Performance Study of Egg Tray Microwave Absorber

Hasnain Abdullah[1], Ida Rahayu Mohamed Noordin[1], Mohamad Hakim Ahya Ilmudin[1], Mohamad Nasir Taib[2], Juliana Md Sharif[1], Asmalia Zanal[1], Rohaiza Baharudin[1], Ahmad Rashidy Bin Razali[1]
[1]*Faculty of Electrical Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang, P. Pinang, Malaysia*
[2]*Faculty of Electrical Engineering, Universiti Teknologi MARA, Shah Alam, Malaysia*
idarahayu660@ppinang.uitm.edu.my

***Abstract*—This paper proposes the physical models of a three-layer egg tray microwave absorber that contains biomass material as the design. The absorbing materials were prepared in three layers: carbon, palm ash and a mixture of coconut shell granular with carbon. To verify the performance of the absorber, it was modeled and measured by free space arch reflectivity measurement to determine the absorption level in a frequency range of 8 GHz to 12 GHz. The absorption level resulting from this investigation were then analyzed and discussed. The investigation shows that palm ash granular with carbon can increase the absorption level performance. Thus, the material has the potential to be used in electromagnetic absorption.**

***Index Terms*—Absorbing Materials; Biomass Material; Egg Tray Microwave Absorber; Reflectivity.**

I. INTRODUCTION

The increased complexity of telecommunication technologies nowadays requires equipment that emits radiation in the microwave frequencies in daily life [1]. A radar absorbing material (RAM) is enabled to eliminate the presence of radiations in the environment. Thus, research for new functional materials used for shielding electromagnetic interference by microwave absorber is necessary. However, the functionality, performance and interoperability of the absorber must be accurately verified and tested in a controlled Radio Frequency (RF) anechoic chamber isolated from unwanted RF interference [2].

Drawn from this idea, microwave absorbers with excellent absorbing materials are required to improve the conventional techniques that used absorbent coatings on the exterior surface, which have been traditionally used for Electromagnetic Interference (EMI) reduction, antenna pattern shaping and radar cross reduction [3]. Microwave absorbers have been used to attenuate energy in electromagnetic waves. Absorbers are used in different applications to remove undesirable radiation. They can be applied externally to reduce the reflection of certain objects and used internally to reduce the strikes due to cavity resonance [4].

The absorbing materials can absorb radiation of electromagnetic wave steadily and reduce its reflection [5]. The materials have received attention due to the important applications in microwave complex technology. In addition, there are several restrictions when designing the absorbing materials, such as electromagnetic radiation absorber materials, absorptivity, the thickness of the materials and manufacturing cost [6].

The aim of this research is to discover new items that can be used to replace the absorbers in the market. Basically, the available absorbers in the market are in pyramidal shape. Therefore, this study provides a platform to create the absorber in various shapes as well as using organic waste in Malaysia.

This paper focuses on the interaction of radiation that absorbs materials with coating wasted biomass materials due to the need for formulating materials with radiation absorption characteristics. Multiple layers of egg tray microwave absorbers were coated with difference biomass material mixture in order to investigate the absorption level performance. Moreover, the use of egg trays has been increasing and their disposal as waste materials has high potential to be an electromagnetic absorber material used in Radio Frequency (RF) anechoic chamber [7].

The multiple-layer structured absorber was assembled in this work as the behavior of the processed biomass materials has been evaluated by considering the radiation of electromagnetic wave. The multiple-layered absorber will provide slowly changing impedance matching layers and high absorption by using high loss materials at the back layers [8].

The objective of this project is to investigate the performance of the egg tray microwave absorber using composite biomass material. In order to optimize the absorber performance, the egg tray microwave absorber is coated with composite biomass material [9]. This is because the biomass composite material is one of the semiconductor materials that allow some charging flows through a proven ability to absorb electromagnetic radiation. In addition, composite materials and renewable biomass can be used in the form of carbon powder [10].

In this research, the present work aims at the processing multilayer type of radiation absorbing materials by using composite absorption coating. The behavior of the composite absorption properties has been evaluated through reflectivity measuring technique using a frequency band from 8 to 12 GHz.

II. METHODOLOGY

Egg tray microwave absorber is used to absorb electromagnetic wave radiation. To verify our approach, the performance of absorber coating with three different materials mixtures was observed using free space arch reflectivity measurement. The result was analyzed and compared in this section.

A. Three Layers Egg Tray Microwave Absorber Structure

For this study, egg trays were used as the main structure of the microwave absorber due to its pyramidal shape and economic material. This selection is also an initiative to respond to the Governments' policy for The Green Technology and Sustainable Energy Development. Three layers of egg tray with the dimension of 60 cm length and 60 cm width were stacked on each other as in Figure 1.

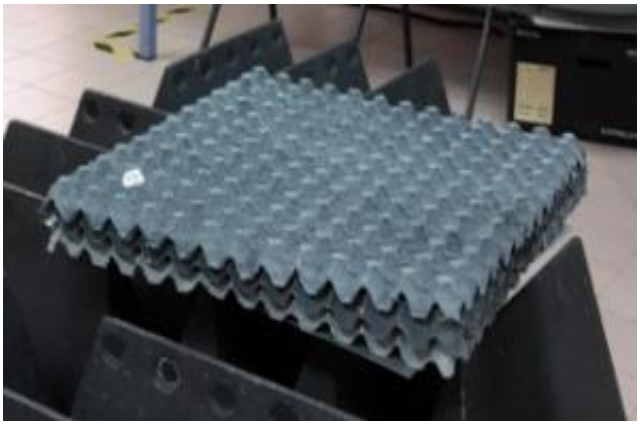

Figure 1: Three layers of egg tray absorber

The performance of the egg tray absorbers was studied by comparing the absorption level of the absorber coating with three different materials mixtures. Thus, each absorber has a different value of dielectric that produces different absorption level. The green biomass coating, such as coconut shell carbon granular and palm ash was selected as the material to be used as egg tray absorber coating, as shown in Table 1. The proper carbon concentration ratio in developing microwave absorber is important to promote a better conductivity. In the literature, carbon is one of the semiconductors. The first three-layer egg absorber (Absorber A) was coated with a mixture of carbon. Meanwhile, the second three layers egg absorber (Absorber B) was coated with a combination of palm ash. These two types of absorber were then compared with the three-layer egg absorber (Absorber C), coating with the mixture of carbon and coconut shell granular carbon.

Table 1
Coating Material Mixture for Three Layers Egg Absorber

Type of Absorber	Coating Material Mixture
Absorber A	Coating with mixing of carbon
Absorber B	Coating with combination of palm ash
Absorber C	Coating with the mixture of carbon and coconut shell granular carbon.

B. Egg Tray Microwave Absorber's Performance

In practice, absorbers are used to eliminate unwanted electromagnetic energy. The absorption level is the fundamentally measured parameters that reflect the interaction between the electromagnetic waves and the developed absorber. The most common parameter to measure the absorption level is the scattering parameter, S_{11}. S_{11} parameter. It represents how much the power is absorbed by the microwave absorber.

C. Free Space Arch Reflectivity Measurement

The free space reflectivity measurement was held in the Electromagnetic Laboratory. As shown in Figure 2, the free space reflectivity measurement that uses the combination of arch method and vector network analyzer (VNA) is used to determine the absorption performance, S_{11} of an egg tray absorber. The amount of the absorption performance is measured by the sweep method that uses Vector Network Analyzer. The samples are placed at the center of arch curvature. A pair of horn antenna is always pointed to the center. The setup also consists of the coaxial signal, a pair of horn antenna, egg tray absorber, vector network analyzer and material measurement software (Agilent 85071E). The arch measurement methods used VNA for reflectivity measurements for magnitude and phase response. In cases where the architecture of a network analyzer involved a signal generator, a test is set with one receiver and a display.

The measurement data were recorded and observed at the microwave region from 8 GHz to 12 GHz. Results analysis and absorber performance measurement for Absorber A, B and C were conducted to define the overall microwave absorber performance. In comparison to the waveguide method, this method has the advantage of allowing the measurement of parameters of a relatively large sample in free space conditions.

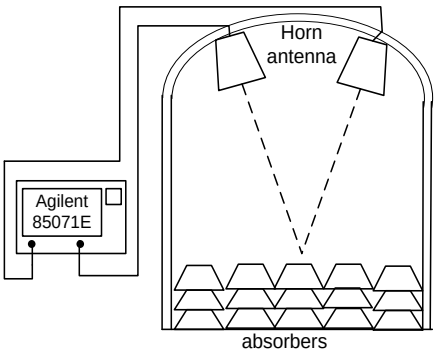

Figure 2: The arch used to measure the properties of absorption materials

III. Result And Discussion

The microwave absorption properties of the absorber, coating with three different materials mixtures have been measured, and the result of microwave absorber are discussed. The frequency range of 8 GHz to 12 GHz is chosen, and the incidence of the electromagnetic radiation was normal to the surface of the three-layer egg tray microwave absorber. Figure 3, 4 and 5 show the measurement of the absorption level of the coating materials produced.

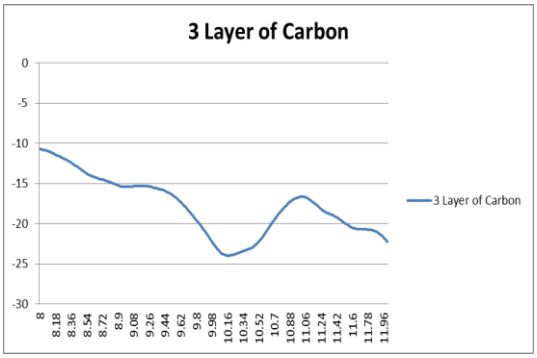

Figure 3: Measurement result of Absorber A

Figure 3 shows the result of the three-layer Absorber A that has the average value of absorption level of -18 dB to -23 dB at 8 GHz to 12 GHz respectively. Where else, the maximum value for this type of absorber is -24 dB and the minimum value is around -16 dB.

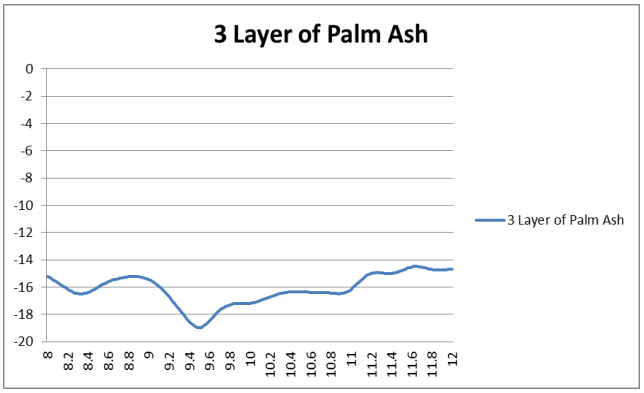

Figure 4: Measurement result of Absorber B

Figure 4 represents Absorber B that has the average return loss value, which is -16 dB to -18 dB at 8GHz to 12GHz respectively. The maximum and minimum value is -19 dB, while the minimum value is around -15 dB. These results give better performance than the three-layer carbon materials.

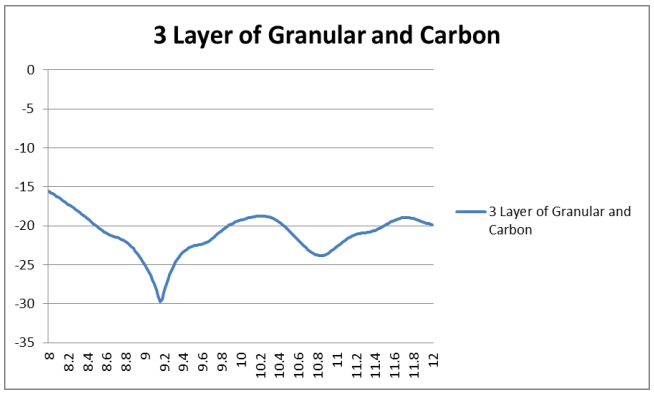

Figure 5: Measurement result of Absorber C

The measurement result of Absorber C shows that the average value of the absorption level is -20 dB to -24 dB. The figure shows that the maximum value is -30 dB, while the minimum value is -21 dB.

Table 2
Measurement Result of Absorber A, Absorber B and Absorber C

Type of absorber	Return loss (dB)		
	Min	Max	Average
Absorber A	-16	-24	-23
Absorber B	-15	-19	-18
Absorber C	-21	-30	-24

Table 2 shows that the performance of the materials tested for Absorber A, Absorber B and Absorber C. A comparison analysis of the results shows that Absorber A and B have good absorption values in the selected frequency range. By adding the third material of granular and carbon to the Absorber C, the configurations improve the performance of the measurement.

The results from Table 2 illustrates that the average reading Absorber C has the highest microwave signal absorption at -24 dB, Absorber A is -23 dB and Absorber B is -18 dB. Meanwhile, the maximum reading of Absorber C shows better performance in comparison to Absorber A and Absorber B. It can be observed that the absorption properties are greatly improved when granular and carbon is adopted. This technique does not only increase the absorption efficiency, but it also improves the microwave absorption of the electromagnetic radiation in a wide range.

In compared with these three materials, granular and carbon materials are very good absorbents of electromagnetic radiation. This composite allows the materials to be transformed by microwave heating and results in a new good carbon.

IV. Conclusion

This study investigated the design and fabrication of the microwave coating with three different wasted biomass materials. Based on the results, it can be concluded that the absorber coating by three layers of granular and carbon leads to high microwave signal absorption performance. These materials demonstrate that it can be used as absorbers of electromagnetic radiation. It is proven that the objective of this paper is achieved since the performance of the egg tray absorbers has been studied by comparing the absorption level of the absorber coating with three different materials mixtures. Therefore, it is acceptable to use granular and carbon as the materials for the microwave absorbers, consume the available green biomass coconut shell granular that is abundant in nature.

Acknowledgment

The authors of this research would like to acknowledge the financial support from Fundamental Research Grant Scheme (600 – RMI/FRGS 5/3 (97/2014) by Ministry of Education Malaysia and Faculty of Electrical Engineering, Universiti Teknologi MARA for the project research.

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