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Recycling Surgical Mask as Acoustic Panel using Hand Lay-Up Methods

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Abstract

The research was conducted to recycle surgical masks as acoustic panels using hand lay-up methods and to test their effectiveness in reducing noise using the tube method. The frequency used as a sound source is 495 Hz. Tests were carried out with variations in panel thickness, they are 1 cm, 2 cm, 3 cm, 4 cm, and 5 cm and three variations composite material, they are first layer, second layer and third layer of surgical mask. The panel test results show that the thicker acoustic panels are more effective in reducing noise based on the regression analysis that show the thicker panel from three variations composite material is 0.98, 0.99 and 0.96, respectively all of which are included in the very strong category. In addition, ANOVA analysis show that the thicker panels from all variation composite material respectively was 0.002, 0.001 and 0.009, they are showed the significant effect between the thickness of the panel and the effectiveness of the panel in reducing noise. Furthermore, based on the regression analysis from acoustic panels composite made of surgical masks from first layer, second layer and third layer were 8.24, 8.39 and 5.81, respectively the panel acoustic from second layer surgical masks are more effective to reduce the noise than other layer. Overall, it can be concluded that acoustic panels made of surgical masks are effective in reducing noise, as well as a solution to increasing surgical mask waste during the Covid-19 pandemic.

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INTRODUCTION

Nassiri et al. (2013) shows that the growth of industrial and technological progress causes noise in the environment. Noise data in Indonesia shows that it has exceeded the standard noise level according to Keputusan Menteri Negara Lingkungan Hidup Nomor : KEP-48?MENLH/11/1996. Fyhri & Aasvang (2010) proved that noise can cause heart disease. According to Mokhtar et al. (2012), industrial noise has an impact on worker performance and productivity. In addition, Hohmann et al. (2013) and (Osborne et al. 2020) proved that noise interferes with pregnancy and children's hearing, noise also causes damage to nerve cells and blood vessels which can increase cardiovascular disease. Therefore, Labombang & Nirmalawati (2017) suggested the use of acoustic panels to reduce noise and create a comfortable environment.

In other side, since the emergence of Covid-19 and being declared a pandemic by the World Health Organization (WHO), the government has followed strict health procedures, one of which is the mass use of disposable surgical masks, according to Wilder, Smith A. MD; Freedman, (2020); Lin et al., (2020); Chintalapudi et al., (2020) related to solutions for handling the Covid-19 pandemic. Radonovich et al., (2019) states that the use of disposable surgical masks is increasing in line with WHO recommendations with relevant scientific evidence regarding the effectiveness of surgical masks in preventing the transmission of Covid-19. As a result of the policy, WHO (2020) estimates that 89 million surgical masks are needed to respond the COVID-19 pandemic each month. This resulted in the emergence of new waste, because surgical masks are made of polymer materials that are difficult to degrade in nature and require hundreds of years to decompose (Nasution, 2015). In addition, according to Wirasasmita et al., (2020) surgical mask waste can cause dangerous diseases such as cancer, pregnancy disorders, and damage to other body tissues.

Therefore we need a solution to the social and environmental impacts caused by surgical mask waste. According to Mohd (2019) stated that polymer waste materials can be used as acoustic panels because they have a fairly high sound-absorbing ability so that surgical mask waste has the potential to be used as acoustic panels because according to the research of Maderuelo-Sanz et al., (2021) a sample of the material from surgical mask exhibits high sound absorption performance over the desired frequency range. So, this study aims to produce acoustic panels by recycling surgical masks using hand lay-up method and test their effectiveness in reducing noise using tube method. Because of the need to obtain accurate research data related to the sound absorption ability of surgical masks, in this study a new surgical mask was used in the manufacture of acoustic panels.

METHOD

In this study, the raw materials used are surgical mask from the same brand and Polyvinyl Acetate (PVAc). While the tools used are digital scales, Krisbow S229D paper chopping machine, Maspion brand pralon with a diameter of 80 mm, hydraulic press machine, and frequency generator from android application. Before use, surgical masks sterilized using 70% alcohol by soaking for 10 minutes as recommended by LIPI. Surgical masks that have been sterilized are dried in the sun. Furthermore, the surgical masks are separated from their constituent layers by cutting the edges which consist of adhesive and iron that unites the three components of the surgical mask. Then, each layer of surgical masks shredded by chopping machine to form a uniform piece of surgical mask with a diameter of 3 mm. The masks formed are then weighed using a digital scale to estimate the need for masks in the manufacture of panels. The weighing results show that one surgical mask produces 1.6 grams of the first and third layer masks and 2 grams for the second layer of masks.

The development of acoustic panels was carried out using the hand lay-up method, where shredded surgical masks was added with Polyvinyl Acetate (PVAc) with ratio 50/50. After that, the composite mixture is formed using a tube mold to form circular panels with a thickness variation, they are 1 cm, 2 cm, 3 cm, 4 cm and 5 cm for each layer of surgical masks. So, they are fifteen sample of panel acoustic that formed. Therefore, in this study with variations in thickness and surgical mask layer required approximately 750 pieces of surgical masks. The panel mold that has been formed is then pressed using a hydraulic press machine so that the formed panel is evenly compressed and dried under the hot sun for further testing of the effectiveness of the panel in reducing noise. The mechanism for making acoustic panels can be seen in Figure 1 below.

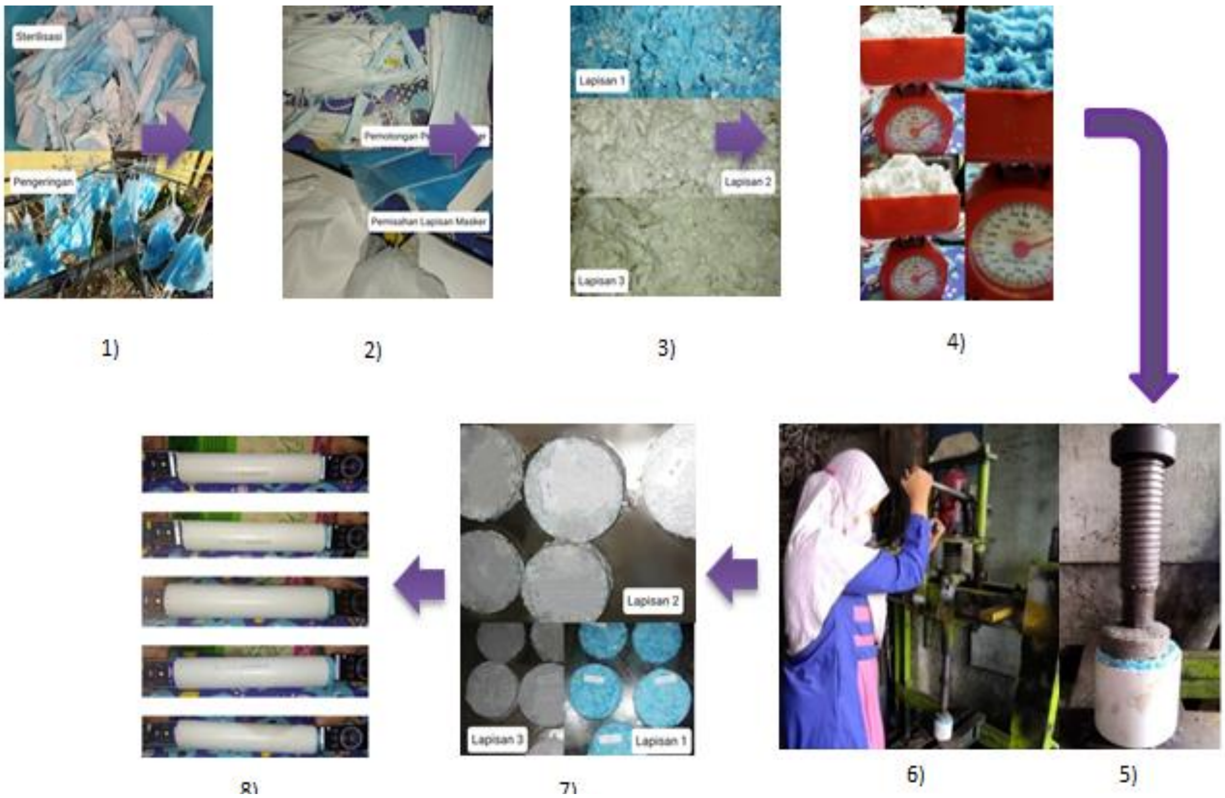

Figure 1. Stages of Making Acoustic Panels

Testing the acoustic value of the panel is carried out using the tube method, where the impedance tube used is made of 40 cm long Maspion brand pralon. Prior to data collection, all test equipment consisting of Frequency Generator Apps, Sound Meter Apps, impedance tubes and acoustic panels were prepared. The test equipment is then arranged according to Figure 2 to determine the noise level at the test site, which obtained a noise level of 62 dB which exceeds the normal noise level for housing. Then the effectiveness of the panel was tested according to Figure 3 to determine the noise level after adding an acoustic panel made of surgical masks. The frequency used in this study is 495 Hz and the sound intensity is measured using decibels (dB). The effectiveness of the panel is obtained by comparing the difference in the intensity of the sound produced by the frequency source before adding the panel and the intensity of the sound produced by the frequency source after adding the panel according to Sasmita et al. (2021) research using regression analysis method. There are two variable independent that used, they are the thickness of panels and the layer of surgical masks. So, the intensity of the sound are the variable dependent in this study.

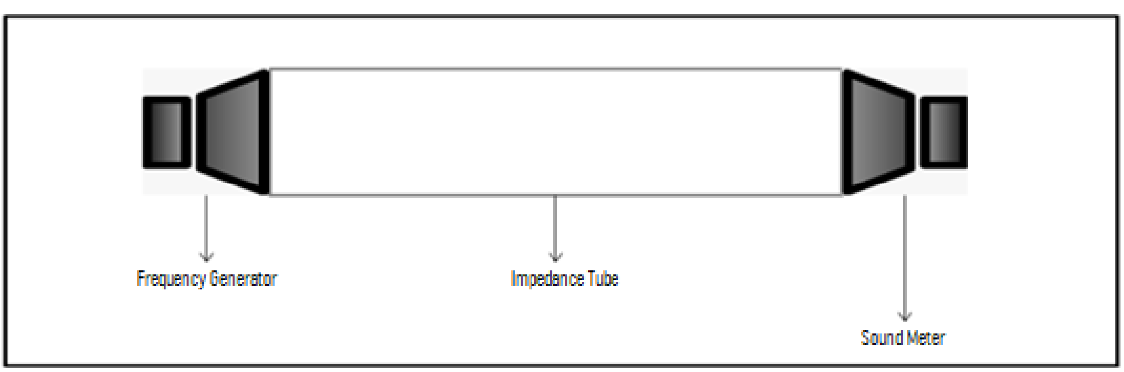

Figure 2. Design of the Sound Intensity Testing Tool

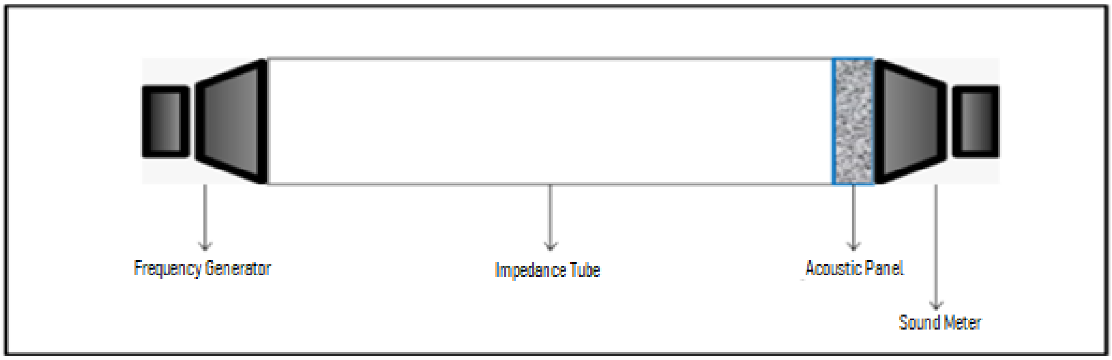

Figure 3. Panel Effectiveness Testing Tool Design

RESULTS AND DISCUSSION

Based on the research methodology, it is hoped that research data will be obtained to support the hypothesis that surgical masks can be used as sound absorbers as a solution treating mask waste which has increased during the Covid-19 pandemic while at the same time knowing how effective they are in reducing sound with variations in thickness and layer masks as materials for acoustic panels. The sound intensity data obtained from the 495 Hz frequency source was obtained before and after being passed through an acoustic panel made of surgical masks. The data obtained can be seen in Table 1.

Table 1. Sound Intensity Before and After Adding the Acoustic Panel

f	Layer Mask	Thick	Intensity	
			Before Added Panel	After Added Panel
495 Hz	First	1 cm	62 dB	33 dB
		2 cm	62 dB	30 dB
		3 cm	62 dB	26 dB
		4 cm	62 dB	19 dB
		5 cm	62 dB	13 dB
	Second	1 cm	62 dB	30 dB
		2 cm	62 dB	27 dB
		3 cm	62 dB	22 dB
		4 cm	62 dB	15 dB
		5 cm	62 dB	10 dB
	Third	1 cm	62 dB	34 dB
		2 cm	62 dB	32 dB
		3 cm	62 dB	30 dB
		4 cm	62 dB	26 dB
		5 cm	62 dB	19 dB

The effectiveness of the acoustic panel from each layer with various thicknesses can be seen in the graph shown in Figure 4. The data show of varying effectiveness numbers, which are above 45%. According to the data, panels acoustic from surgical mask are able to absorb noise. This is proven by obtaining intensity that can adjust to the level limit noise for housing according to Keputusan Menteri Negara Lingkungan Hidup Nomor : KEP-48?MENLH/11/1996, which is 30 dB.

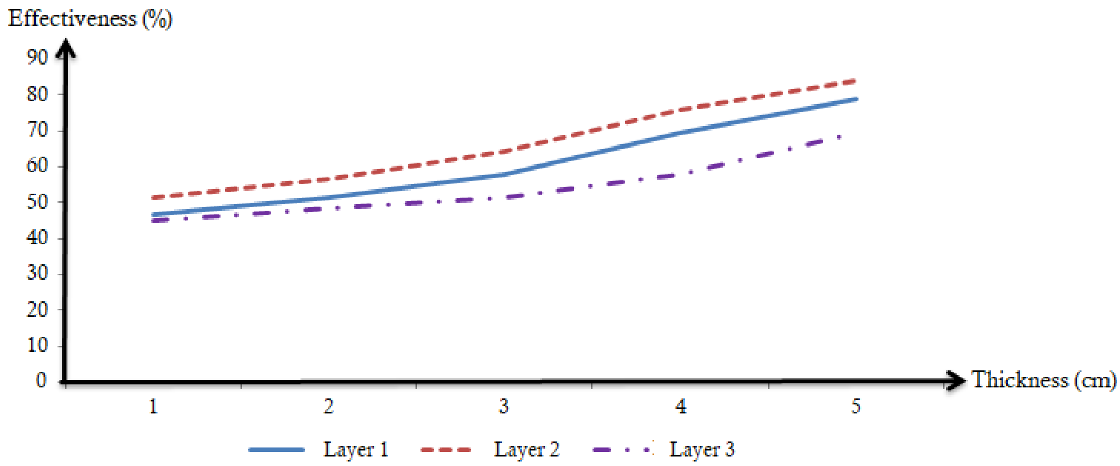

Figure 4. Acoustic Panel Effectiveness Chart

In general, the effectiveness of the panels made with composite materials of the second mask layer is more effective than the first and third mask layers. This is in accordance with the research of Handika, et al. (2018) which states that the fiber diameter image of all mask brands in the second layer is smaller than the first and third layers, so that acoustic panels made of second layer masks are more effective than acoustic panels made of other masks layer.

Based on the regression analysis, the thickness correlation value with the effectiveness of the acoustic panel made from the first layer, second layer and third layer of surgical masks is 0.98, 0.99 and 0.96, respectively, all of which are included in the very strong category. Therefore, it can be concluded that the thicker the acoustic panel, the more effective it is in reducing noise. In addition, the determination value of the panel of the first layer, second layer and third layer is 0.97, 0.98 and 0.89, respectively. This shows that the effect of thickness on the effectiveness of the acoustic panels made of surgical masks in the first, second and third layers, respectively, is 97%, 98% and 89%. Furthermore, based on the ANOVA analysis, the significance value of the acoustic panels of the first layer, second layer and third layer respectively was 0.002, 0.001 and 0.009, where a significance value of less than 0.05 indicates that there is a significant effect between the thickness of the panel and the effectiveness of the panel in reducing noise. Based on the regression analysis, the regression coefficient data from acoustic panels made of surgical masks first layer, second layer and third layer were 8.24, 8.39 and 5.81, respectively the panel acoustic from second layer surgical masks are more effective to reduce the noise.

CONCLUSION

All panel specimens tested at a frequency of 495 Hz have good effectiveness in absorbing sound intensity. More than that the results of the panel effectiveness test are in the good category so that it can reduce sound to the noise limit for housing. In addition, it is also known that among the three layers from surgical masks, it turns out that the second layer has a higher effectiveness than the first and second layers. So it can be concluded that acoustic panels made from surgical mask are effective as sound absorbers, as well as a solution for treating mask waste which has increased during the Covid-19 pandemic.

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