Test of Microwave absorber of rice husk and burned rice husk

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Test of Microwave Absorber of Rice Husk and Burned Rice Husk

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***Abstract*—This paper studies about the performance test against rice husk and burned rice husk material as a microwave absorber material. The nature of this microwave absorber is tested in frequency of 2 GHz 4 GHz with the method of free space measurement to obtain the value of reflection loss .This reflection loss value is used to find the absorption nature of the material. By finding out the absorption value amount, we can find the material permittivity value. This permittivity value is further used to do the simulation. The software used for the simulation is CST. The simulation and measuring results show a relatively small difference**

Keywords : *microwave absorber material,rice husk material*

I. Introduction

The absorber material becomes the spotlight in various application sectors of electromagnetic wave, radar, communication, satellite system, and anechoic chamber for the usage of both civil and military field [1].Microwave absorbing material is used to absorb the microwave energy in order to reduce the reflection signal. The anechoic chamber is the application that uses the absorbing material. Good electromagnetic absorbing materials are very important to ensure the good perfomance of an RF anechoic chamber. Some absorbing materials frequently used among other things are polystyerene or polyurethane. Two types of absorbers pursuant to the frequency which are frequently used are the frequency range of microwave (1 GHz to 4 GHz) and the frequency range of low frequency of 30 MHz to 1 GHz. The use of absorber in the low frequency range usually uses ferrite [2].

The materials like polystyerene or polyurethane are not environment friendly. So, alternative agricultural materials like banana leaves, coco peat, coconut shell powder, Rice husk etc. are used [3]. Rice husk and burned rice husk are utilized as a microwave absorber for its carbon content. Carbon is an important element which assists the absorption process of microwave because it has resistive nature so that it changes the flow into heat energy and re-waves heat in its surrounding [4].This work will focus on test of Rice Husk and Burned Rice Husk materials, to get aspects of the absorber of microwave absorbing materials. To prove the capacity, the S-parameter measuring using Vector Network Analyzer (VNA) should be carried out. This VNA use is to find out the characteristic of S_{11}. After we find out its characteristic, we will also find out the dielectric constant of rice husk and burned rice husk material S_{11} or the reflective coefficient may show the performance of the absorber material and be the functions of permittivity, permeability and frequency. It mea the S_{11} value is highly influenced by those three factors.Reflectivity, R can denote the performance of absorbent material and is a function of complex permittivity and material permeability, and wave frequency. The formulation of R (reflective coefficient) is stated as follows [4]:

$$R = 10Log_{10}\frac{P_r}{P_i} \quad (1)$$

Where P_r is the energy density of reflective wave and Pi is the reflective density of incoming wave. The measuring value for a good microwave absorber is average below -10 dB [4]. The material is classified as a dielectric if it has the ability to store energy when an external electric field is applied. Epsilon (ϵ) is the absolute permittivity of dielectric, which is measure of the electrostatic energy stored within it and therefore dependent on the material [5].The material dielectric constant is defined as a relative permittivity value (ϵ_r) or relative absolute permittivity (ϵ) against permittivity free space (ϵ_0). The electric constant highly determines the spreading speed of microwave through material. The larger dielectric constant, the slower the spreading speed of microwave [5] in complex mathematics, the relative permittivity is stated as follows:

$$\epsilon^* = \epsilon' - j.\epsilon'' \quad (2)$$

Where
ϵ' = dielectric constant
ϵ'' = dielectric loss factor.

The absolute permittivity value of vacuum space (ϵ_0) is determined under the formula of :

$$C_0\,\mu_0\,\epsilon_0 = 1 \quad (3)$$

Where
C_0 = light speed
μ_0 = magnetic constant

Rice husk is a material which does not contain magnetic component so that it only responds to electricity field. Rice

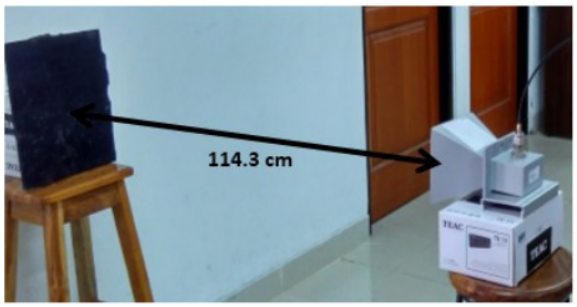

Fig. 1. Measuring Series

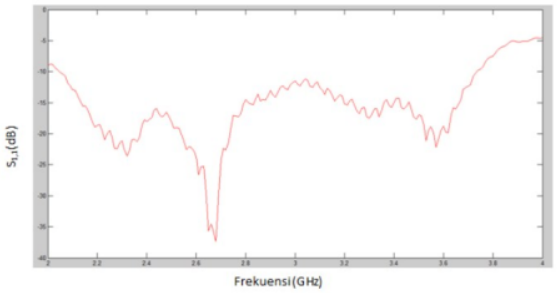

Fig. 2. Horn antenna characteristic measuring

husk and burned rice husk is the study focus in this paper, where the material is tested in the frequency range of 2 GHz to 4 GHz. the study focus in this paper, where the material is tested in the frequency range of 2 GHz to 4 GHz. The content of rice husk and burned rice husk obtained by testing using Scanning Eletron Miroscopy (SEM) / EDX (Energy Dispersion X-ray). The result is displayed consecutively in table 1.

TABLE I
COMPONENTS IN RICE HUSK AND BURNED RICE HUSK

Material Name	Elements				
	O	*Si*	*C*	*N*	*Total*
Rice husk	69.3	18.24	10.75	1.37	100
Burned rice husk 1	66.43	7.84	24.37	1.35	100
Burned rice husk 2	62.75	8.51	28.12	0.62	100
Burned rice husk 3	68.52	7.2	23.82	0.46	100

II. TESTING METHOD

The absorber performance is indicated from the S_{11} value which is obtained from the measuring result. The measuring is carried out through the following steps: 1st step, prepare the measuring devices of VNA, horn antenna, N-connector, rice husk board and burned rice husk board. In the 2nd step, prepare testing series as set out in Figure 2.1, and in the 3rd step, place absorber between transmitter and receiving antennas according to far-field calculation from the horn antenna. The formula in use is [6]:

$$R_{far-field} = \frac{2.D^2}{\lambda} \tag{4}$$

where D is the largest dimension which is measured from the diagonal size of the antenna. The horn antenna used has the length of 12.5 cm and the width of 16.5 cm. Thus the D value can be measured under the following formula:

$$D = \sqrt{12.5^2 + 16.5^2} = 20.7\,cm \tag{5}$$

λ means minimum and maximum λ size.

$$\lambda_{max} = \frac{C}{f_{min}} = 13.3\,cm \tag{6}$$

$$\lambda_{min} = \frac{C}{f_{max}} = 7.5\,cm \tag{7}$$

Thus, its radiation far field value can be determined as follows:

$$R_{far-field(Min)} = \frac{2.D^2}{\lambda_{max}} = 64.4cm \tag{8}$$

$$R_{far-field(Max)} = \frac{2.D^2}{\lambda_{min}} = 114.3cm \tag{9}$$

Further in the 4th step, the absorber is placed in the maximum distance of 114.3 cm from the horn antenna, as shown in Figure 1.In antenna testing, the obtained characteristic of horn antenna in use is as Figure 2. Further, the test is carried out by covering antenna field with absorber material. The result is showed in Figure 3.The figure shows that the signal is being reflected again in nearly all frequency ranges. The signal being reflected again is indicated with S1,1 value of 0 dB. In the subsequent testing, the absorber material is put in the far field distance location, as shown in Figure 4.

III. RESULT AND DISCUSSION

There are four types of absorber materials, namely the absorber that are made of mixed resin 157BQTN with rice husk. The table of mixed material with resin is as Tabel 2.

TABLE II
COMPOSITION OF ABSORBER MATERIAL

Absorber Item	Composition	
	Resin 157 BQTN	*Material*
Abs1-	1.62 kg	1.6 kg of Original rice husk
Abs2-	1.62 kg	1.6 kg of Chopped rice husk
Abs3-	1.62 kg	1.6 kg of Original burned rice husk
Abs4-	1.62 kg	1.6 kg of Sifted burned rice husk

Test results of each burned rice husk are shown in Figure 5.

From Figure 5, it is shown that S_{11} is below -20 dB in the frequency of around 2.21 GHz, 2.37 GHz, 2.58 GHz, 2.7GHz, 3.29 GHz, 3.48 GHz, and 3.65 GHz, with the formula [7] :

$$A(\%) = [1 - (S_{11})^2].100\% \tag{10}$$

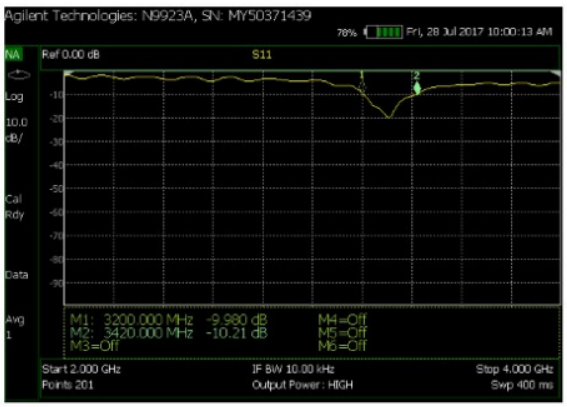

Fig. 3. Measuring with closed horn antenna

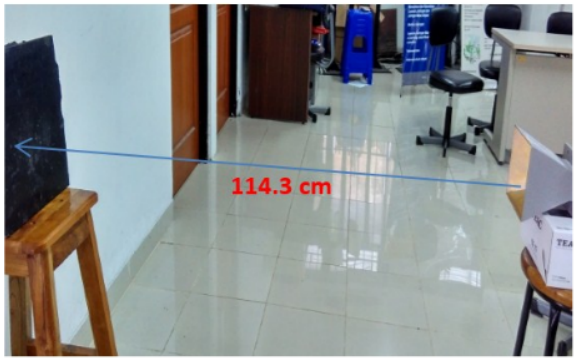

Fig. 4. Absorber testing

Where A(%) states the percentage of absorption loss and S11 states reflection loss. The absorption value chart based on the formula is shown in Figure 6.

IV. Conclusion

The composition of resin 157BQTN with rice husk is able to produce the material with the capacity to absorb microwave. Rice husk or burned rice husk has a relatively same capacity. However, the capacity of burned rice husk is better compared to rice husk.

From Figure 4 it can be seen that a very good absorption (80% - 99%) is in the frequency range of 2 GHz to 3.7 GHz. In the frequency above 3.7 GHz to 4 GHZ, the composition of rice husk and burned rice husk suffers capacity decrease in the absorption of around 60%-80%.

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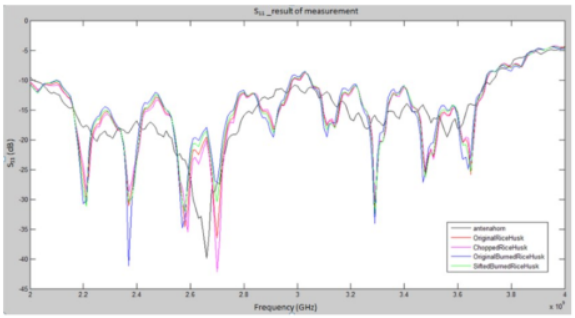

Fig. 5. Measuring result of S_{11} of Absorber

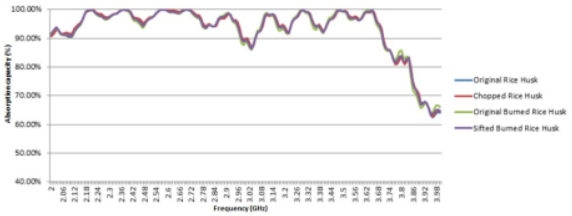

Fig. 6. Chart of absorption capacity of absorber material

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