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By Basuki Rahmat

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***Research** paperr*

The Use of Free Space Measurement Method to Identify Dielectric Constant of Rice Husks

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Abstract

An absorber works by reducing wave reflection. Used as an anechoic chamber, an absorber has a very important role. A good absorber material is able to attenuate wave reflection that can affect the performance of a tool being tested. Absorber that is used and mass produced is an absorber made of polyurethane. The alternative material for making an absorber is rice husks. To determine the ability of rice husk as a microwave absorber, a simulation using CST software is needed. Problem arises since the dielectric constant value of the rice husk is unknown. Therefore, it is necessary to test the rice husk absorber board to determine the dielctric constant value. The method used to determine the dielectric constant is free space measurement. The free space measurement method can be explained as: two horn antennas which serve as transmitter and receiver positioned at a certain distance. Both are connected with the Vector Network Analyzer. Rice husk board is placed between the two antennas. The measurement is aimed at gaining reflection loss value and transmission coeficient value. The value is then used to determine the dielectric constant. The result of the test indicate that the constant value is between 3.5 to 3.7

***Keywords**: Free Space Measurement Method; Rice Husk; Chamber; Dielectric Constant.*

1. Introduction

Indonesia is one of the largest rice producers in the world. As a result, the waste of milled rice, namely husk, is very abundant causing bad-looking soil. Along this time the rice husk is used as planting medium with low economic value. Even some are burned which then causes soil pollution. In addition, it is also used as an energy biomass. The abundance of rice husk encourages researchers to use it as a microwave absorber [1] [2].
The use of rice husk as an alternative material for absorber is due to the carbon substance in the husk [3]. Containing carbon, rice husk can be an absorber material with good absorption performance. Its ability to absorb electromagnetic waves helps the performance of the RF anechoic chamber. Absorber capability is indicated from the material permittivity value [4].
Permitivity of the absorber material is called as dielctric constant and loss tangent. The permitivity of material has a real and imaginary mathematical representation. The real part determines the amount of electrostatic energy stored in the material which is determined per unit of volume. While the imaginary part, also called as energy loss, is a representation of mathematical notation [5]. Loss tangent indicates the power or energy dissipation of the incoming wave [6].
There are many types of RF absorber. The first type is the Absorber for high frequencies between 1 GHz to 300 GHz. The second type is the low frequency absorber, which is 30 MHz to 1000 MHz. There are various types of absorber according to its working frequency, including: pyramid-shaped, wedge, walkway, convoluted, ferite tile, oblique and metamaterial [5][6].

2. The Production of Rice Husk Particle Board

The production of particle board from rice husk is performed by mixing resin and husk. The rice husk is shown in Figure 1. The Rice husk particle board is built in two ways. First is by using the rice husk right away (without milling). The other way is by milling the rice husk using hammer mill type K1020 [7]. The board manufacturing process begins by mixing the rice husk (either original or milled) with resin and hardener. The resin used is BTQ1507 and hardner.

Fig 1. Rice husk

The dimensions of the board is 30 cm x 30 cm. The composition of rice husk and the resin is 50:50. With this composition a particle board is produced from 1.68 kg of husks and 1.68 kg of resin. After husk is mixed with resin and hardner, the blend is then formed into a mattress. After that, to get a good result the pressing process is carried out. Figure 2 shows the manufacturing and pressing process of the particle board.

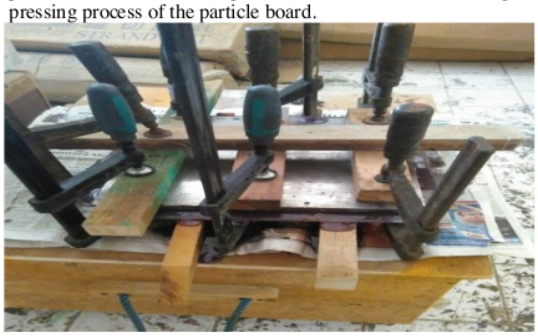

Fig 2. The process of making particle board

After 3 days, the mold is taken off. The finish board is shown on Figure 3. The steps of making the board is shown in Figure 4 where the husk is mixed with resin which has been given hardener in a certain composition. Next, stir evenly and then the mixture is poured into the board mold.

Fig 3. Rice Husk Particle Board

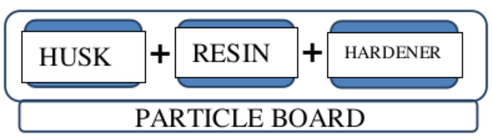

Fig 4.The Steps of Producing particle board

3. Test Using Free Space Measurement Method

Free Space Measurement is a method used to determinis S_{11} dan S_{21} [8]. The process of conducting the test is shown in Figure 5 . In this method, a pair of horn antenna and VNA (Vektor Network Analyser) are used.

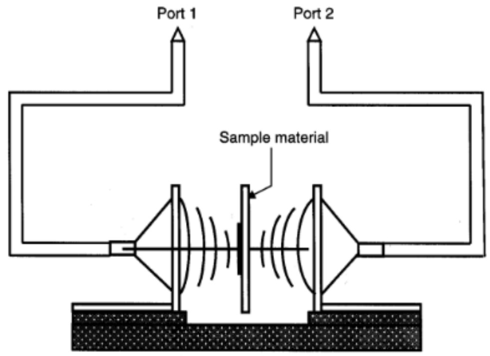

Fig 5. Free-Space Measurement Method

Port 1 is the first port of the Vector Network Analyzer (VNA), which is connected with a horn antenna as a transmitter. Port 2, is the second port of the VNA which is connected to the other horn antenna functioned as a receiver. Equipment used for testing is: 1) Vector Network Analyzer, namely Anritsu VNA Master Model: MS2034B, 2) absorber holder, (3) Rice Husk Board as the Absorber (4) 2 horn antennas.

As shown in Figure 6, absorber as material under test (MUT) is positioned between the two antennas that function as a transmitter and a receiver.

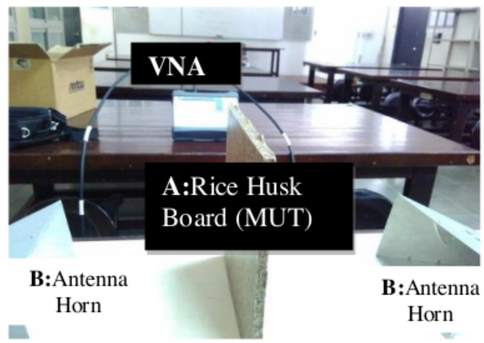

Fig 6.Board Test Using Free Space Measurement Method

The antenna used is shown on picture 7. As for antenna specifications, the dimension is 24.5 cm x 14 cm, with the ability to operate under the frequency of 1 GHz to 18 GHz. The absorber dimension is 30 cm x 30 cm x 1 cm. The test is performed using a frequency of 2 GHz to 4 GHz. Because VNA is only capable of a maximum of up to 4 GHZ. The board absorber as the test object is placed perpendicularly toward the base and holded with a holder. The holder is used to keep the sample from falling. Without the holder, the MUT may shift and result in inaccurate measurement.

Fig 7. Horn Antenna

The MUT (particle board) is placed between two antennas and it must adhere to far-field calculation of the horn antennas.

$$R_{far-field} = \frac{2.D^2}{\lambda} \quad (1)$$

where D is the biggest dimension measured from the antenna diagonal. The length of the horn antennas is 24.5 cm and the width is 14 cm . The value of D is measured under the following formula:

$$D = \sqrt{24.5^2 + 14^2} = 28.2\ cm \quad (2)$$

Meanwhile, λ is minimum and maximum:

$$\lambda_{maksimum} = \frac{C}{f_{minimum}} = 30\ cm \quad (3)$$

$$\lambda_{minimum} = \frac{C}{f_{maksimum}} = 7.5\ cm \quad (4)$$

C, is the speed of light. so, the far field radiation value can be determined as follows:

$$R_{far-field(min)} = \frac{2.D^2}{\lambda_{max}} = \ 53.02\ cm \quad (5)$$

$$R_{far-field(max)} = \frac{2.D^2}{\lambda_{min}} = 114.3\ cm \quad (6)$$

$R_{far\text{-}field(min)}$ is used as a reference for the distance between the horn antenna and the board particles.

4. Analysis

The test results are shown in Figure 8. The graph shows the S11 value is below -25 dB which appears at frequency of 2.15 GHz (-32.28 dB), 2.81GHz (-30.16 dB), 3.47GHz (-25.45 dB) and S21 value below -40 dB lies within frequency of 2.15 GHz (-41.26 dB), 2.81GHz (-44.57 dB), 3.47GHz (-48.09 dB). Based on S_{11} dan S_{21} test results, the wave attenuation is shown on Figure 9.

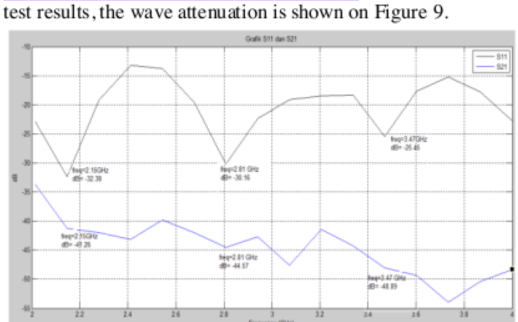

Fig 8. S11 and S21 measurement charts

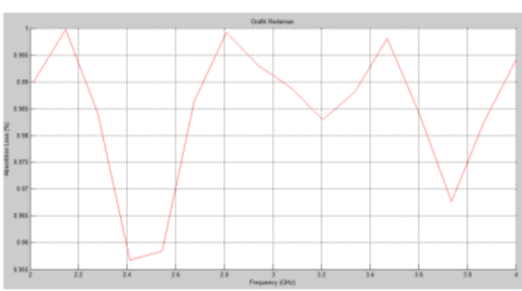

Fig 9. Attenuation Graph

The attenuation calculation adheres to the following formula [7]:

A (%) = [1- (S11) 2- (S21) 2]. 100% (7)

Where A(%) represents the absorption loss percentage, S11 represents reflection loss, and S21 shows transmission loss. The greatest attenuation value occurs at frequency: 2.15 GHz (99.89%), 2.81GHz (99.92%), 3.47GHz (99.81%).

The calculation to determine the permitivity value (ε') of materials is [8]:

$$\varepsilon' = \left(\frac{\lambda_0}{2\pi}\right)^2 \left[\left(\frac{2\pi}{\lambda_c}\right)^2 - (\alpha^2 - \beta^2)\right] \quad (8)$$

$$\varepsilon'' = \left(\frac{\lambda_0}{2\pi}\right)^2 (2\alpha\beta) \quad (9)$$

α and β are from T. Quantity measurement and other parameters are given in the following equation :

$$T = \frac{(1-\tau^2)exp(-\gamma L)}{(1-\tau^2)exp(-2\gamma L)} \quad (10)$$

$$T = \frac{(1-\tau^2)^{e^{-\gamma L}}}{(1-\tau^2)^{e^{-2\gamma L}}} \quad (11)$$

Where: L = length of material

γ = propagation coefficient

τ = reflection coefficient

$$\gamma = \alpha + j\beta \quad (12)$$

$$\tau = \frac{Z - Z_0}{Z + Z_0} \quad (13)$$

α, β represent antenuation and the coefficient of phase change of the applicator with the test material. Z dan Z0 are impedance of the characteristic of the applicator with and without test material. It is determined by:

$$Z = \frac{j\omega\mu_0}{\gamma} = \frac{2\pi\eta_0}{\lambda_0}\frac{\beta\left(1 + j\frac{\alpha}{\beta}\right)}{\alpha^2 + \beta^2} \quad (14)$$

Where

μ_0 = air permeability from air applicator

η_0= intrinsic impedance of air from the air applicator

γ_0= propagation coefficient of the air applicator

β_0= the phase change coefficient of the air applicator

Based on the formula, the value of material permittivity obtained is shown on Figure 10.

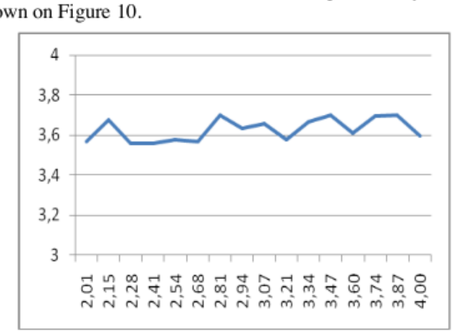

Fig 10. Dielectric Constant Value

5. Conclusion

Dielectric constant values obtained from the test using free space measurement method is of 3.5 to 3.7. This value is then used in simulation utilizing CST. The simulation result shows that rice husks can be used as an alternative material to absorb microwaves. It can reduce almost 8[illegible]% of the wave reflection, where the best muted frequency is of 2.15 GHz, 2.8 GHz and 3.47 GHz.

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