International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 03, March-2017

Acoustic Sound Absorpation Material Characteristics of Fiber Using the King Banana Stem Polyurethane and Gypsum as Matrix

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***Abstract*— The main objective of this study is to determine sound absorption characteristic of the acoustic material of fiber rod *Roystonea Regia* by using polyurethane and gypsum as matrix. The variable in this study is the changes of the material fiber rod *Roystonea Regia* size and composition in the matrix of polyurethane and gypsum. Preparation of sample is started by hewing, cleaving, drying, taking fiber, chopping, blending, sifting, mixing with polyurethane and gypsum, shaping the specimen and testing the *Roystonea Regia* rod. The specimen then formed in cylindrical shape with 4 inchi diameter and 2 cm thick in order to be tested its density, porosity, sound absorption characteristic and the microstructure. The result of this study can be concluded that the highest absorption coefficient at a frequency 2000 Hz is 0.7966 is obtained from the fiber sized 32 mesh, with the composition 60%, the density is 0,4335 gr/cm^3 and the porosity is 57,8791%. Whereas, the highest absorption coefficient at the fiber composition 50% is 0,6016, the density is 0,4511 gr/cm^3 and the porosity is 55,6001%.**

Keywords*— *The King Banana Stem, Polyurethane, Gypsum, Acoustic Sound

I. INTRODUCTION

Particular to reduce the noise in narrow spaces such as housing and offices. This is because porous materials are relatively cheaper and lighter than other types of dampers[1] [2]. Material that has long been used in the silencer of this type is glass wool and rock wool. But because the price is expensive, various substitutes of these materials began to be made. Among them are various kinds of materials is composed of fiber [1].

Many porous materials and fibrous materials around us that might be used to serve as an absorbent composite material analysis of sound results. From acoustic characteristics of coco fiber composite boards matrix ceramics obtained parameters that affect the sound absorption, such as a ratio of fibers and matrices, density and homogeneity mix.

A composite material made from corn cobs and polyurethane with a composition ratio of 40% corn cobs and 60% polyurethane, 50% corn cobs and 50% polyurethane, 60% corn cobs and 40% polyurethane made with the grain size of 6/10 mesh, mesh 10 / 16 and mesh 16. corn cobs with a small grain size (16 mesh) and a composition of 40% corn cobs can muffle the sound that has the absorption coefficient (α) of 0.63.[3] [1] [4]Has investigated the possibility of using waste oil as raw material rod acoustic panels. Reported from the initial study palm kernel acoustic characteristics with a simulation method that polymer composite materials made from oil palm trunk fiber produced decent enough. Study "The sound absorption coefficient of Fiber Composite Materials Sawn Trunk Oil and Gypsum as Sound Absorbent Materials Using Impedance Tube Method [5]

Absorption coefficient values obtained the highest on the variation of palm fiber trunk - gypsum - water mixture is at 0.4: 1; 1:25 at a frequency of 4000 Hz with a thickness of 3 cm is 0.408. Acoustic material is an engineering material whose primary function is to absorb sound or noise to eligible [6] of wall. Acoustic material is a material that can absorb the energy of the sound coming from the sound source. Basically, all materials can absorb sound energy, but the amount of energy absorbed is different for each material. There are different types of sound-absorbing material, such as a type of porous material (for sound with medium to high frequencies), a panel type. The type of resonator (low frequency), the type of micro-perforation (specific frequency). Magnitude is used to demonstrate the performance of absorbent material sound is the coefficient of absorption (alpha), which has a value of 0-1, 0 indicating no sound energy is absorbed by the material, whereas 1 shows the entire sound energy that comes to the surface of the material to be absorbed entirely and not returned to the room.

Soundproof material or functionally Sound Proofing Materials used to block out sound energy out of the room or into the room. This material is required for the function rooms that should not be disturbed by noise from outdoors (example: a recording studio, a TV studio, concert halls, etc.) or the function of producing sound with great energy so that unwanted.

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THEORY

A. *Noise*

As The main characteristic of this material certainly should not be a conductor of sound energy (mechanical) good or in other words is not easy to vibrate when exposed to acoustic energy (sound) or transforms sound energy into another form of energy when the cross, or in other words, as little as possible to pass sound energy through it.[1]

Sound, psychologically, is defined as the result of pressure variations medium sector in both air and water that apply to the surface of the ear that converts pressure variations into electrical signals and received by the brain as sound. Sounds can also be defined as a physical disturbance in the media which has the force and as a transfer medium of sound waves. This medium can be air, gases and solids. Minister of Environment in a decision (No:48/MENLH/ 11/1996; on the standard noise level) termed the "Noise is unwanted noise from the business / human activities in the rate and time that can cause human health problems and comfort environment".

For most air and gas, the speed of sound in this medium can be determined by application of the laws of thermodynamics gas equation as follows:

$C=\frac{\sqrt{GT}}{M}$

Note:
c = Free Sound Waves
γ = the ratio of specific heat at constant pressure to the specific heat at constant volume
G = constant gas = 8317 $m^2 / s^2 K$
T = Temperature ^0K
M = The molecular weight of gas

Because a lot of the sound intensity is influenced by environmental factors, it usually uses reference intensity based on the sound pressure of 0.0002 microbar (1 microbar = 1 dyne / cm2), with substitution this price, reference sound intensity to be the same at 10-12 W / m2 or 10-16 W / cm2 or in metric becomes (N / m2) or Pascals (Pa) and 1 lb/ in2 = 6894 Pa.

1. Impedance tube method (Resonator)

With this method, the absorption coefficient is determined directly from the pressure amplitude in the pattern of standing waves are arranged in a tube. This method is mainly used in research work or in a quality setting for the manufacture of the materials sound absorption.

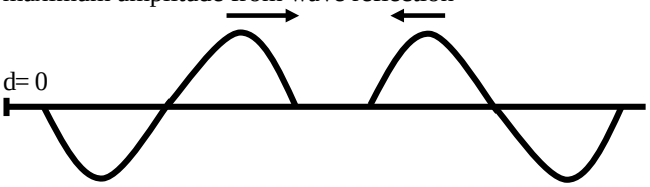
If the pure tones produced by an oscillator that is used to vibrate the loudspeaker that produces waves, and if the movement of the waves occur at any time, it can be stated as follows:

$d_1= A \sin(\omega t–kx)$

$k= 2 \pi/\lambda$ and the reflected wave displacement can be expressed as follows:

$d_2= A' \sin(\omega t + kx)$

where: A: starting point of maximum amplitude and A': maximum amplitude from wave reflection



$d_1= A \sin(\omega t-kx)$ $d_2= A' \sin(\omega t+kx)$

Figure 4: Two waves which propagate in the opposite direction

a result of displacement at any point is given by:

$d = d_1 + d_2$
$= A \sin(\omega t – kx) + A' \sin(\omega t + kx)$
$= A(1 + A') \sin \omega t \cos kx + a (1 - A') \cos \omega t \sin kx$

2. Reverberation Room Method

With this method, measurements are made by providing a source of sound in the room until the sound reached the plateau through a uniform level of material in about one second. Sources then turned off quickly and the sound pressure level that is room measured. This can be done by reading the slope of the curve measuring instrument.

3. Steady State Method

This method consists of measuring the sound pressure level in the room in a state of steady, then a given sound power in the room. Sources placed not too far and not too close to the surface to be measured. Sound level meter is equipped with one or 1/3 octave bandwidth filter.

II. ANALYSIS AND DISCUSSION

When a sound wave comes at a surface boundary that separates the two regions with different wave rate, then the chances of that happening are:
1. reflected all.
2. Transmitted all.
3. Some waves will be reflected and partly transmitted. This can be seen in the picture

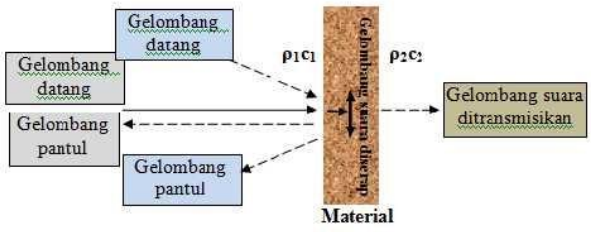


Figure 1. Reflection and absorption of sound in a land advance of two acoustic media

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Suppose two media acoustic impedance properties ρ1c1 and ρ2c2, which comes from the wave propagates toward the left upright to the interface.

Fiber rod nut king.
Fiber specifications (Annex 1):
The density of (ρ) = 0.37206 g / cm3
The water content = 10%

Figure 2: fiber rod nut king

1. Gypsum

Gypsum type that will be used as an adhesive in this specimen is gypsum SNI 15-0129-2004, brand A Plus Special Cor, white color, density 2.261775 g / cm3. (Attachment 1)

Figure 3: fiber rod nut king

2. Polyurethanes

Polyurethanes are used is rigid polyurethane product millionate MR-200 (A) and JKR-7631L (B), which consists of polyisocyanate and polyol compound manufactured by Nippon Polyurethane Industry CO.LTD - Japan. (Annex 2) of rigid polyurethane product specifications MR-200 (A) and JKR-7631L (B).

Table I: Polyurethane Specification

Product	Millionate MR-200
Composition	Polyisocyanate
Appearance	Brown
Viscosty (mPa.S,25 ^{0}C)	150 – 250
Specific Gravity (gr/cm^3,25^{0}C)	1,220 -1,240
Water conten (%)	-
NCO Conten	30,5 – 32

Figure 4: Polyisocyanate

Rod nut king already cut, cut, placed in the shade with a tilted position. Once dry take part in its trunk fiber and cleaned of ash and other impurities by hitting him repeatedly and then chopped using a machete. So, crushed with a blender until smooth, powder, powder obtained is separated by using a screen size of 10 mesh, 14 mesh and 32 mesh above the screening machine, so obtained powder with powder size that passes from 10 mesh screen but does not pass on the 14mesh screen, powder escaped the 14mesh screen but does not pass on the 32mesh screen and powders that pass 32 mesh screen.

In making the acoustic material is known to two terms of materials such as the matrix material and a filler material, in this case, the stem nut powder king is a filler, whereas as a matrix composed of rigid polyurethane and gypsum. Mix filler and a matrix are inserted into a mold made of PVC pipe diameter and 4 inches thick (high) mold 2 cm. Comparison filler and This matrix is made varies.
an accordance with the intent of the study, the following variables will be the focus of research that needs to be conditioned to get maximum results. Absorb testing will involve several variables were observed: A. Variable fixed
1. Volume amplifier (Vt)
2. The thickness of the test (2 cm)

- The independent variables
- Variations in the size of the powder comprising: - Powder escaped the 10mesh screen but does not pass on the 14mesh screen, - Powder escaped the 14mesh screen but does not pass on the 32mesh screen - And powder that escaped the 32mesh screen.
- Variation comparison rod nut powder king, polyurethanes and gypsum percentages by weight are: 30:70, 40:60, 50:50, 60:40, 70:30%
- Frequency (f), namely: 125, 250,500,1000,1500,2000 Hz 4. The density and porosity
- The microstructure

Step and procedure of testing:

1. Cut each specimen with a length of 20 mm, a width of 20 mm and 20 mm thick
2. Calculate the volume of specimen invitation to the formula, length x width x thickness (expressed as the volume of specimen = cm3)
3. Weigh the heavy weight of each specimen (expressed as weight of dry specimens = gr)

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4. Provide a 250ml beaker many as 15 pieces and filled with water
5. Enter each specimen into a beaker that has contained water
6. Let stand for 24 hours
7. Each specimen is removed and drained on a sieve for 1 hour (the water was no longer dripping)
8. The specimen is weighed again (expressed as the weight of wet specimens = gr)
9. Calculate the mass density (ρ) using the formula: ρ = m (g) v (g)
10. Calculate the porosity (ϕ)

A. Sound absorption testing

Experimentally, testing and data collection to get the sound absorption coefficient of the material is done by using an impedance tube and other support tools. Schematic and set up a tool for testing the sound absorption coefficient is shown in the picture

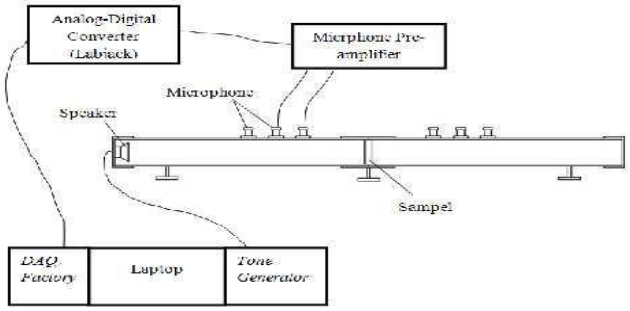

Figure 5: Sound absorption testing

B. Testing Procedure

The testing procedure is carried out as follows:

1. Prepare all test equipment. set according to the image set up testing equipment.
2. Insert the test specimen in the impedance tube, which is the middle of a test chamber with a direction perpendicular to the tube space.
3. Measurements were taken at a frequency of 125Hz, 250Hz, 500Hz, 1000Hz, 1500Hz and 2000 Hz.
4. 4. Connect the microphone 1 and microphone 2 on the mic pre-amp channel 1 and 2. For frequencies below 228Hz 125Hz frequency that is worn microphone 1 and 2

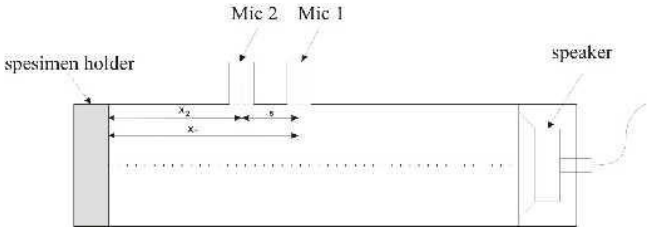

Figure 6. Microphone positions 2 and 1

5. Connect the output channel pre-amp mic to channel 1 and channel 2 on Lab jack.
6. Connect Lab jack to the USB port on the laptop and open the DAQ Software Factory to analyze the signal.
7. In the DAQ Factory open sound recorder 4ch program.
8. To generate sound signals, open the program Tone Gen. The sound is issued in the form of pure tone.
9. Set the frequency of the tone and reopen DAQ Gen Factory to see a graph of voltage noise at each microphone.
10. Click the start / stop save for logging data. Data chart will be automatically saved in drive (D :) on a laptop.
11. Take the average voltage values at each microphone (A and B) to calculate the absorption coefficient.
12. Repeat the above procedure for frequencies and different samples.
13. Enter the data that has been calculated in the table and in the plot into graphic form in order to see a comparison of sound absorption coefficients at different frequencies and at each sample.

Results of testing the density, porosity and sound absorption coefficient of the average specimen material silencer from fiber rod nut king by using Polyurethane and gypsum as a matrix[1] .

Table II: Results of testing the density, porosity and sound absorption coefficient

No.	Serbuk	Serbuk (%)	Rapat massa ρ (gr/cm³)	Porositas ϕ (%)	Koefisien absorpsi suara rata-rata (α)
1	Mesh 10/14	30	0,6951	10,8569	0,3399
2		40	0,6051	20,7906	0,5279
3		50	0,6012	23,9092	0,4193
4		60	0,4995	36,4315	0,3793
5		70	0,3740	52,0583	0,2382
6	Mesh 14/32	30	0,6425	13,3019	0,3613
7		40	0,5697	25,6396	0,3305
8		50	0,4899	46,5667	0,3305
9		60	0,434	55,7269	0,4131
10		70	0,3738	56,2502	0,3988
11	Mesh 32	30	0,5959	30,4280	0,3558
12		40	0,5928	44,5360	0,4647
13		50	0,4511	55,6001	0,6016
14		60	0,4335	57,8791	0,4915
15		70	0,3731	58,2029	0,4279

Then the data above can be made into the form of a graph, as shown in Figure 7.

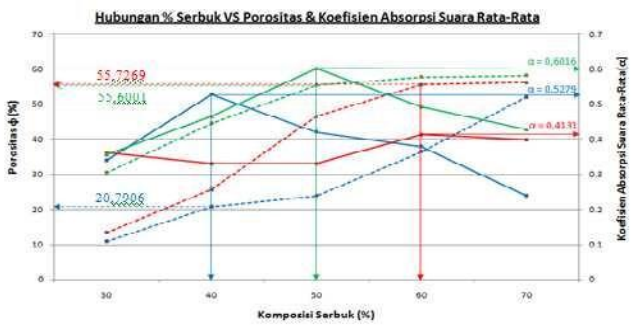

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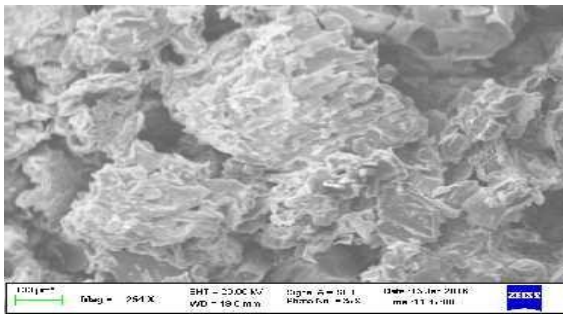
Figure 7: Graph relationships powder content, porosity and average sound absorption

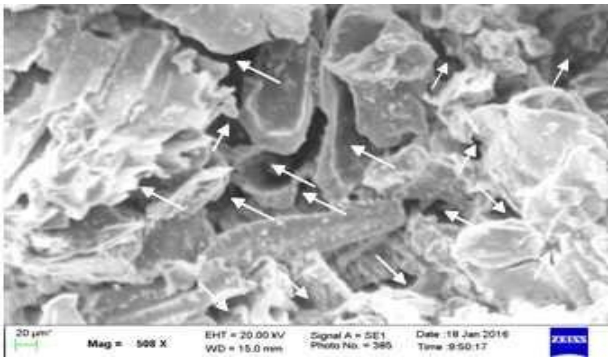
Table V and Figure 7. shows that the increase in porosity is not proportional to the increase in sound absorption coefficient, sound absorption coefficient of the highest average sound absorbing materials of fiber rod nut king by using polyurethane and gypsum as a matrix that is generated by the 0.6016 material made of powder that escaped 32 mesh screen, with a composition of 50% powder, density 0.4511 g/cm3 and porosity of 55.6001%. From the results of testing the material sound absorption coefficient of fiber silencer rod nut king by using polyurethane and gypsum as a matrix consisting of powder that escaped the 32 mesh screen with different fiber compositions, which produces sound absorption coefficient between 0.2008 s / d 0 , 7966 meet the requirements based on ISO 11 654, which is where the ISO 11 654 classifying the sound absorption material of 0.15 s / d 1.

The Final test results microstructure with Scanning Electron Microscope (SEM). To view the distribution of powder material in the silencer from the fiber rod nut king by using polyurethane and gypsum as a matrix was examined by means of Scanning Electron Microscope (SEM). Observations can be observed from figure 12 (a), (b), 13 (a), (b). and 14 (a), (b) below:

Figure 8 (a) and 12 (b) shows the surface structure of the specimen material silencer from fiber rod nut king by using Polyurethane and gypsum as a matrix consisting of 60% powder and 40% polyurethane and gypsum with a powder size that passes from the screen 32 mesh, 0.4335 mass meetings gRM / cm3, porosity 57.8791%, the highest sound absorption coefficient of 0.7966 at a frequency of 2000 Hz and an average coefficient measured at frequencies of 125, 250, 500, 1000, 1500 and 2000 Hz is 0, 4915.



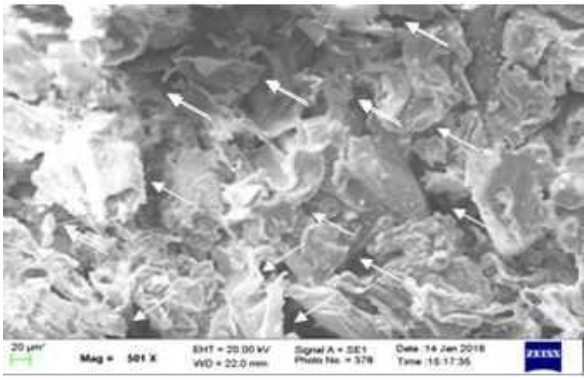
(a)



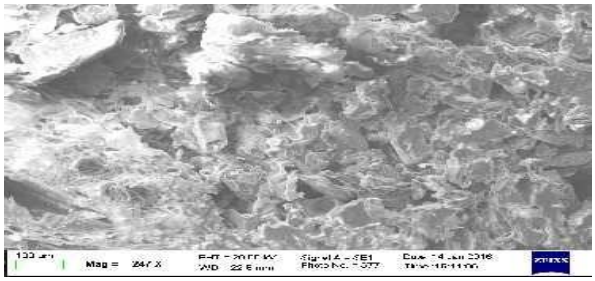
(b)

Figure 8. Sound dampening material microstructure of powder that escaped from the screen 32 mesh with a composition of 60% powder. (A) magnification (254X and (b) 508X magnification.

In figure 8. (A) and (b) the visible surface of a dark colored (black or gray) and white (light). Light colors indicate high surface or stand out, whereas dark colors indicate low surface and signifies cavities or pores on the surface of the specimen.



(a)



(b)

Figure 9. Sound dampening material microstructure of powder that escaped from the screen 32 mesh with a composition of 50% powder. (A) enlargement and (b) 501X magnification.

Figure 9 (a) and 4:13 (b) shows the surface structure of the specimen material silencer from fiber rod nut king by using Polyurethane and gypsum as a matrix consisting of 50% powder and 50% polyurethane and gypsum with a powder size that passes from the screen 32 mesh, 0.4511 mass meetings gRM / cm3, porosity 55.6001%, the highest sound absorption coefficient of 0.7162 at a frequency of 125 Hz and an average coefficient measured at frequencies of 125, 250, 500, 1000, 1500 and 2000 Hz is 0, 6016[1].

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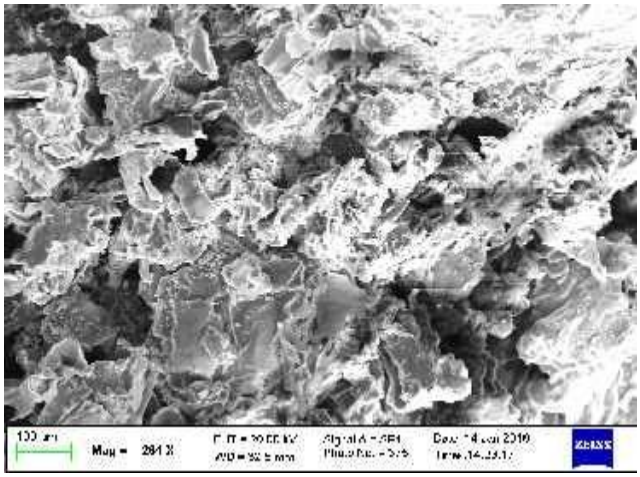
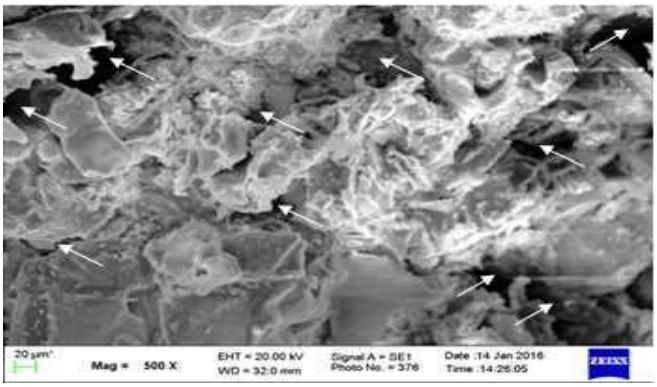


(a)



(b)

Figure 10. Sound dampening material microstructure of powder that escaped from the screen 32 mesh with a composition of 40% powder. (A) 261X magnification and (b) magnification of 500 X.

Figure 10 (a) and 10 (b) shows the surface structure of the specimen material silencer from fiber rod nut king by using Polyurethane and gypsum as a matrix comprising 40% powder and 60% polyurethane and gypsum with a powder size that passes from the screen 32 mesh, 0.5928 mass meetings gRM / cm3, porosity 44.5360%, the highest sound absorption coefficient of 0.5426 at a frequency of 125 Hz and an average coefficient measured at frequencies of 125, 250, 500, 1000, 1500 and 2000 Hz is 0, 4647 [1]. Figure 10 (a) magnification 254X and 508X magnification on the image increased to 10 (b).

Scanning Electron Microscope (SEM) only to see the surface structure and can't measure the depth of the pores on the surface of the specimen. From the analyze as in figure 8 (a), (b)., 9 (a), (b). and 10 (a), (b). shows that the percentage of the powder mixture affect the microstructure of the resulting sound-absorbing material, or it can be said that the percentage of fiber rod nut different kings will result in the distribution of fibers in matrix also will be different, of course this will affect the sound absorption coefficient of the material.

The shape and size of the cavities or pores in specimens made from powder mesh 32 with a composition of 60% (figure 8 (b) greater than the specimens of the content of powder of 50% (Figure 9 (b) and fewer than specimens of specimens with a composition of 40% (Figure 10 (b).

While the specimens made from powder with a composition of 50% (Figure 9 (b) having cavities or pores smaller but numerous and evenly. Material with a percentage of 50% powder produces a more uniform fiber distribution when compared to a material consisting of 60% and 40% powder[7] [8] [5].

Specimens made of powder with a composition of 40% powder (Figure 10 (b) seem to have cavities or pores less than in specimens made from powder composition of 60% and pore size larger than specimens made from powder 50%. From the figure of micro structure above it can be stated that the composition of the powder affect the pores in the specimen and also affects the sound absorption coefficient.

To test the thermal properties or testing resistance to the temperature of the material silencer from fiber rod nut king by using gypsum as a matrix Polyurethane and this needs to be tested by means of differential thermal analysis (DTA).

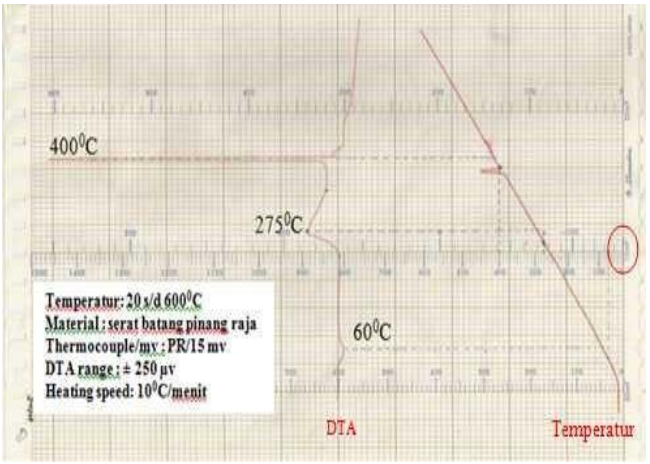


Figure 11. Draw a graph of test results on fiber rod nut DATA king.

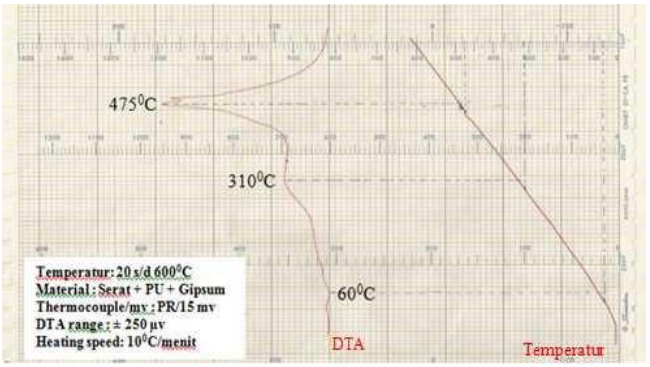


Figure 12. Draw a graph of test results on fiber + DATA + gypsum polyurethane

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III. CONCLUSION

Testing DTA which doing on fiber rod nut king (Figure 15) shows the temperature of 600C evaporation of water and volatile substance other reactions this vaporization is endo term or decrease temperature, the temperature of 2750C decomposition of fiber and its nature is external term or occur increase in temperature, the temperature at a temperature of 4000C fiber burned.

At Figure 12 Testing DTA pictures to gypsum (CaSO4.2H2O), two water molecules evaporate at temperatures of 600C and at temperatures of 1300C and nature is endo term. While the tests performed on the material of the fiber silencer rod nut king by using Polyurethane and gypsum as a matrix, at a temperature of 600C evaporation of water and other volatile substances, at temperatures of 3100C decomposition Polyurethanes and fiber, the material burning at a temperature of 4750C. That is, the sound absorbing materials can be used at temperatures below the decomposition temperature of the fiber and polyurethane (below 3100C).

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