of

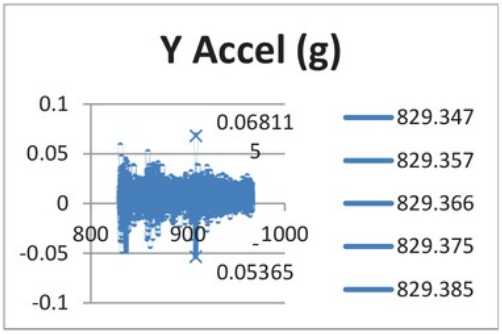
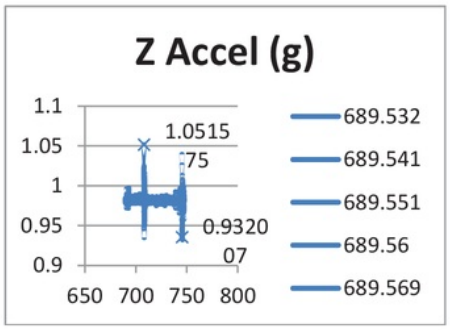


Figure 13. Graph of vibration Y direction of

speaker box of MGMW.

commercial speaker box.



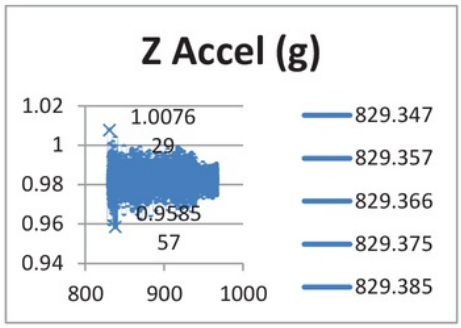


Figure 14. Graph of vibration Z direction of speaker box MGMW.

Figure 15. Graph of vibration Z direction of original speaker box.

While the commercial speaker box experience maximum vibration amplitude value X axis of 0.055298 and a minimum value of 0.068115, Y axis experience the thrill of maximum and minimum values of 0.068115 -0.05365, whereas in the Z-axis vibration maximum values obtained by 1.007629 – 0.9 = 0.107629 and minimum 0.958557 – 0.9 = 0.0585. For frequencies above, the natural direction of the Z axis in the speaker box mushroom growing media waste is lower than in the speaker box manufacturer, it means that the speaker box mushroom growing media waste is denser than the original speaker box to the Z direction. From the results of analysis, the comparison of vibration test of speaker box MGMW and commercial speaker box, it indicates that speaker box MGMW has yield related to damping vibrations with maximum vibration value X, Y, Z axis at -0.7927, -0.797644,0.151575 while the original speaker box maximum vibration values in X, Y, Z of -0.844702, -0.831885, 0.107629.

CONCLUSIONS

From this research, several conclusions can be drawn as follows:

1. Composition of 60% MGMW + 1% PVC glue + 39% (50% starch + 50% urea) at a frequency of 125 Hz has low coefficient of sound absorption and at high frequencies of 2000 Hz, it can absorb sound well.
2. Composition of 60% MGMW + 1% PVC glue + 39% (50% starch + 50% urea) has the highest hardness of 14.9 BHN.
3. Vibration obtained the amplitude values to the Z-axis, minimum of 0.032007 and maximum of 0.151575. From the acoustic test, the results indicated good sound absorption at frequency of 500 Hz and it has better damping absorption.

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