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THE ANALYSIS NOISE LEVEL REDUCTION FOR PORTABLE GENERATOR USING ENCLOSURE ACOUSTIC

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Abstract. This research aims to design an acoustic enclosure combined with coconut fiber to reduce the level of external noise generated by the portable generator. The study conducted with measuring the noise level in the generator before and after installing acoustic enclosure. The experiment has done with measuring the noise level of the generator before and after pairing the enclosure. Measurement of noise level has done according to ISO standard. Measurements are made five times in each point, the data shown is the average value of the measurement results. Then noise level data is displayed in table form and noise contour. Enclosure made using steel plates with a thickness of 3 mm and coconut coir fiber sheet of thickness of 35 mm. The results show that noise levels after installing with enclosure acoustic less than 70 dB. The noise level of the portable generator was 91.20 dB before covering with acoustic enclosure. Experimental results show that the use of enclosures combined with coconut fiber can lower the noise level of the portable generator. The use of coconut fiber in the acoustic enclosure is expected to replace the use of industrial acoustic materials. So, the public can make a cheaper acoustic enclosure.

Introduction

Noise is sound sources that disturbing sense of human hearing. The noise level is a measure of how high and low degree of noise expressed in decibels (dB). The high-level noise sources can cause an impact on environmental, people mental health and physical. Noise source with 8 hours/day exposure and pressure intensity level 85 dB can cause people an impact in the health conditions. Therefore, it is necessary to control the level of noise that generated by the portable generator. There were several methods to control the level noise. Controlling the level of noise can be doing at the source of a noise. It is something a primary concern to reduce noise at its source. Whenever possible, technologies should be used. Secondly, the controlling noise can be held at transmission path. This method can be carried out by designing an acoustic barrier, wall insulation as well as cutting off the vibration through the installation using vibration absorber. Third, the noise control carried out on the receiver. This method has a purpose to prevent the listener exposed the noise with high intensity and longer periods of time.

A portable generator is a small-scale electricity supply plant that is currently available at the market. It is widely used especially in the situation of the abrupt electric outage. This type of generator is also widely used by official/residential buildings. Especially people on the rural community have not been electrified from government's company. In their operation, generally, portable generators emit noises loudly. The components of the portable generator set such as the diesel engine, and engine exhaust, would arise as main noise sources in buildings and surrounding environment. In this paper, an acoustic enclosure for portable generator was designed to reduce the noise level below sound pressure level (SPL) of 80 dB from the high level exceeding 90 dB. Enclosure is designed using an absorbent material made from natural fibers. Natural fibers combined with steel plates and heat-resistant foam which sold in the market.

Noise Absorber Material

Indonesia is an agricultural country where the majority of people still rely on life in agriculture. Coconut fiber is one of the byproducts of agriculture. Most of the coconut fiber has used as a filler material mattress; the material has made as a breakwater and a rope. These coconut fibers can have used as acoustic materials. Several studies have been carried out for this purpose (Rozli, 2010 & 2011, Firmansyah, 2013, Zulkarnain, 2011). However, these studies were basic development research in the manufacture of acoustic material using coconut fibers. Many of the researchers conducted research on the acoustic properties of other natural fibers such as rice husks, palm fiber, tea leaves, and others (Rozli, 2010 & 2011, Firmansyah, 2013). These study results showed that this natural fiber has the absorption coefficient value good at high frequencies. To improve their noise absorption in the low frequency, usually natural fibers were combined with perforated plates or industrial absorbent material which is generally expensive (Asdrubali, 2007, Baranek, 1992).

This study aims to apply coconut fiber that has been known their acoustic characteristics from the earlier study. The decrease noise level on the portable generator is carried out by making the acoustic enclosure. Acoustic enclosure panel have made with a combination of steel plate, coir fiber, and foam heat insulation. Acoustic enclosure design expected to reduce noise by about 30 dB.

Acoustic Enclosure

The primary objective of any noise control project is to identify the main sources of noise on the portable generator. The key reduction in noise can achieve by reducing the noise

generated from the noise sources. The noise of vehicles and machines mainly generated by their motor generator which is usually an engine. One of the standing out contributor is the noise emitted by the engine surfaces. There are several methods to define the main noise radiating of the engine surfaces (Tandon, 1998).

One of the initial procedures in controlling noise is to determine the type barrier or panel (Cho, 2018). It aimed at reducing noise transmitted out optimally. In the design of acoustic panel, one should be able to calculate the value of transmission loss of a wall or barrier at a predetermined frequency range. Enclosure panels usually composed of two or more solid layers often used as partitions and other acoustic structures. The transmission loss for Region II, the mass-controlled region, may determine from the equation.

$$TL = 10\log\left[1+\frac{\pi f M_s}{\rho_0 c}\right] \quad (1)$$

Where M_s the specific mass for the layered panel is given by the following Equation.

$$M_s = \rho_1 h_1 + \rho_2 h_2 \quad (2)$$

The layers bonded at the interface with no air space, and then the composite panel bends about an overall neutral axis. The critical or wave coincidence frequency for the layered panel may be find from the following equation.

$$\chi = \frac{E_1 h_1^2 - E_2 h_2^2}{2(E_1 h_1 + E_2 h_2)} \quad (3)$$

$$f_c = \frac{c^2}{2\pi}\left(\frac{M_s}{B}\right)^{\frac{1}{2}} \quad (4)$$

The quantity c is the speed of sound in the air around the panel, and B is the flexural rigidity of the panel, given by the equation 5. The transmission loss for a layered panel may determined from equation I with the overall damping coefficient calculated from the following equation 6 (Barron, 2001).

$$B = \frac{E_1 h_1^3}{12(1-\sigma_1^2)}[1+3(1-2\chi/h_1)^2] + \frac{E_2 h_2^3}{12(1-\sigma_2^2)}[1+3(1-2\chi/h_2)^2] \quad (5)$$

$$\eta = \frac{(\eta_1 \varepsilon_1 h_1 + \eta_2 \varepsilon_2 h_2)(h_1 + h_2)^2}{\varepsilon_1 h_1^3 [1 + 3(1 - 2\chi/h_1)^2] + \varepsilon_2 h_2^3 [1 + 3(1 - 2\chi/h_2)^2]} \quad (6)$$

$$TL = TL_n(f_c) + 10 \log \eta + 33.22 \log(f/f_c) - 5.7 \quad (7)$$

Acoustic enclosure is a structure that covers the source of noise usually machine that aims to protect the environment from exposure to noise. Based on size, the acoustic enclosure can divide into two kinds of small and large enclosure. Acoustic enclosure called a small if the dimension of the wavelength of bending and acoustical wavelength is greater than the largest size of the panel and enclosure volume. Acoustic resonance does not occur in the interior volume of the enclosure (Barron, 2001).

Inside the enclosure a reverberant sound field is produced in addition to the noise from the source. Reducing the acoustic resonances, the absorbing material can be used on the panel of the enclosure. Absorbing material has three advantages on enclosure panels. First, it can suppress the amplitude of the standing waves on enclosure. Second, it can increase the frequency of all standing waves resonances and lastly, it can widen the standing waves. The layer of sound absorbing material should be about half the thickness of the air space to damp out the resonance considerably. In the proposed enclosure the gap between engine surface and enclosure varied from 15 cm at various points (Munjal, 2013). A uniform layer of coconut fiber sheet with thickness 35 mm applied to the inside panel of the enclosure. The absorption coefficient of coconut fiber varies from 0.28 to 0.85 in the frequency range of 63 Hz – 4000 Hz (Zulkarnain, 2011).

Measuring performance for all types of acoustic enclosure used insertion loss values. The operational definition of insertion loss illustrated in the following figure. Figure 1 demonstrates setup the measurement of insertion loss values that are outside the engine room based on the measurement of Sound Pressure Level (*SPL*) formulated as follows.

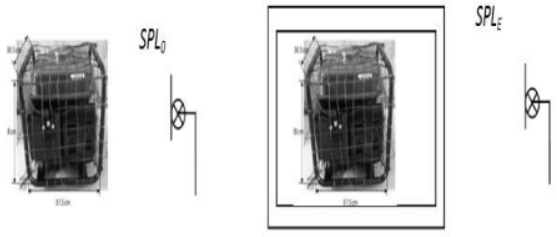


Figure 1. Measurement setup to calculate the value of Insertion Loss

$$IL_P = SPL_0 - SPL_E \quad \text{dB} \qquad (10)$$

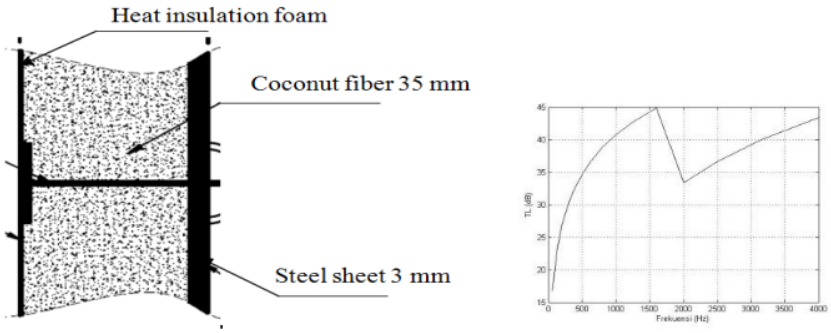
SPL_0 where the average value of the measured sound pressure level around the location of the machine, SPL_E is the value of the pressure level engine covered acoustic enclosure. SPL value measurement can do at surrounding the sound source. Distance measurement must meet at least three times the size of the largest dimension of the enclosure. Analysis can also be performed using the following formula (Baranek, 1992).

Method

Portable generators used to produce electricity power of 700 watts. Measurement pressure level (SPL) conducted three times. To measure the noise level is done by measuring the generator has not been operated and after the generator be operated. Time consume for collecting data about 1 minute. The noise levels recorded to represents the difference between the noise level before and after the generator on operating. Designing acoustic enclosure has to be made based on the standard ISO 15 667: 2000E.

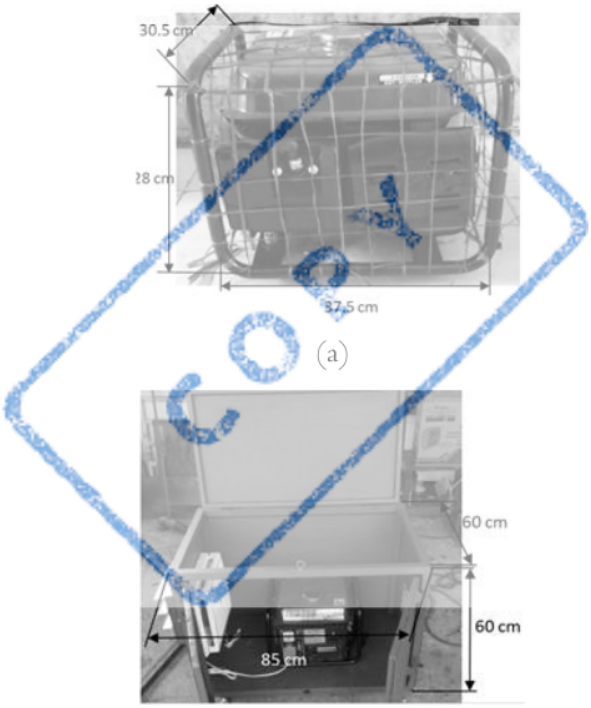
Figure 2 illustrates the arrangement of the acoustic enclosure panel and the acoustic panel TL value is calculated using equation 1-7. The steel plates were for the outermost layer, and then combined with coconut fiber that it made into sheets and in the deepest part of the acoustic panel used the heat-retaining foam. Figure 2(a) describes the composition of the panel enclosure. The steel plate is used having a thickness of 3 mm and coconut fiber sheet having the thickness of 35 mm. The TL value of the acoustic panel can be seen in Figure 2(b), the value of TI is calculated by analytical equation.

Figure 3 (a) gives the dimensional dimension of the generator, while the enclosure size created is shown in Fig. 3 (b). Generator has length 37.5 cm, width 30.5 cm and height 28 cm. The acoustic enclosure size 80 cm x 60 cm x 60 cm. Noise level was measurement using Sound Level Meter SLM-814 and a calibrator. To deliver results accurately, generator and enclosure divided by into 5 sections, namely the measurement of the top, front, rear, left and right. For the illustration see figure 4(a) and 4(b). Figure 4 (a) is the measurement points before the generator is covered with the enclosure while the 4 (b) image is the measurement point of the generator covered with the enclosure.



(a) (b)

Figure 2. (a) composition of panel enclosure acoustic (b) TL for acoustic panel



(a)

(b)

Figure 3. dimensions of (a) Portable generator (b) with enclosure

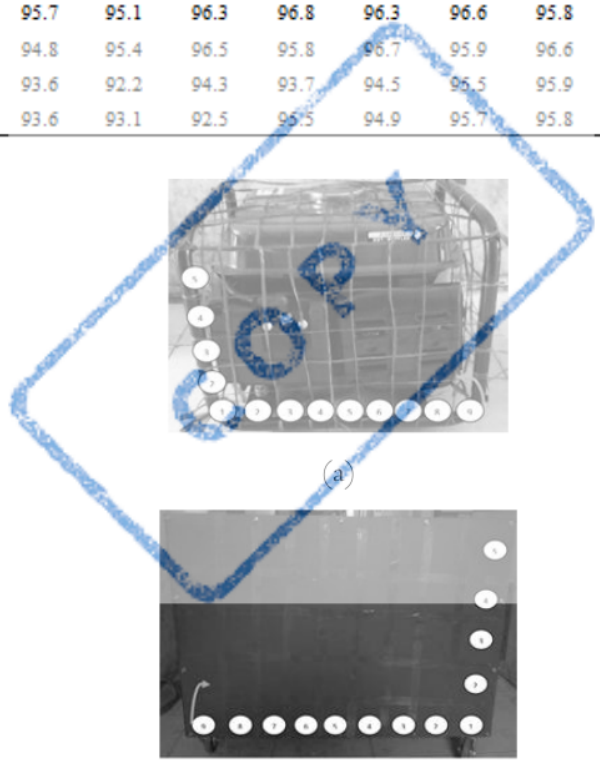
Results and Discussion

Measurement of noise levels on portable generator both before and after covering of the enclosure done at each measurement point. The data presented in Table 1 and 2 is the

average data of the noise levels. Table I is the value of the noise level at the rear of the generator which in this part is the most dominant noise contributor. Because in this section has the engine of the portable generator engine and the exhaust. In this section, the noise level is in the range of values between 93.3 dB – 97.7 dB. Furthermore, the level noise data at table I presented into noise level contour as can be seen in can be seen in Figure 5 (a) that the noise level contour image generator before mounted enclosure. Figure 5 (b) noise level contour that shows a decrease in the noise level after covering the enclosure.

Table I. The level noise portable generator without enclosure acoustic

NO	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9
Point 1	93.3	93.8	94.5	96.0	96.3	95.9	97.7	96.5	95.7
Point 2	95.7	95.1	96.3	96.8	96.3	96.6	95.8	96.4	96.1
Point 3	94.8	95.4	96.5	95.8	96.7	95.9	96.6	95.5	95.9
Point 4	93.6	92.2	94.3	93.7	94.5	96.5	95.9	95.8	95.1
Point 5	93.6	93.1	92.5	95.5	94.9	95.7	95.8	95.2	95.1



(a)

(b)

Figure 4. Noise level measurements point (a) portable generator (b) with enclosure

Table 2. The level noise portable generator with enclosure acoustic

NO	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9
Point 1	63.4	63.2	63.9	64.0	64.4	64.2	64.3	64.1	63.9
Point 2	63.2	62.8	63.0	63.2	63.8	64.3	63.1	63.2	63.2
Point 3	62.9	62.9	63.2	63.5	64.4	64.1	63.6	63.1	62.8
Point 4	63.0	63.2	62.7	62.8	62.9	63.1	63.8	62.2	62.3
Point 5	62.0	61.6	61.1	61.5	61.7	61.6	61.3	61.4	61.6

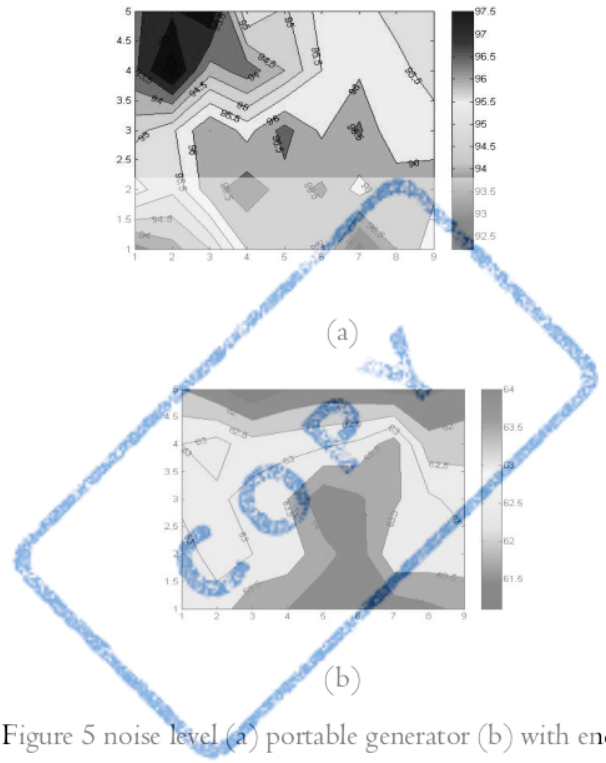


Figure 5 noise level (a) portable generator (b) with enclosure

The noise level of the portable generator on the rear side without enclosure exceed 93.3 dB, while the maximum value of 97.7 dB noise caused by the exhaust manifold of portable generators. The noise level of the portable generator on the rear side after covering with enclosure was approaching 62.20 dB. Figure 6 provides a comparison of noise level reduction that occurred generator has been fitting with enclosure. Calculations using equation 7-15 shows the error values are quite small. But on the left, an error value reduction of noise levels showed considerable value. This is occur because exist the passage of air duct at this point.

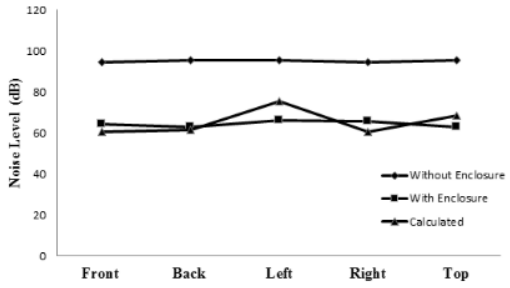


Figure 6. Noise level at the portable generator set with and without enclosure compare with simulation.

Conclusions

Using of coconut fiber as alternative materials to substitute industrial absorbent materials in the acoustic enclosure show significant results in a reduction of noise level of the portable generator set. Before covering with enclosure acoustic, the noise level on a portable generator can exceed average to 97.7 dB. After the portable generator in covers enclosure acoustics, the average value of the noise level that about to 62.20 dB. From the results of this test has been able to decrease the noise level of 35.50 dB. However, the uses of coconut fiber still provide a sizeable obstacle. The first coconut coir has flammable properties and can easily be damaged by climate. Therefore, for further research needs careful observation of the increasing temperature in the enclosure. It is also necessary to research to improve the resistance to fire of coconut husks and climate.

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