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Foam glass material to absorb electromagnetic waves

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Abstract

Electromagnetic radiation arising from the operation of microwave electronic devices creates significant interference reduces the accuracy of measurement and electromagnetic compatibility of equipment. High frequency radiation has a negative impact not only directly on human being, but also on the operation of the various devices. Therefore, the current studies are aimed at developing radar absorbing materials effective in a wide range of frequencies. Promising in this direction are lightweight materials with high porosity such as foamed glass, which has the ability to reduce the level of reflected and transmitted electromagnetic radiation. However, the effectiveness of radar absorption foam glass inferior to some types of absorbers, so work is underway on modification of foam glass by introducing into its composition of various additives. This paper is devoted to comparison of the absorption capacity of foam glass before and after modification, as well as the economic feasibility of the work.

Keywords: electromagnetic radiation, foam glass, absorption capacity, carbon nanotubes, technological cost;

1. Introduction

Since the mid-20th century, the number of electromagnetic waves (EMW) has increased 10,000 times. Today, all mankind are immersed in electromagnetic smog, but we do not feel. However, in recent years the number of complaints of headaches has increased, memory impairment, manifest as different oncologic diseases. This is all about human exposure to large amounts of electromagnetic radiation (EMR), which also adversely affect operation of the equipment. Therefore, an important direction of research is to develop an effective radar absorbing material to protect from this type of radiation. Today there is a wide range of radar absorbing materials (RAM),but not all materials meet the requirements of environmental friendliness and safety. One of the most eco-friendly and fireproof material is foam glass. The main application of foam glass is the insulation. The advantages of the material include fire protection, chemical and biological stability, durability, and ease of machining and light weight material [1, 4]. It should be noted that the foam glass obtained from carbon-containing blowing agent can reduce the level of reflected and passing through the material of EMR [2]. However, the effectiveness of radar absorption foam glass inferior to some types of absorbers. Therefore, current studies are aimed at improving these characteristics, especially in the extremely high frequency region (above 100 GHz), which relates to the byway.

2. Experimental considerations

2.1. Rationale for the use of carbon nanotubes

To achieve the required characteristics it is modified a version of the foam glass. As a modifying additive selected multilayer carbon nanotubes (MCNT), as they have a frame structure which provides strength, flexibility and conductivity of the material. The latter property ensures an even distribution of the electromagnetic wave across the surface of the material. The study used MCNT with a specific surface of 300 m^2/g and a diameter of 10 nm.

2.2. Study of parameters

As the object of study selected industrial foam glass block, obtained using carbon black as the blowing agent. We used surface modification of foam glass by applying on the surface of the liquid-glass compositions containing MCNT at 0.5 wt. %. The composition was prepared using ultrasonic treatment of a solution composed, and the processing mode determined experimentally. The gel composition was applied to the samples of foam glass in a thin layer, with subsequent drying at room temperature.

According to the study of electromagnetic characteristics of the samples of foam glass, depending on the frequency of radiation established the following. The maximum value of the absorption coefficient has the coated sample (0.98 relative units), and the ratio does not change over the whole measured frequency range, in contrast to foam glass without coating (Fig.1). For the sample coated with the absorption coefficient increased by 5 times at a frequency of 120 GHz, and 2 times at a frequency of 260 GHz, and the transmission coefficient decreased to 78 times at a frequency of 120 GHz and 42 times the frequency of 260 GHz.

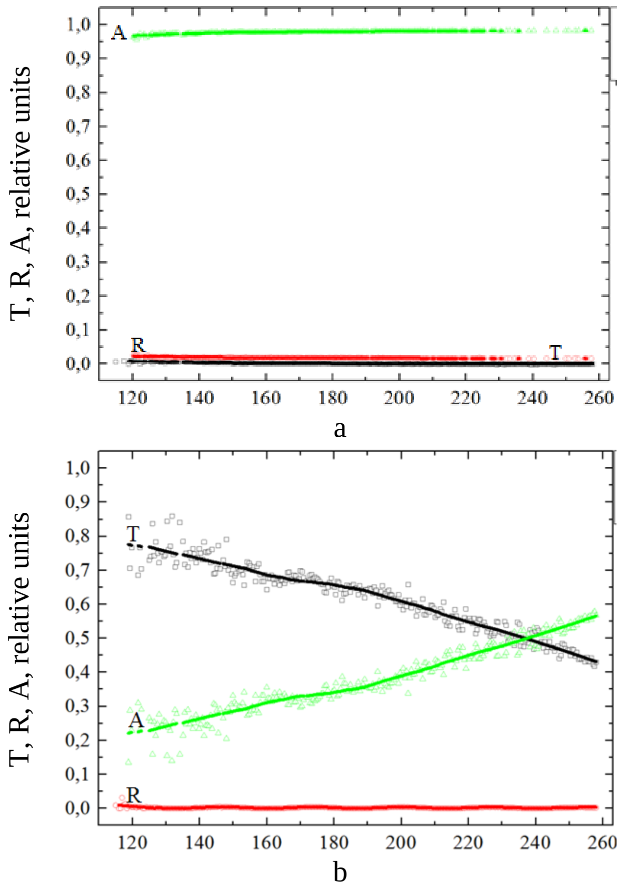

Fig. 1. Parameters of the electromagnetic response of foam glass with coated (a) and uncoated (b): A – absorption; T – transmissivity; R – reflection

3. **Results and discussions**

Thus, the foam glass with coating containing carbon nanotubes has improved radar absorbing characteristics. In addition, experimentally the samples of foam glass was determined by the value of the dielectric constant, foamed glass without coating it has to 1.18, and for foam glass with a coating of 1.27.

4. **Economic aspect**

The calculation of the technological cost of production according to calculation items [3]:

- raw and materials, net of implemented waste;
- purchased semi-finished products and components;
- fuel and energy for technological purposes;
- basic wage of production workers;
- additional salary of production workers;
- deductions on social needs;
- the wear of tools and devices target destination and other special expenses;
- the cost of maintenance and operation of technological equipment.

Obtained in the calculations values presented in table 1.

Table 1. The results of calculation of calculation articles

Name of articles of consumption	**The amount for the year, RUB**	**% , total**
Raw and materials for the production	841 000	64,08
Equipment for manufacturing	133 600	10,18
Fuel and energy for technological purposes	8 716,80	0,66
Basic wage of production workers	191 093,76	14,56
Additional salary of production workers	22 931,28	1,75
Deductions on social needs	92 030,76	7,01
The wear of tools and devices target destination and other special expenses	19 109,40	1,46
The cost of maintenance and operation of technological equipment	3981,12	0,30
The RESULT, production cost	**1 312 463**	**100,00**

To determine the cost of individual units of the product it is necessary to split the final amount on the expected volume of goods produced during the same year:

$$\text{Cost units cont.} = \text{Production cost} / \text{Volume of product} \quad (1)$$

$$\text{Cost units cont.} = 1312463/300 = 4374{,}88 \text{ RUB}$$

Most appropriate for comparison material is the mark of a C-RAM MT at a price of 40 – 90$ per 1 m^2.

5. Conclusion

The study showed that the surface modification of the MCNT foam glass increases its radar absorbing ability in a high frequency range 120 – 260 GHz, in contrast to materials of the company, Cuming Corporation, a frequency range which reaches only up to 100 GHz. Low dielectric conductivity of the glass matrix, porous structure, and modification of the nanotubes show the promise of using this material as an effective radar absorbent material. Having given the studied frequency range has great prospects of application in medicine for diagnosis of various diseases, in security systems to detect explosives in industry to detect hidden defects in products, foam glass can benefit in a variety of fields. This would also be consistent with the economic point of view.

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