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GREEN TECHNOLOGY DESIGN OF MODIFIED WEDGE MICROWAVE ABSORBER USING RICE HUSK

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ABSTRACT

Green technology wedge microwave absorber is design is done by using the rice husk as the main material. This material effect to reduce the size and effect the environment friendly. Besides that, the shape of microwave absorber is the important parameter that affects the performance of RF absorbers. In this work, different dimension of wedges are discussed to compare the reflection loss or S_{11} result of wedge microwave absorber. The frequencies range that consider in this works starting at 0.01 GHz to 10 GHz. The design is started with the basic design (Design *A*) of wedge microwave absorber is contains two wedge with height = 15 cm. For Design *B*, a wedge microwave absorber with varies dimension of centre absorber height from 6 cm to 14 cm. This microwave absorber is design in CST Microwave Studio using agricultural waste of rice husk with dielectric constant of 2.9.

Keywords: rice husk, agricultural waste, microwave absorber, green technology, wedge absorber.

INTRODUCTION

Currently, the better pyramidal and wedge microwave absorber are important to make sure the accuracy of the measurement performance result in anechoic chamber. This RF anechoic chamber is used to performing the measurements of antenna gain and also the radiation pattern by eliminate the unwanted reflected signals. The problem of the pyramidal and wedge microwave absorber is the cost of the fabrication and also the percentage of the high hazardous chemical in the mixture of the absorber.

In the reality world, the agricultural waste such as rice husk from paddy field is considered as not valuable to the public. This residues material had been left in the field or burn into the air after the crop has been harvested. This bad situation can increase the pollution and also effect to the quality of environment. Rice husk is a waste creation of the agriculture activity in most countries in Asian region. This waste had been used before as biomass fuel for alternative power (Mohamad, 2008) and in building construction area by added rise husk with concrete (Habeeb, 2009). This two application potentially can be reduce the cost of end product. Figure-1 shows the raw rice husk material after harvested from paddy field.

Microwave absorber is one of the main components that install in anechoic chamber to avoid unwanted signal for measurement setup. There are several shaped that used in designing the microwave absorber such as pyramidal (Aoyagi, 2014), optimized geometry pyramidal (Kent, 2013), truncated pyramidal (Malek, 2012), wedge (Smolnikova, 2012), quadruple wedges (Catalkaya, 2014) and optimized geometry wedge (Pometcu, 2014).

Figure-1. Raw rice husk material after harvested from paddy field.

This wedge microwave absorber is presently majority prepared up by using the mixture of the polyurethane material that contain the carbon coating. This hazardous material for commercial microwave absorber are not 100 % environmental friendly that chemical base material. So, this waste is potentially to use as the alternative material for green technology for microwave absorber fabrication.

Besides that, it also can reduce the cost of the fabrication of the microwave absorber because it can get direct from the field. The addition of rice husk into the microwave absorber also can reduce the percentage of chemical based nearly 10 %. There are several design of microwave absorber using rice husk, such as in (Iqbal, 2012) and (Iqbal, 2014). Beside this rice husk, there are many waste that also have potentially to use as the main material on designing the pyramidal microwave absorber.

The others material that used is sugar cane baggase (Zahid, 2013, Zahid, 2015), banana leaves (Farhany, 2012), rubber tire dust (Cheng, 2012), rubber wood sawdust-based (Azizah, 2015), corn stover (Smythe, 2014) absorbing paint (Hasnain, 2012), rice husk-carbon nanotube composites (Lee, 2013, Lee, 2015), oil palm ash (Noordin, 2012), sugarcane-beach sand based (Panwar, 2014) and others.

In this work, the green technology design of wedges microwave absorber had been simulated in CST Microwave Studio simulation software. The parametric study on several dimension of the peak of the wedges also considered to show best performance of the reflectivity or reflection loss, S_{11}. Before that, the dielectric properties measurement using dielectric probe technique is done to measure the exactly value of the dielectric constant and the permeability of the rice husk.

DIELECTRIC PROPERTIES MEASUREMENT

Dielectric properties is the important parameter before the designing the microwave absorber. Two dielectric properties components are the dielectric constant, εr and tangent loss, $tan\ \delta$ of the material under test (MUT) of rice husk. Loss tangent refers to the dissipation of power or energy from incident waves.

This measurement can define the physical and chemical properties that are related to storage and loss energy in respect to different kinds of materials. To measure this dielectric property, the particle board of the rice husk had been done. To make this particle board, polyester resin and methyl ethyl ketone peroxide (MEKP) as hardener agent is necessary to mixed together with rice husk and rubber tire dust. These resins basically are used in adhesives, finishes and molded objects.

Figure-2. Measurement setup of dielectric probe measurement technique.

Figure-2 shows the measurement setup of dielectric probe measurement technique. The dielectric probe technique is used to measure these dielectric properties. This measurement uses the Agilent dielectric probe, network analyze Agilent Technologies 85070 measurement software and coaxial cable.

In this measurement, the real part of the permittivity, ε', and the imaginary component of the permittivity, ε'' is measured. The ε' defines the amount of electrostatic energy stored per unit volume in a material while the ε'' is the loss factor. Then, the $tan\ \delta$ is calculated using this formula of:

$$\tan\delta = \frac{\varepsilon_r^{''}}{\varepsilon_r^{'}}$$

MICROWAVE ABSORBER DESIGN

This wedge absorber is design in CST Microwave Studio simulation software. The wedge microwave absorber has two main parts. The first part is the base part while the second part is the wedge part. Figure-3 shows the comparison between Design *A* of basic wedges microwave absorber and Design *B* of modified microwave absorber design. It shows that the dimension of the wedge height is 15 cm for both Design *A* and Design *B*. The difference between these two design is the Design *B* have addition of wedge shape at the centre of the absorber. The addition wedge height is varies from 6 cm to 14 cm while other two wedge height ar remain. Table-1 shows the dimension of Design *A* and Design *B* for wedge microwave absorber.

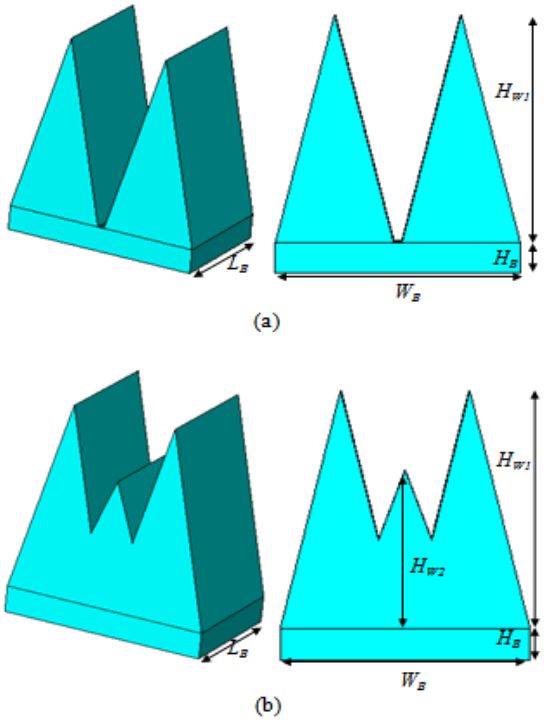


Figure-3. Perspective view and side view of wedges microwave absorber design, (a)design *A* – basic

wedges, (b) design *B* – modified wedges.

The material that use in this wedge microwave absorber is rice husk. The technique used to measure the dielectric contant is dielectric probe using dielectric probe and PNA network analyzer with 85070 Agilent measurement software. The dielectric constant of this rice husk is 2.9.

Table-1. Dimension of wedge microwave absorber for Design *A* and Design *B*.

Part	Dimension (cm)	
	Design *A*	**Design *B***
H_{W1}	15	15
H_{W2}	-	10
H_B	2	2
W_B	15	15
L_B	10	10

Figure-4 shows the simulation setup of array wedges microwave absorber in CST Microwave Studio simulation software. The source signal or Port 1 is located in the direct path of the wedge microwave absorber. The source signal is located as normal incident (0^0) with a distance of 30 cm from the origin (the tips) of microwave absorber.

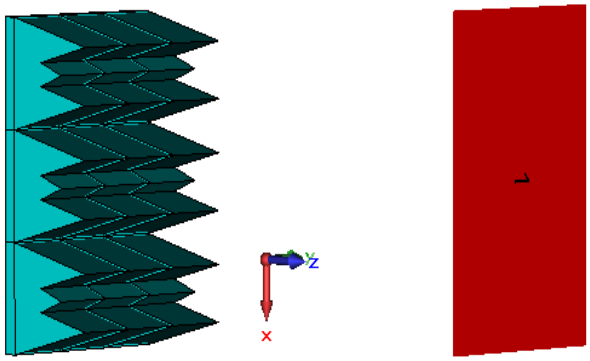
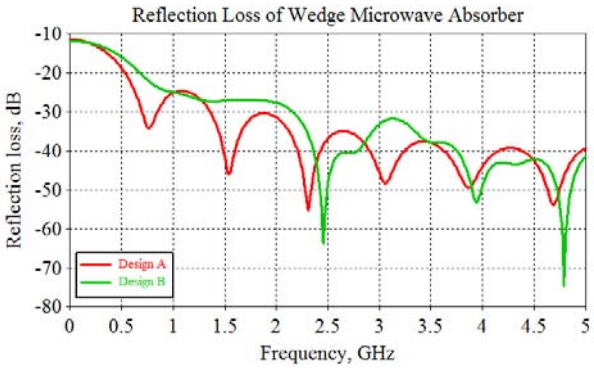


Figure-4. Simulation setup of wedges microwave absorber in CST microwave studio.

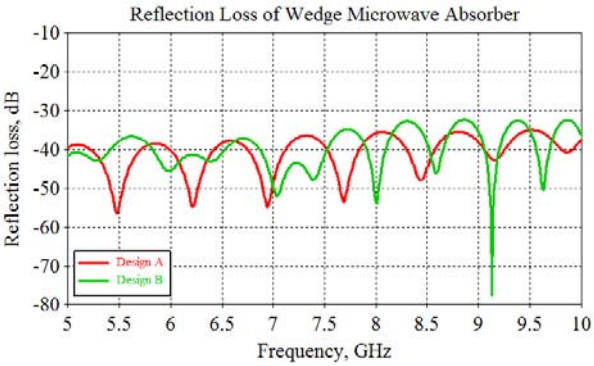
RESULT

The necessity for a acceptable performance for a wedge microwave absorber is to have reflection loss (S_{11} in graph) better (below) than - 10 dB. A desirable performance is to achieve an average reflection loss of better (below) than - 30 dB. After the dielectric properties measurement done, the measured average dielectric values for the rice husk is 2.9.

Figure-5 show the reflection loss results for differential wedge microwave absorber (Design *A* and Design *B*). Figure-3 (a) describes the frequency range between 0.01 GHz to 5 GHz while Figure-3 (b) represent the 5 GHz to 10 GHz. The best points are shown at 9.13 GHz of Design B. It shows that the performance of -77.468 dB compare with the best point of Design A (-56.389 at 5.48 GHz). There are three significant improvement point in Design B compare with the result in Design A, shown at 2.46 GHz, 4.79 GHz and 9.13 GHz with - 63.731 dB, -74.644 dB and - 77.468 dB. Table-2 represent the reflection loss results for differential wedge microwave absorber (Design *A* and Design *B*).



(a)



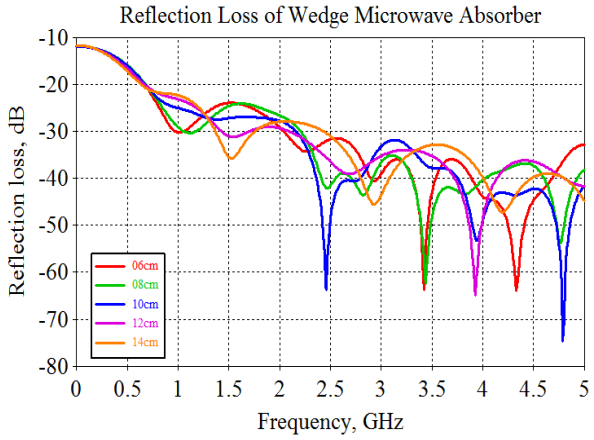
(b)

Figure-5. Reflection loss of wedge microwave absorber of design *A* and design *B*, (a) frequency range of 0.01 GHz to 5.0 GHz, (b) frequency range of 5.0 GHz to 10.0 GHz.

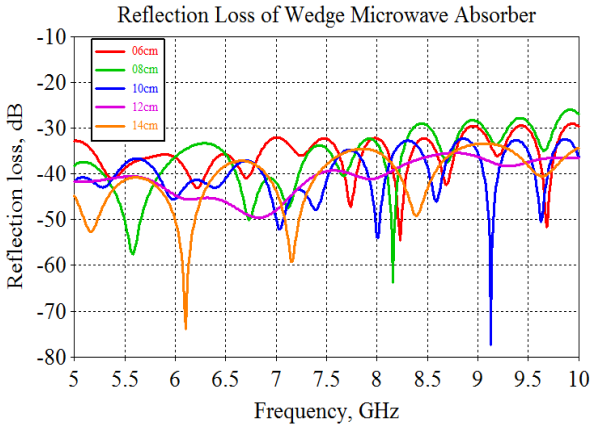
Table-2. Reflection loss of wedge microwave absorber of Design *A* and Design *B*.

Frequency (GHz)	**Pyramidal microwave absorber**	
	Design A	**Design B**
0.01 - 1	-20.496	-17.197
1 - 2	-31.490	-26.804
2 – 3	-38.865	-38.073
3 - 4	-42.637	-38.257
4 – 5	-43.201	-45.868
5 – 6	-42.461	-40.385
6 – 7	-43.861	-41.192
7 - 8	-40.856	-42.298
8 – 9	-38.647	-36.968
9 – 10	-38.352	-38.065
0.01 - 10	-38.081	-36.478
Best point	-56.389 at 5.48 GHz	-77.468 at 9.13 GHz

Figure-6 and Table-3 show the reflection loss results for wedge microwave absorber with varies dimension of centre absorber height from 6 cm to 14 cm. 10 cm of centre absorber height effect the best performance with -77.468 at 9.13 GHz, followed by 14 cm with - 73.928 at 6.1 GHz.



(a)



(b)

Figure-6. Reflection loss of wedge microwave absorber with varies dimension of centre absorber height from 6 cm to 14 cm, (a) Frequency range of 0.01 GHz to 5.0 GHz, (b) Frequency range of 5.0 GHz to 10.0 GHz.

Table-3. Reflection loss of wedge microwave absorber of with varies dimension of centre absorber height from 6 cm to 14 cm.

Frequency (GHz)	**Pyramidal microwave absorber**				
	6 cm	**8 cm**	**10 cm**	**12 cm**	**14 cm**
0.01 - 1	-18.062	-17.636	-17.197	-16.978	-17.097
1 - 2	-26.243	-26.501	-26.804	-28.171	-28.982
2 – 3	-33.813	-36.601	-38.073	-34.856	-33.496
3 - 4	-40.069	-42.16	-38.257	-39.209	-35.578
4 – 5	-43.530	-40.610	-45.868	-39.066	-41.882
5 – 6	-36.781	-43.029	-40.385	-41.573	-44.917
6 – 7	-37.741	-38.452	-41.192	-46.906	-43.530
7 - 8	-35.237	-37.543	-42.298	-41.573	-40.959
8 – 9	-35.877	-33.965	-36.968	-37.039	-38.979
9 – 10	-33.27	-29.896	-38.065	-37.144	-36.292
0.01 - 10	-34.064	-34.64	-36.478	-36.23	-36.156
Best point	-63.659 at 3.42 GHz	-68.728 at 8.16 GHz	-77.468 at 9.13 GHz	-64.983 at 3.93 GHz	-73.928 at 6.1 GHz

CONCLUSIONS

Agricultural waste material based such as rice husk have the potential as the alternative material in designing the wedge microwave absorber. It can reduce the cost of fabrication and also to effect the environmental friendly to the community. The reflection loss results of the wedge absorber obtained for the rice husks wedge microwave absorbers are significantly better than - 10 dB in all range of frequency from 0.01 GHz to 10 GHz. The parametric sweep of the centre wedge absorber height changes the performance of the wedge microwave absorber.

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