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Investigation of the Helmholtz Green Resonator Panel from Rice Husk Waste and Office Paper Reinforced with Coconut Coir Skin as a Noise Absorbing Panel

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Abstract

This study was conducted to determine the potential of acoustic panels Helmholtz resonator made from office paper, waste rice husk, and polyvinyl acetate (PVA) with a thickness of 20 mm (the compaction is 4 MPa). Specimens made from office paper crushed then mixed with rice husks. The composition of office paper (O.P.): rice husk (R.H.) is an 80:20%, and coupled with the PVA binder 6 % of the total weight of the O.P. + R.H. In acoustic cells then perforated cavity resonator used with variations in the diameter of the holes 15, 20 and 25 mm holes spaced 40 mm and 20 mm cavity depth. Cavity cover is made from coconut fibre - polyester with a ratio of 35:65 %, v_f, the hole in the cover (resonator neck) with variation in holes diameter 4, 6, and 8 mm, and the distance between holes is 40 mm neck resonator. This specimen tests based on the ASTM E1050 standard test using the two-microphone impedance tube. The optimal noise absorption coefficient (α) is 0.41 to 0.85 at an acoustic panel with a diameter of resonator cavity and neck, respectively 25 mm and 8 mm.

Keywords - *cavity depth, coconut choir, Helmholtz, PVA, rice husk.*

I. INTRODUCTION

In January 2007, Deepak Prasher Swiss surveyed due to noise on human health. The results showed that about 2% of Europeans suffer from sleep disorders, and 15% suffered severe disruption due to environmental noise. In the long run, the noise can cause about 3% of deaths from chronic heart disease (approximately 210,000 deaths) in Europe each year. Besides, noise can also result in hearing loss, sleep disturbances, social disability, decreased productivity, and accidents [3]. According to Fangueiro [1], fibrous material (porous) can be used as an excellent sound dampening when used in conjunction with other materials that serve to reduce noise at high frequencies. In contrast, the absorption of low-frequency noise can be done by adding a cavity resonator on material porous to enhance the effects of noise and air insulation. Natural materials, such as plant fibres or wool, can be used as sound absorbers to prevent noise and more effective than conventional absorbers made of a combination of minerals and plastics [9]. The combination of porous material and the cavity resonator of natural fibres can benefit from noise absorbing material of high-frequency and low-frequency [2].

Many researchers have developed a natural fibre as an absorber or noise barrier. Some of which, such as particle composite boards produced from agricultural wastes, have been developed and studied by few researchers [5,6]. Agricultural lignocellulosic fibres such as rice straw, wheat straw, or oil palm frond can be easily crushed to chips particles. They may be used as substituted for wood-based raw materials [7,8] to explore local natural fibre as filler for a composite system in the noise control application.

II. MATERIAL

Paper waste and rice husk derived from Surakarta, Indonesia. Paper waste, crushed using a crusher machine, intends that particles the paper can be mixed evenly on the rice husk.

III. METHODS

A. Acoustic cell

Processing techniques in the treatment of waste office paper (O.P.) and rice husk (R.H.) is the crushing of that office paper into paper particles. Office paper particles and grains of rice husk mixed at a ratio of 80:20%, v_f. Subsequently, the mixture was added with polyvinyl acetate (PVA) as much as 6% of the total weight (O.P. + R.H.) and stirred using a mixer. The next step is to make an acoustic cell sheet from the mixture using a mould and compacted with a pressure of 3:4; the dimensions of the acoustic cell sheet are 200 x 200 x 20 mm. Mechanism of the acoustic cell manufacture shown in Fig. 1. After moulding complete cell acoustic, then results of being cut shaped moulding of the cylinder, as acoustic cell

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specimen the noise absorption test. The specimen diameter of 100 mm with a thickness of 20 mm and subsequently given to the variation of cavity diameter 15, 20, and 25 mm (as Processing techniques in the treatment of waste office paper (O.P.) and rice husk (R.H.) is the crushing of that office paper into paper particles. Office paper particles and grains of rice husk mixed at a ratio of 80:20%, v_f. Subsequently, the mixture was added with polyvinyl acetate (PVA) as much as 6% of the total weight (O.P. + R.H.) and stirred using a mixer. The next step is to make an acoustic cell sheet from the mixture using a mould and compacted with a pressure of 3:4; the dimensions of the acoustic cell sheet are 200 x 200 x 20 mm. Mechanism of the acoustic cell manufacture shown in Fig. 1. After moulding complete cell acoustic, then results of being cut shaped moulding of the cylinder, as acoustic cell specimen the noise absorption test. The specimen diameter of 100 mm with a thickness of 20 mm and subsequently given to the variation of cavity diameter 15, 20, and 25 mm (as shown in Fig. 2, the distance between the cavities was 40 mm.

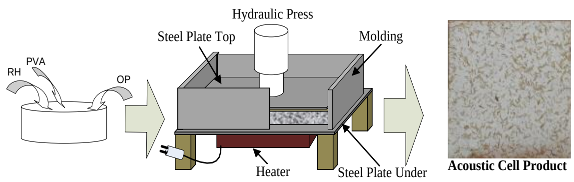


Figure 1. Mechanism of the acoustic cell manufacture

Figure 2. Acoustic cell specimens before and given a Helmholtz resonator

B. The back cover and neck resonator

Making the back cover and neck resonator (as the skins) using a composite made of coconut fibre reinforced polyester (polyester: coconut fibre; 65:35 %, vf). First of all, coconut husks soaked in an alkaline solution (NaOH 5 %) for 2 hours aim for a strong bond between the polyester and coconut fibre. Cover sheet dimensions are 200 x 200 x 5 mm, mechanism of the cover sheet manufacture shown in Fig. 3.

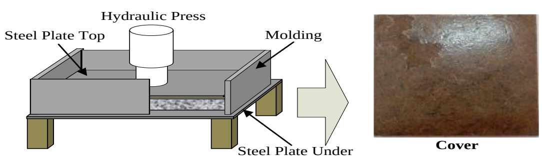


Figure 3. Mechanism of cover manufacture

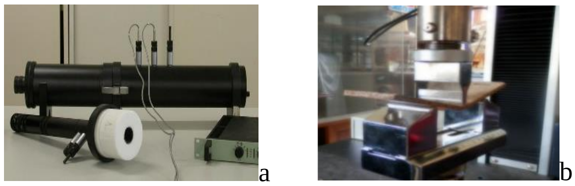
There are two types of cover used for the manufacture of acoustic panel specimens: a) the forward cover of the acoustic cell, the diameter of the cover is 100 mm with a thickness of 3 mm and a neck resonator hole (diameter variations, 4, 6, 8 mm), and the distance between the holes was 40 mm, As shown in Fig. 4a; b) the back cover of the acoustic cell, the diameter is 100 mm with a thickness of 3 mm and the cover is solid as shown in Fig. 4b.

a b

Figure 4. back cover and front cover (neck resonator)

C. Physical and mechanical test

ASTM E1050 was used to test the ability of noise absorption panels Helmholtz resonator. The tools used in this test is a two-microphone impedance tube (see figure 3), where the 100 mm diameter specimens were used in this test. Three-point bending has been done according to the ASTM D-1037 (see Fig. 5); the dimensions of the specimens are approximately 194 x 50 x 6 mm.



a b

Figure 5. a. Two-microphone impedance tube; b. three-point bending test

IV. RESULT AND DISCUSSION

A. Effect of neck resonator holes diameter

In this study, the acoustic cell is designed by varying the diameter of the resonator neck hole is 4, 6, and 8 mm. In contrast, the resonator cavity diameter and depth are fixed, respectively, 20 mm and 3 mm. Based on the research results (see Fig. 6) is widening the diameter of the neck resonator. It will lead to the higher value of the noise absorption coefficient (NAC) due to the amount of volume of noise entering through the neck of the resonator is also greater; thus, the amount of reflected noise will be smaller. Differences in the diameter of neck resonator holes influence on the level of noise absorption. The diameter of neck resonator hole is 4 mm, 6 mm, and 8 mm, respectively optimal absorption rate at a frequency of 400-700, 700-1000 Hz and 1100-1400 Hz (see Figure 6), and has a value of the noise reduction coefficient (NRC) of

0.43, 0.52, and 0.73. The above results indicate that the optimal value in the neck resonator holes had a diameter of 8 mm.

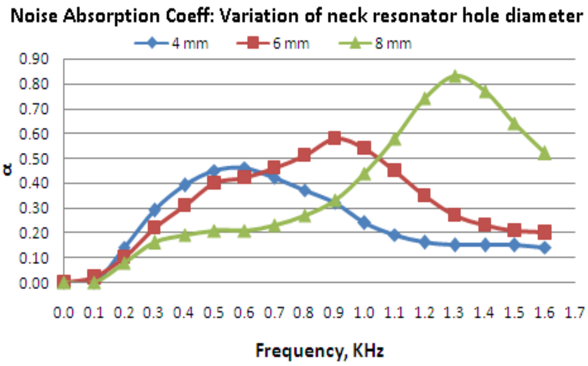


Figure 6. Noise absorption curve: variation of neck resonator diameter

B. Influence of the diameter of the cavity resonator

The acoustic cell will be designed by varying the diameter of the cavity resonator, which is 15, 20, and 25 mm, while the diameter and depth of the neck resonator hole are fixed, each 8 mm and 5 mm. The test results of noise absorption acoustic cell with a diameter variation of cavity resonator, as shown in Fig.7. The figure indicates that the acoustic cell, which has the highest noise absorption coefficient, is a cell acoustic cavity resonator has a diameter of 20 mm and 25 mm. Both have the effectiveness of absorption at frequencies 900 - 1300 Hz. The results of the above tests, it can be recommended that the acoustic cell potential for further development is the acoustic cell with a diameter of 20 mm and 25 mm and a thickness of 20 mm. furthermore, both have a value of the noise reduction coefficient (NRC), respectively 0.73 and 0.58. The optimal noise absorption coefficient (α) is 0.41 to 0.85 at an acoustic panel with a diameter of resonator cavity and neck, respectively 25 mm and 8 mm.

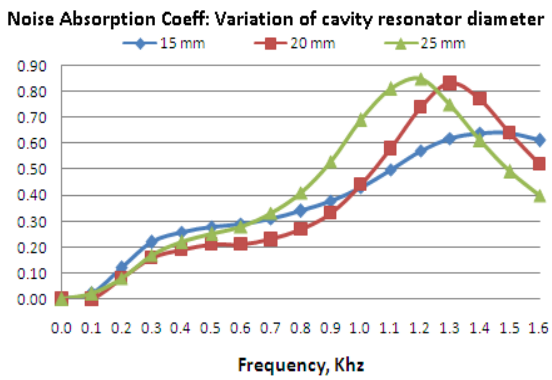
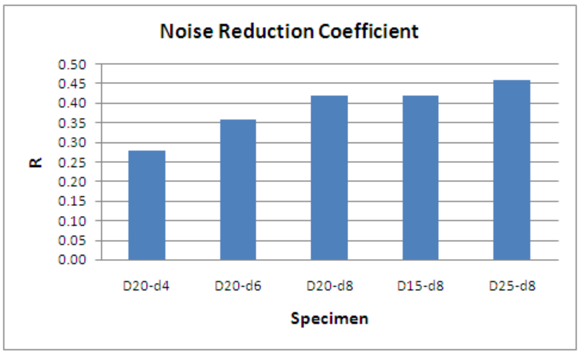


Figure 7. Noise absorption curve: variation of cavity resonator diameter

C. Noise Reduction coefficient, NRC

The noise reduction coefficient is to be calculated at a frequency of 300, 600, 900, 1200, and 1500 Hz. Fig. 5 shows the results of calculations on all specimens. Fig. 8 shows the result of the NRC obtained. It shows that the highest NRC value was obtained for the diameter of the cavity resonator and diameter of the neck resonator, each of which is 25 mm and 8 mm.



Were: D=cavity resonator diameter (mm)
d= neck resonator diameter (mm)

Figure 8. Noise reduction coefficient value for all specimen

D. Bending

The three-point bending test showed any that the value of modulus of rupture (MOR) / bending is 3.50±0.07 MPa. Based on the ANSI A208.1-1999, the bending value already exceeds the value of the classification of LD-1. So that the acoustic cell can also be used as particleboard, which is designated as door cores.

V. CONCLUSION

The study of office paper waste and rice husk material for sound absorption purposes has been reported. The composition of office paper (O.P.): rice husk (R.H.) is 80:20%. The optimum noise absorption of acoustic panels Helmholtz resonator was obtained at a diameter of cavity resonator 25mm, a diameter of neck resonator 8mm, depth of neck resonator hole 3 mm. furthermore, the value of α lies between 0.41-0.85 at frequencies between 800-1200 Hz. At the optimal value of the NRC, the average noise reduction is 0.46. Bending tests on the material of the acoustic cell showed that this material has a modulus of rupture of 3.50±0.07 MPa. Based on ANSI A208.1-1999, that value already exceeding of bending classification LD-1, this value is supposed as a door core. Final words conclude that the waste office paper and rice husk can be used as a green absorber panel of the Helmholtz resonator acoustic.

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