COMPARISON BETWEEN THE DIFFERENT AGRICULTURAL MATERIALS USED AS RADAR ABSORBING MATERIAL FOR ANECHOIC CHAMBER APPLICATION

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Abstract

This paper represents the comparison between the different agricultural materials used for the application like anechoic chamber testing. Anechoic chamber is considered good when there is no signal reflection inside the chamber and also when there is no incoming signal from outside the chamber [XI]. With the comparison it is shown that the material having pyramidal shape shows better reflection loss. The amount of carbon content added in the material also has their different effects on the reflection and absorption properties of the Radar Absorbing Material. It is also shown that how different shapes effect the absorbing properties of the materials.

Introduction

The production of Radar Absorbing Material (RAM) is directly related to the development of new material for providing several applications involving tight requirements in the microwave reflection suppression. There are several forms in which RAMs are used such as paints for stealth technology, foam based absorbers and different shapes of absorbers are used for anechoic chamber application. In the earlier stage of microwave absorber development, carbon has been the first material used in absorbers which are widely used in many applications due to its characteristics of good electric and thermal conductivities, low density, low thermal expansion and low elasticity [I]. In the microwave absorbing material carbon is used as a resistive element which transforms the current to the heat energy and releases it to the surrounding environment. RAMs are used to provide shielding from EM interference produced by nearby system, since the operating frequency of electronic devices continuously raises [II]. The testing is done by using the Vector Network Analyzer (VNA) on the different frequency ranges which is shown in table 1.

Letter	Frequency range	Letter	Frequency range
L Band	1 to 2 GHz	Q Band	30 to 50 GHz
S Band	2 to 4 GHz	U Band	40 to 60 GHz
C Band	4 to 8 GHz	V Band	50 to 75 GHz
X Band	8 to 12 GHz	E Band	60 to 90 GHz
Ku Band	12 to 18 GHz	W Band	75 to 110 GHz
K Band	18 to 26.5 GHz	F Band	90 to 140 GHz
Ka Band	26.5 to 40 GHz	D Band	110 to 170 GHz

Table 1. Microwave Band [I]

For the testing purpose we use X band (8 to 12 GHz). Absorption also depends upon impedance matching of absorbing material with free space, specific resistance of the material, frequency response and flexibility of material to get operated over different frequency ranges, dielectric losses and magnetic losses. With the use of Vector Network Analyzer the S-parameters are measured, due to which the reflection and transmission coefficients are to be measured using formulas [XIII, XIV]:-

$$\tau_{in} = \frac{V_1^-}{V_1^+} = \frac{b_1}{a_1}\Big/_{a_2 = 0} = S_{11} \quad (1)$$

With the help of the above equation, the values of permeability and permittivity values will be known as:-

$$\mu_r = \frac{1+\tau}{(1-\tau)\Lambda\sqrt{\left(\frac{1}{\lambda_0^2}\right)-\left(\frac{1}{\lambda_c^2}\right)}} \quad (2)$$

$$\varepsilon_r = \frac{\lambda_0^2}{\mu_r}\left(\frac{1}{\Lambda^2}+\frac{1}{\lambda_c^2}\right) \quad (3)$$

$$\frac{1}{\Lambda^2} = -\left[\frac{1}{2\pi L} In\left(\frac{1}{t}\right)\right]^2 \quad (4)$$

Permittivity describes the coupling of electric component of the incoming radiation with the material whilst the permeability describes the coupling with the magnetic component. In case of agricultural material only permittivity of the RAM is found due to the negligible metal content present in the material. But in case of the ferrite, both the permeability and permittivity is to be measured with the attenuation (A) and reflection loss (R in db) using the formula:-

$$A = \sqrt{\frac{\mu}{\varepsilon}} \quad (5)$$

$$R(db) = 20\log_{10}\frac{(iA\tan kd-1)}{(iA\tan kd+1)} \quad (6)$$

Where, $k = \frac{2\pi f}{c}\sqrt{\mu\varepsilon}$

1.1 WHY WE USE AGRICULTURAL MATERIAL AS RAM?

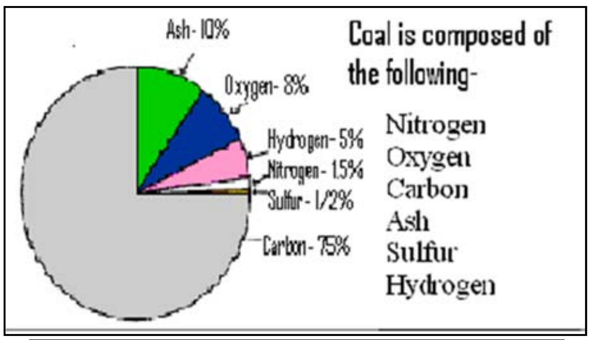
Abandoned agricultural waste poses a risk to the environmental and public health. The materials like polyurethane and polystyrene used to design the pyramidal microwave absorber are not environment friendly and are also costly [V]. So to reduce the cost of designing pyramidal microwave absorber agricultural materials like Coconut shell powder, Corn Stover, Coco peat, Rice husk, Banana leaves, Groundnut shell powder etc. are used. These types of absorbers are environment friendly. In these types of absorbers dielectric properties are to be measured. In these types of absorber we require higher dielectric loss and the lower the permittivity to attain the minimum reflection loss.

1.2 TYPES OF AGRICULTURAL WASTE USED WITH THEIR SHAPES.

1. Rubber wood sawdust [VI].
2. Coco peat [III].
3. Rice husk [IV].
4. Sugarcane bagasse [VII, VIII].
5. Dried banana leaves [V].
6. Coconut shell powder and coconut shell activated carbon [XI, XII].

These materials are having carbon content present in it but are of very low quantity. So we add the carbon externally like charcoal, lead, activated carbon of any waste material like coconut shell powder, groundnut powder, peat, fly ash etc. [XIV]. In the previous papers, it is shown that charcoal has more carbon content present in it and show better result than other materials [X]. Coal or Charcoal consists of 75 % of carbon, 5 % of hydrogen and 1.5 % of nitrogen as shown in figure 1. Along with the carbon content, coal also gives us porosity which is good for refraction of EM wave. Table 2 defines the no. of different materials used in the previous papers with their shapes.

Figure 1. Composition of Coal



S.No.	Agricultural material	Shapes
1.	Rubber wood Sawdust + ZnCl2	Cubical shape
2.	Sugarcane Bagasse + coal	Pyramidal shapes
3.	Rice Husk	Pyramidal shapes and double
	Rice Husk + coal	

		pyramidal shapes
4.	Dried Banana Leaves	Pyramidal shapes
	Dried Banana Leaves + coal	
5.	Coco peat	Cubical shape
6.	Coconut shell powder	Pyramidal shape
	Coconut shell activated carbon	

Table 2. Different agricultural materials with their different shapes used as a RAM

1.3 COMPARISON BETWEEN DIFFERENT AGRICULTURAL WASTE MATERIALS USED AS A RAM

The amount of carbon present in the material is measured using CHN analyzer.

S.No.	Agricultural materials	Carbon %	Reflection loss	Frequency (GHz)
1.	Rubber wood Sawdust + ZnCl2	43.27 %	-25.2 db	1.8 GHz
			-25.1 db	2.3 GHz
2.	Sugarcane Bagasse	17.89 %	-44.48 db	8-12 GHz
	Sugarcane Bagasse + coal		-49 db	8-12 GHz
3.	Dried Banana Leaves	43.5 %	-45.2 db	2-20 GHz
	Dried Banana Leaves + coal		-76 db	
4.	Coconut shell powder	48.370%	-40 db	2-20 GHz
	Coconut shell activated carbon	83.940%	-70 db	
5.	Coco peat	61.01 %	-38.58 db	8-12 GHz
6.	Rice Husk		-32.67 db	8-12 GHz
		35.77 %	-42.54 db	0-20 GHz
	Rice Husk + Coal		-38.77 db	8-12 GHz
			-73 db	0-20 GHz
	Rice Husk with double pyramidal shape		-40.47 db	1-20 GHz

Table 3. Comparison of different agricultural materials used as RAM [II-IX]

Table 3 represent the comparison between the reflection losses of the different agricultural materials with the different carbon contents added in it. The above table shows that there is a lot of difference between the cubical shape structure and the pyramidal shape structure whose dimensions can be simulated by using the CST microwave studio suit software.

1.3.1 Comparison of the absorbers without adding coal as carbon content.

As shown in the table 2 and 3, the only two materials were used as a cubical shape structure which shows that the carbon content present in the coco peat and rubber wood saw dust is 61.01% and 43.27% which shows the reflection loss performance of -25 db and -38 db. As shown in the table 3 coconut shell powder shows the reflection loss performance of -40 db without adding any carbon content whereas the rice husk shows the reflection loss of -42 db at 2 to 20 GHz. While comparing the rice husk with sugarcane bagasse the reflectionloss performance of the sugarcane bagasse is more (upto -44 db at 8-12 GHz). The dried banana leaves shows the reflection loss better than the other materials either it is SCB, coconut shell powder or any other material.

1.3.2 Comparison of the absorbers with the addition of coal as carbon content.

As shown in the table 3, the sugar cane bagasse shows the reflection loss of -49 db at 8-12 GHz whereas the coconut shell powder shows the reflection loss of -70 db. While comparing the coconut shell powder with the Dried banana leaves the reflection loss performance of dried banana leaves is more (upto -76 db at 2-20 GHz). The comparison of these all materials having the different additional quantities of coal as a carbon in it have result in different sizes of the pyramidal absorbers. By comparing the results of the sugarcane bagasse, dried banana leaves, coconut shell powder and rice husk, the only rice husk shows the better reflection loss of -73 db.

CONCLUSION

It is concluded that, the dried banana leaves and dried banana leaves + coal shows the best result of reflection loss upto -45db and -76db at 2-20 GHz. This result is shown by the pyramidal shape of the absorbers whereas the cubical shape structure of RAMs show the reflection loss of -25 db and -38 db. It is to be observed that, by addition the carbon content externally shows the remarkable result in the absorption of EM waves and the reflection performance. In addition to these materials, the rice husk with double pyramidal structure shows the reflection performance of -40 db, but this is only a simulation result because practically it is very difficult to implement on the large scale.

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