Performance Evaluation of Flat Shape Absorbers Coated with Multi-Layer Biomass Composite

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Abstract**—Microwave absorber is one of the main components used widely in anechoic chambers for antenna measurement. It is also used to absorb unwanted radiations in electronic products and other applications. This paper presents an investigation on the performance of flat shape microwave absorbers coated with biomass composite namely sawdust carbon and palm ash composite. The layer of biomass composite applied on the surface of this flat shape absorbers was found to contribute significant impact on the performance. This study is also looking at the impact of using two different board materials that is cardboard and plywood as the base of the absorbers. The wave frequency ranging from 8GHz to 12 GHz was chosen for the purpose of this study.**

Index Terms**—Flat Shape Absorber; Biomass Composite; Microwave Absorbers; Reflectivity; Absorption.**

I. INTRODUCTION

Microwave absorbers are known as materials that have the ability to absorb radiation of electromagnetic waves due to their intrinsic electric or magnetic losses where the absorbed electromagnetic waves are converted into heat [1]. Lately, there is an increase in the need for numerous kinds of electromagnetic wave absorbers, primarily in wireless data communication industries. Microwave absorbers are used in an anechoic chamber to absorb the waves reflected on the wall of the chamber. In electromagnetic, anechoic chambers are also equipped with absorber material to reduce the reflection of electromagnetic waves and are used to measure the properties of antenna or electronic devices which emit or susceptible to interference from electromagnetic energy.

Three most essential requirements for an absorber are high absorption of the electromagnetic wave, high heat conductivity and good adhesion to the substrate [2]. Yet, these characteristics are reliant on the material used and the shape of the absorber itself. Traditionally, in the absorber construction, ferrite is used to coat the absorbers. However, some substitute alternatives such as carbon fillers and metallized geometrical are used [3].

Carbon is the main element of the biomaterial [4]. Carbon is used as a lossy resistive material in microwave absorber application. Due to its outstanding electrical and thermal conductivity, light weight, and low cost, carbon black (CB) is widely used as EM wave-absorbent materials. In microwave absorbing application, carbon has been used as a resistive element in converting incoming microwave into heat, hence helping the reduction in microwave reflection [5].

The justification of this study is to uncover new materials that can be used to replace pricey materials such as ferrite. If the biomaterial can be used prudently, the capacity industrial waste, as well as harmful environmental emission may be reduced [4].

Agriculture waste bears a huge potential to be applied as alternative ways and beneficial invention for various applications. Agricultural waste is essentially made up of organic compounds from organic sources that have many benefits that many people do not realize. Agricultural wastes were considered not useful and were commonly dumped or burned after crop harvesting. In comparison to the presently used materials, such as polystyrene and polyurethane, agricultural wastes are way down cheaper and are environmental friendly [6]. The proposed materials here are biomass composites, namely sawdust carbon and palm ash composites where its performance is usually identical to ferrite or other lavish materials.

In terms of the shape of the absorbers, basically, there are four types of absorbers namely walkway, wedges, pyramidal and flat top. The type of interest in this study is the flat top. Two different board materials are used, namely cardboard and plywood.

Understanding the needs to further improve the absorption level of the designed microwave absorbers, we are proposing the use of two different biomass materials, namely sawdust carbon and palm ash. The purpose of this research is to explore the effects of increasing the number of layers of biomass materials coating on the cardboard and plywood that acted as the base for the flat absorber. The experimental result of the biomass materials applied on the flat absorbers is presented in this paper to prove that the proposed arrangement has improved the absorption level of the proposed design microwave absorbers. This study was carried out in the X-band region (8-12 GHz).

II. APPROACH

ETS-Lindgren Rantec Microwave Absorber is used as the reference for this study. The features of Flat Laminate Absorber are a thin broadband microwave absorber with a graded dielectric material that has been extensively used in the microwave and antenna fields [7]. Figure 1 shows the absorber shape design.

Figure 2 shows the measurement result for absorption performance of the ETS-Lindgren flat absorber. From the figure, the average absorption for the commercial absorber is at -34.90 dB and maximum absorption recorded at -50.46 dB between the ranges of 8 to 12 GHz.

Figure 1: The ETS-Lindgren Rantec Flat Laminate absorber shape design

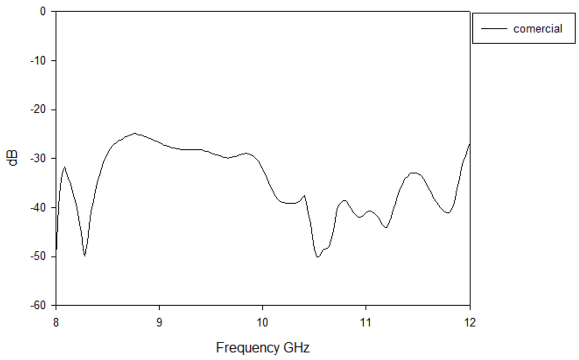

Figure 2: The ETS-Lindgren Rantec Flat Laminate Microwave Absorber performance

For the purpose of this research, two types of flat type absorbers have been developed using two different board materials which are cardboard and plywood. The dimension chosen are 60 cm x 60 cm x 1mm and 60 cm x 60 cm x 1.5mm for cardboard and plywood, respectively.

Each board materials are applied with one, two then followed by 3 layers of sawdust carbon on each side. Next, the same process was repeated but this time using palm ash composite. The proper carbon concentration ratio in developing microwave absorber is important to promote a better conductivity [8]. Thus, amount of coated carbon must be handled with appropriateness.

Figure 3: Board applied with (a) carbon (b) palm ash

Figure 3(a) and (b) show the cardboard applied with carbon and palm ash, respectively.

Figure 4: Plywood applied with (a) carbon (b) palm ash

Figure 4 (a) and (b) show the plywood applied with carbon and palm ash, respectively.

Figure 5 shows the free space dielectric measurement arrangement, used to determine the dielectric of flat shape absorbers. The flat shape absorber is positioned between two horn antennas facing each other and followed by measurement of its dielectric constant value.

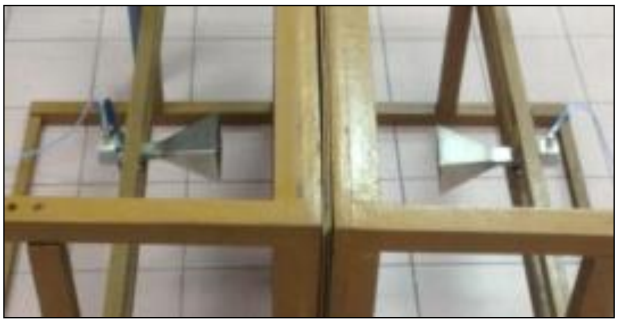

Figure 5: Free space dielectric measurement setup

Figure 6 shows the setup for free space dielectric measurement. Free space arch measurement is a contactless and nondestructive measurement method [9]. The measurement setup consists of two horn antennas facing each other, absorber to be measured and measurement software (Agilent 85071E) [10]. Scattering matrix is observed and recorded at 8 GHz to 12 GHz corresponding to the working condition of the absorber.

Figure 6: Free space arch measurement setup

III. Results

The effect of the number of layers of the applied paint to the absorber performance is quite conclusive. The measurement of absorption level was conducted to determine the absorbers performance.

Figure 7 and 8 show the absorption results for cardboard applied with sawdust carbon and palm ash composite, respectively.

According to Figure 7, the cardboard applied three layers of sawdust carbon have the highest average absorption of -18.28 dB and maximum absorption of -23.92 dB. The absorption pattern is evenly distributed (below -10dB) within the range of 8 to 12 GHz frequency.

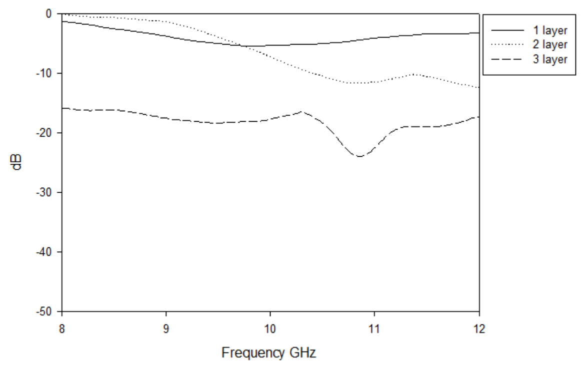

Figure 7: Absorption against frequency for cardboard applied with different layers of sawdust carbon

The same trend is observed in Figure 8 where cardboard applied with three layers of palm ash has the highest average absorption of -13.06 dB and maximum absorption of -20.38 dB but with a slightly narrower frequency range of 8 to 10 GHz only (having absorption level of below than -10 dB).

Figure 9 and 10 represent the absorption result for plywood coated with one, two and three layers of each of sawdust carbon and palm as, respectively.

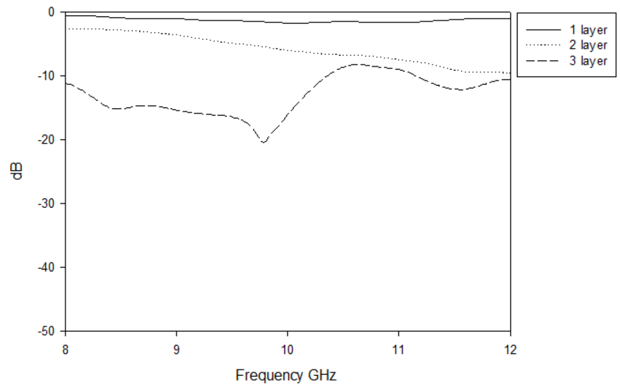

Figure 8: Absorption against frequency for cardboard applied with different layers of palm ash composite

It can be observed that from Figure 9, between the plywood absorber applied with one, two and three layers of sawdust carbon, the three layers showed the highest average absorption of -11.83 dB and also has a maximum absorption of -14.82 dB. However, the absorption lowers than -10 dB is only tabulated within the span of frequency between 8 to 11 GHz.

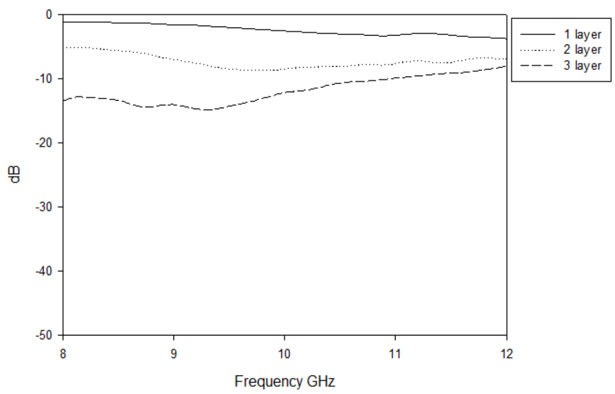

Figure.9: Absorption against frequency for plywood applied with sawdust carbon

From Figure 10, both absorbers that are applied with two and three layers of palm ash showed good performance with average of -12.25 dB and 14.45 dB, respectively. The absorber coated with two layers of palm ash is observed to have a very high absorption until -45.48 dB at 9 GHz, but the average absorption is lower than the three layers.

Table 5 shows the summary of average absorption for all types of the developed absorbers.

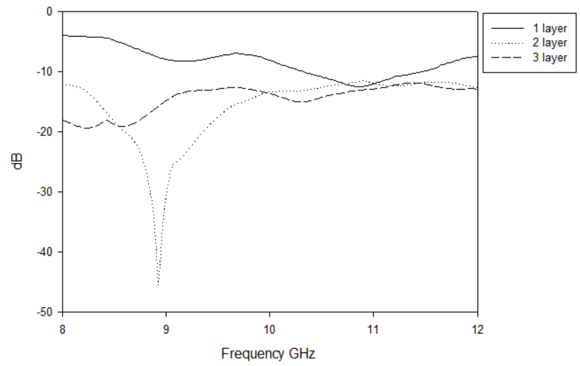

Figure 10: Absorption against frequency for plywood applied with palm ash

From Table 5, all absorbers with three layers of biomass composite coating have the highest absorption level. Overall, the performance of cardboard with three layers of sawdust carbon has the highest average absorption.

Table 5
Average Value of Absorption Level For Different Types of Absorber

Absorber	1 layer	2 layers	3 layers
Cardboard with sawdust carbon	-3.92	-6.47	-18.28
Cardboard with palm ash composite	-1.24	-5.78	-13.06
Plywood with sawdust carbon	-2.37	-7.25	-11.83
Plywood with palm ash composite	-8.32	-12.25	-14.45

IV. CONCLUSION

Increasing the number of layers of biomass composite coating on absorbers made from cardboard and plywood has increased the absorption level of the flat absorbers. Both the cardboard and plywood has shown very high average absorption after it being applied with three layers of biomass composites. Cardboard applied with the sawdust carbon is found to have the highest absorption level in this scope of the study. In terms of the board materials used, there is no significant impact observed when either cardboard or plywood is used in this research.

In a nutshell, by increasing the content of biomass composites on flat shape absorber is proven to have increased the absorption level of the absorbers for better microwave absorption.

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