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Manufacture of Acoustical One Side-Waffle Panel Made of Natural Resources With Hydraulic Hot Press Machine

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Graphical abstract

Abstract

Waste generated from natural resources should be recycled as more useful materials. This research has produced acoustical waffle panel material which is useful as an absorber on the noisy housing. Acoustical waffle panels was made by Hydraulic Hot Press machine. The purpose of this discussion is to describe the machine design process and compare waffle panels made of coconut fiber and wood sawdust in the best acoustic performances. The result is that the hydraulic hot press machine has the structural strength and stability on the load of 2,500 N and 5,000 N. The hot press machine is safe for both the transverse tensile stress and longitudinal tensile stress which are smaller than the allowable stress of steel material of 40 at 1,100 kg/cm^2. It also has the highest Sound Transmission Loss (STL) with the value of 40. 059 dB.

Keywords: Waffle panel, acoustic performannce, steel

Abstrak

Sisa yang dihasilkan daripada sumber semula jadi hendaklah dikitar semula sebagai bahan yang lebih bermanfaat. Kajian ini telah menghasilkan bahan panel wafel berakustik yang berguna sebagai penyerap bunyi pada perumahan yang terdedah kepada bunyi bising. Panel wafel akustik telah dhasilkan oleh mesin penekan hidraulik. Tujuan perbincangan kerja kerja ini adalah untuk memberi gambaran berkenaan proses reka bentuk mesin dan membandingkan panel wafel diperbuat daripada serat kelapa dan habuk papan kayu kebolehan akustik terbaik. Hasilnya adalah bahawa mesin penekan panas hidraulik mempunyai kekuatan struktur dan kestabilan pada beban 2500 N dan 5000 N. Mesin penekan ini adalah selamat untuk kedua-dua tegasan tegangan melintang dan tegasan tegangan membujur yang lebih kecil daripada tekanan yang dibenarkan daripada keluli bahan 40 pada 1100 kg/cm^2. Ia juga mempunyai tertinggi Kehilangan Penghantaran Bunyi yang (STL) dengan nilai 40. 059 dB..

Kata kunci: Panel wafel, kebolehan akustik, keluli

1.0 INTRODUCTION

Coconut plantations and timber products are amazing natural resources. Waste of plantations such as coconut fibers are recycled into acoustic panels on previous research [1, 2]. Similar to coconut fibre, wood sawdust can also be recycled as acoustic panels. Industrial manufacture became a destination for the construction industry with the concept of Green Construction. To be able to answer the purpose of making the material acoustic panels made of coconut fibers and sawdust, then a single machine hot press with hydraulic-powered heating system was created. Fluid on hydraulic press machine gives the style press to print material of coconut fibers and sawdust. The design of hydraulic press machine is equipped with a suppressor textured waffle plates, electric panel, drive shaft and heating system up to 300°c [2]. In previous research, it was found that acoustic one side waffle panel has a better acoustic performance than the two side waffle panel. Therefore, in this discussion, it will be discussed the acoustic performance comparison between acoustical one side waffle panel made of coconut fibre and sawdust [2].

2.0 LITERATURE REVIEW

This study used two methods consisting the planning method of the machine to find the hydraulic hot press machine design of the right manner [3] which could make the acoustical panel as well as waffle measurement methods of acoustic performance by using impedance tube to determine the acoustic characteristics of each panel [2].

Hydraulic pressing machine works based on pascal's theory, which states that when pressure is applied to the fluid in a closed system, the pressure in the whole system will always be constant [4]. Hydraulic press machine utilizes the pressure exerted on the fluid for pressing and forming something [5]. The Press machines typically has a metal plate that serves for pressing and forming somekind of material [6]. According to the research conducted by A. Satyapratama and S.T Atmadja [7], Planning hydraulic press machine was conducted by supporting software of Fenite Element Method simulation. This simulation serves as a comparison with manual planning to facilitate and understand the phenomena that occur in a hydraulic press machine, so that the hydraulic press machine can be designed safely and in accordance with the needs.

3.0 METHODOLOGY

The research methodology consists of two parts, namely the planning method of the engine and the test method of acoustic material. Planning method of the machine consists of the stages of the simulation and planning stages. At this stage the simulation sequence activities are the identification of the components of the voltage on the machine then the determination of safety factor on the software. In the planning process, the analysis of voltage, the voltage on the load percentage identification and voltage permissions on material, i.e. steel 40 and 55 had been conducted. Like the previous research [8], the acoustic test of material on this research consists of absorption coefficient test and Sound Transmission Loss (STL).

3.1 Simulation Process

Simulation method was done as comparison for the manual machine design. simulation of machine design used Fenite Element Method Software on solidwork simulation. Solidwork simulation was used to identify the distribution of voltage on the material and compare it to the voltage permit.

3.2 Mechanical Design

Planning design of hydraulic hot press machine was used to make the acoustic waffle material. Strength of materials in tension and buckling into consideration so that the material can be produced with a good quality. Modeling of static and buckling load performed on hydraulic drive shaft when the given loading. Force applied by the engine press is assumed to be centered at the top of the rod of hydraulic cylinder, the style is converted into pressure. The pressure is the magnitude of the broad in unity of style. While the object is assumed to be uniformly distributed in each section of the supressor plate as a result of force applied to hydraulic hot press machine. Figure 1 shows the load and constrain on drive shaft.

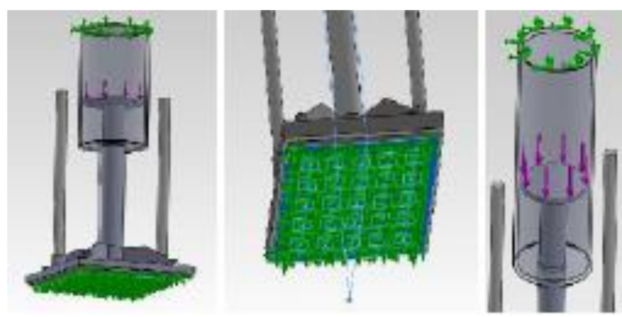

Figure 1 Load and constrain on drive shaft [7]

Static and buckling load modeling was conducted in order to receive a load of hydraulic drive shaft. On load modeling, the force caused by the mass of the payload was assumed to be uniformly distributed in every area. In order for the burden that occurs on the surface of each plate can be uneven, the style is converted into pressure. Figure 2 shows the simulation ofl and constrain in frame.

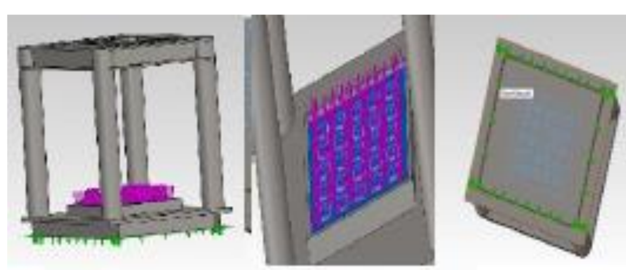

Figure 2 Simulation of Load and constrain in frame [7]

3.3 Absorption Coefficient Test

The absorption coefficient of material can be accurately calculated in the impedance tube. The sound absorption coefficient (α_0) is calculated by measuring the sound pressure that fall on the surface material and reflected by it. The absorption coefficient test refers to the standard of JIS A 1405 1963 [2, 8, 9]. These coefficients can be calculated using the equation as follows [2, 8, 10]:

$$\alpha_0 = \frac{4}{n + \left(\frac{1}{n}\right) + 2} \quad (1)$$

Whereas α_0 is sound absorption coefficient (dB) and n is standing wave ratio.

(3

3.4 Sound Transmission Loss (STL) Test

The Sound Transmission Loss test is quite different with the absorption coefficient test. The Sound Transmission Loss (STL) Test used impedance tube equipped with 4 microphones that have sensitivity to high frequency sound. Sound Transmission Loss/STL of a partition is defined as the ratio of logarithmic between the transmitted sound powers (W_t) and the sound power of partition material which comes to the surface (W_i) [2,11]. In general it can be formulated as:

$$TL = 10 \log \frac{W_t}{W_i} \quad (2)$$

$$TL = 10 \log \frac{1}{r} \quad (3)$$

Whereas r is the sound transmission coefficient of such material, i.e. the ratio between the transmitted sound power through partition of material against the coming sound. Based on the ASTM E 413-2004, measurement of Sound Transmission Loss in impedance tubes is carried out using the frequency range of 125 Hz up to 4000 Hz with 1/3 octave filter [2,12].

4.0 RESULTS AND DISCUSSION

The research results will be discussed in accordance with the order as in the method.

4.1 Simulation Process and Mechanical Design

Loading performed at known stress von mises located in the largest hydraulic drive shaft of 7.3 N/mm^2 which is the maximum stress experienced on a centralized treatment of F = 2500 N and obtained safety factor of 38.51 This means that the component will not experience failure when administered treatment with a concentrated load F = 2,500 N. Figure 3 shows the simulation on hydraulic drive shaft with a maximum Von Mises/voltage of 8.4 N/mm^2

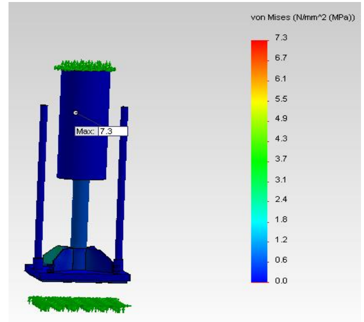

Figure 3 Simulation on hydraulic drive shaft with a maximum Von Mises/voltage of 8.4 N/mm^2 [7]

On the imposition of a known voltage von Mises conducted the largest is located on the top of the cylinder in hydraulic drive shaft and the buckling load factor obtained i.e. of 2706,3 against the style press of 2,500 N. This means that the component will not fail when given a centralized load treatment with F = 2,500 N. Figure 4 shows the buckling simulation on hydraulic rod.

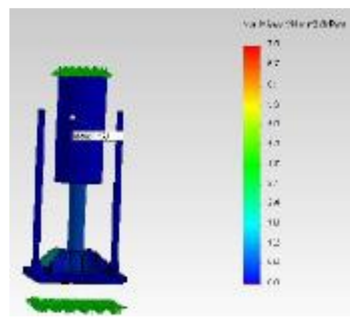

Figure 4 Buckling Simulation on hydraulic Rod [7]

Simulation on hydraulic Rod buckling

Diameter motion tube	:	D= 20 cm
		R = 10 cm
The thickness of motion tube	:	R = 0,8 cm
Dimensions of drive shaft	:	D = 6.7 cm
		R = 3,35 cm
Suppressor style prints	:	250 kg = 2450 N

1. Planning motion Tube:

Voltage maximum tensile steel 40	:	5500 kg/cm2
	:	Safety factor = 5

Allowable stress = maximum voltage drop / Safety factor

= 5500 kg/cm2 / 5

= 1100 kg/ cm2

The pressure in the tube

Note D = 20 cm

r = 10 cm

A broad cross-section of the tube:

$$A = \pi . r^2$$
$$= 3{,}14 \times 10^2$$
$$= 314 cm^2$$

Tensile longitudinal stress [7]:

$$\sigma = \frac{P_{cr}}{A}$$
$$= \frac{P_{cr}}{\pi r^2}$$
$$= \frac{608.606{,}87 kg}{3{,}14.(3{,}35 cm)^2}$$
$$= 17.275{,}2 kg / cm^2$$

Tensile transverse stress [7]:

$$P = \frac{F}{A}$$
$$= \frac{2500 kg}{314 cm^2}$$
$$= 0{,}79 kg / cm^2$$

Tensile longitudinal stress [7]:

$$Q_t = \frac{pD}{2t}$$
$$= \frac{0{,}79 kg / cm^2 .20 cm}{2.(0{,}8) cm}$$
$$= 9{,}87 kg / cm^2$$
$$= 0{,}79 kg / cm^2$$

Voltage transversal and longitudinal tensile load is said to be safe because it is smaller than the voltage permit materials amounting to 1100 kg/cm².

2. Planning drive shaft [7]:

Planning drive shaft : 6600 kg/cm2
: Safety factor = 5

Allowable stress = maximum tensile stress / Safety factor
= 5500 kg/cm2 / 5
= 1320 kg/ cm2

The pressure in the tube
Note i D = 6,7 cm

$A = \pi . r^2$ = 3,35 cm

$$= 3{,}14 \times 3{,}35^2$$
$$= 35{,}23 cm^2$$

A broad cross-section of the tube:

$$P = \frac{F}{A}$$
$$= \frac{250 kg}{35{,}23 cm^2}$$
$$= 7{,}09 kg / cm^2$$

Tensile longitudinal stress:
Momen inersia:

$$I = \frac{A}{K^2}$$
$$= \frac{3{,}14.(6{,}7) cm^4}{64 cm^4}$$
$$= 98{,}86$$

Critical Load [7]:

$$P_{cr} = \frac{C \pi^2 EI}{l^2}$$
$$= \frac{2.3{,}14^2.(2 \times 10^6 kg / cm^2).(98{,}86)}{(80 cm)^2}$$
$$= 608.606{,}87 kg$$

Critical load (Pcr) amounted to,87 kg 608.606 is said to be safe because it is greater than the load of 250 kg of materials.

Buckling critical voltage on drive shaft [7]:

4.2 Absorption Coefficient Test

From previous studies it is known that absorption coefficient of a material with the texture of the waffle 1 side has the more absorbance bak rather than material waffle 2 sides. Therefore, it will compare the difference between the material side of waffle 1 coconut fibers and sawdust. Table 1 and Figure 5 show the results of the comparison of the characteristics of both materials

Tabel 1 The weight and Density of the Material

NO	SAMPLE of MATERIAL	Volume (CM3)	Weight (GRAM)	DENSITY (GRAM/CM3)
1	Panel Sawdust waffle 1 sides t = 10 mm	7,065	2,320	0,328
2	Coconut Fibers waffle Panel 1 side t = 10 mm	10,598	2,440	0,230

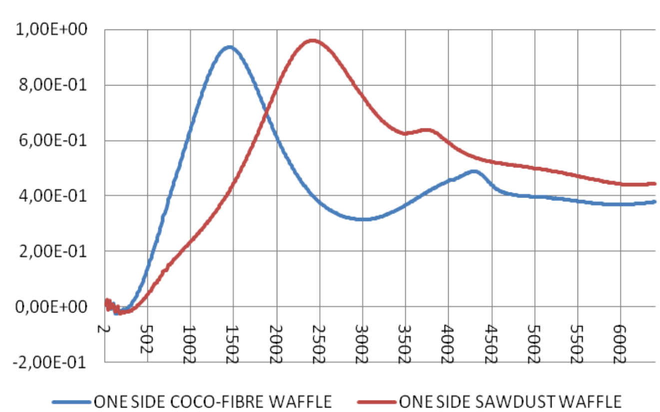

Figure 5 Comparison Of The Absorption Coefficient of The Material

Based on the data density on Table 1, note that both of these materials are included in the category of low-density particle material. The graph illustrates that one side waffle sawdust panel has the absorption coefficient 0.60 – 0.95 on the frequency range 2 k – 3.5 k. Therefore, material one side effectively muffle the sound of the sawdust waffle on the Middle frequencies. While one side waffle coco-fibre has a peak value of the coefficient absobsi in frequency of 1500 Hz. absorption coefficient value of 0.50 – 0.95 recorded at a frequency of 1000 – 2000 Hz. coco-fibre Material will very effectively muffle the sound at low frequencies.

4.3 Sound Transmission Loss (STL)

Absorption coefficient, equal to the value of Sound Transmission Loss material with waffle 1 side better than the waffle material 2 sides. The following is a description of the Sound Transmission Loss for the material made of coco-fibre and sawdust. Figure 6 shows the comparison of STL of materials

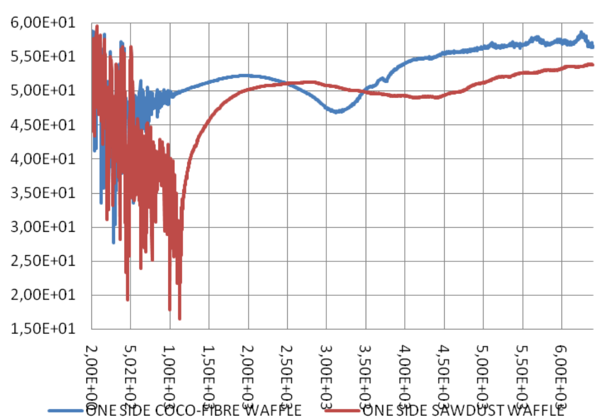

Figure 6 The Comparison of STL of materials

Of the curve above it can be concluded that the material from coconut fibers texture waffle 10 mm thick side 1 will have STL between 48 – 58 Hz. While on the frequency 3200 Hz, the STL will be slightly down < 48 dB. Whereas the material from the sawdust will have the STL start riding on a frequency of 1250 Hz. frequency while in others, the value of the STL well enough between 40 – 52 dB. Value of STL is best > 52 dB above the frequency of 6000 Hz.

5.0 CONCLUSION

From the curve above it can be concluded that the material from coconut fibers texture waffle 10 mm thick side 1 will have STL between 48 – 58 Hz. While on the frequency 3200 Hz value STL will be slightly down < 48 dB. Whereas the material from the sawdust will have the STL start riding on a frequency of 1250 Hz. frequency while in others, the value of the STL well enough between 40 – 52 dB. Value of STL is best > 52 dB above the frequency 6000 Hz. Material waffle the panel made of sawdust have effective absorption coefficient in the Middle frequencies, while material from coco-fibre has an effective absorption coefficient at low frequencies. Good material waffle made of coco-fibre and the sawdust has a good keammpuan STL on all frequencies.

Acknowledgement

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