Fibre Based Microwave Absorbers for Radio Communication Technique

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Abstract – **A technology for treating of coco-nut fibres with absorbing compounds based on styrene butadiene latex and absorption active fillers was developed. Lightweight broadband microwave absorbers, intended for elimination undesired signals in radio- and television technique were obtained.**

Keywords - **Microwave absorber, Absorbing compound**

I. Introduction

The development of new improved and more effective microwave absorbing materials in the last years is determined by the growth of the fields of their potential applications [1-3]. These materials have to meet the following main requirements :

- Minimal reflection and maximal absorption of the electromagnetic waves
- Wide exploitation frequency range
- High strength and firmness
- Minimal dimensions and weight
- Ability to work in wide range of mechanical and temperature conditions
- Reliability and durability
- Reproduction of all exploitation parameters [4,5].

The aim of the paper is to present a technology and latex based compounds developed for production of fibre based microwave absorbers, intended for elimination undesired signals in radio- and television technique (especially high quality parabolic antennas).

The main tasks, that we had to solve to achieve optimal parameters of the absorbers and to meet the requirements mentioned above were:

1. To select a suitable fibres and elastomer in a latex form
2. To select absorption active fillers
3. To develop a latex based absorbing compounds with sufficient stability, so that it could be used for fibre treating
4. To develop a technology for coating the fibres with the absorbing compounds

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II. Sample preparation

Coco-nut fibres was used as a basic materials because of their low cost and low weight. Styrene butadiene latex (Baystal S 30R, product of Bayer: styrene content – 59%, emulsifier system-anionic, solid content - 50%, density - 1,03 g.cm^{-3}, viscosity according to Brookfield, temperature 25^{0} C – 41 mPa.s, pH 4) was selected as polymer matrix, because it gives articles with better resistance to climatic aging, excellent compatibility with different kind of fillers and also good dielectric properties. Graphite and furnace carbon black were used as absorbing fillers. The filler's concentration ranged from 5 to 40 mass parts in relation to the solid content of the latex. As a dispersing agent was used an aqueous solution of sodium salt of the condensation product of naphtalene-β-sulphonic acid and formaldehyde (Tamol NN 9104, product of BASF). Aromatic polyglycol ether (Emulwin W, product of Bayer) was used as emulsifier and stabilizer to protect the latex from mechanical and chemical influences.

On the basis of a lot of experiments the following absorbing compound was develop for treating of coco-nut fibres (mass parts to latex solid content):

1. Styrene butadiene latex– solid content – 36,0
2. Sulphur – 6,0
3. Aromatic polyglycol ether - 1,0
4. Sodium salt of the condensation product of naphtalene-β-sulphonic acid and formaldehyde (Tamol NN 9104) – 2,0
5. Zinc oxide – 10,0
6. Kaolin – 29,0
7. N,N-diethyl-benzothiazyl sulphenamide (Wobesit AZ) –10,0
8. Graphite, furnace carbon black – 11- 14

The filler was first converted to dispersions. To the absorption active filler was added an optimum amount of dispersing agent (5% aqueous solution of Tamol NN 9104) and the mixture was homogenized After that the latex with the requisite ingredients were slowly added in portions with constant stirring. As a result the absorbing latex compound was obtained. The technology of fibrous absorbing materials obtaining consist of: treating and coating the previously prepared coco-nut fibres with latex based absorbing compound, afterwards drying the coco-nut matting and vulcanization.

Two technological variants were used for coating the fibres with absorbing compound. By the first one a fibrous plane with the needed thickness was immersed in a tank filled with absorbing compound. After good moistening the plane was

drained off, dried and at the end was vulcanized. Two fibrous planes with density equal to the half of the needed one were used by the second variant. Both planes were sprinkled even bilateral, then were stuck in a press, dried and vulcanized.
Our preference to the second variant was determined not only by the better quality of the absorbing coating, but also by its higher economy. By this variant could be precisely dosed the quantity of the absorbing compound, needed for the sample preparation.

The numerous experiments showed that these variants for coating the fibres with absorbing compound did not provide absorbing materials with enough reproducible parameters and were not sufficiently technological, having in mind the future industrial production. The better the fibres were steeped with the absorbing suspension in the depth, the more constant the electrical parameters of the material were. That was why the use of the centrifugal principle was necessary. Due to the centrifugal forces, it became possible the penetration of the absorbing latex compound through the fibrous planes and steep even of the fibres.

By this method the obtaining of absorbing fibrous planes, having strictly defined mass, through controlling of the centrifuging time offered not difficult.

Final technological stage of absorbing materials production is the vulcanization, which is completed in autoclaves and with a regimes follows:

- time of reaching temperature of 120^0 C – 10 min
- time of vulcanization – 25 min
- time of cooling by air – 15 min

III. Sample Testing

For measuring of the attenuation coefficient of the absorbing material it was used experimental equipment the most close to the conditions in which is expected to be used the absorbing material (AM). In real conditions the AM is placed on a metal ring, which encircles the aperture of the parabolic reflector of the antenna, high-quality production. An electromagnetic wave is transmitted from the antenna with a definite radiation pattern. In that way the wave reaches to the metal ring, faced with AM, under angle α. That angle is determined by the angle of the first side lobe from the radiation pattern and in this case, it is approximately 11 degrees. Next step is to make experimental equipment, shown on Figure 1.

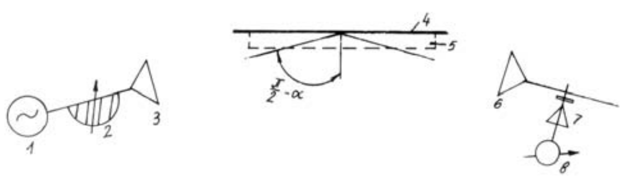

Fig. 1. Experimental equipment for measurements of the attenuation coefficient

The power from high frequency (HF) generator 1 passes through variable attenuator 2 and reaches transmitting antenna 3. In the far-field region of antenna 3 is placed a metal screen under an angle (π/2 - α) rad. On the other side of screen 4 under the same angle is fixed receiving antenna 6 with detector 7 and indicator 8. If antenna 3 transmits to the screen 4, receiving antenna 6 will receive definite power P_1 that is given on indicator 8. In case of putting AM 5 on screen 4, antenna 6 will receive power P_2 (antenna 3 transmits constant power). In order to measure the attenuation coefficient in AM it is necessary to reduce the transmitted power in the first case (without AM on the screen) with variable attenuator 2 so that the indicator has to show the same power value measured in second case with AM on the screen. The difference in the indications of the attenuator gives the value of attenuation coefficient.

IV. Results and Discussion

The results of attenuation coefficient measuring for two different frequencies – 2 and 3 GHz, are shown on fig. 2. For comparison are given the values for a similar existing absorbing material, produced by other company [6].

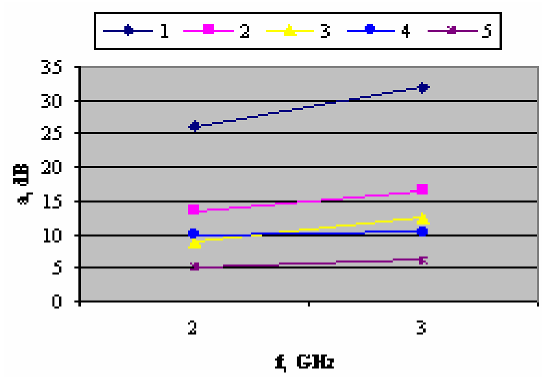

Fig. 2 Attenuation coefficient frequency dependence (samples 1and 4 – absorbing filler carbon black, first and second variant; samples 2 and 3 – absorbing filler graphite, first and second variant; sample 5 – material, produced by other company).

It is evident, that the best results for attenuation coefficient are obtained when using the first technological variant and carbon black as absorption active filler, but the mass of each fibrous plane is increased. By increasing the frequency aattenuation coefficient grows up and has significantly higher values for those absorbers than for the existing material.

Due to the requirements for absorbing material properties reproduction and a low mass of the absorbers a new series of experiments were carried out. In them was used graphite as absorption active filler. For a more constant deposition of the absorbing compound on the fibres was used the principle of centrifuging.

In Table 1 the results of the attenuation coefficient of five different samples are given

TABLE I
ATTENUATION COEFFICIENT, dB

Frequency range, GHz	S 1	S 2	S 3	S 4	S 5
1,7 – 2,1	6	5,5	5	7	5
5,6 – 6,1	14	15	12	13	11
5,9 – 6,4	16	15	12	13	11
7,4 –7,7	15	15	14	14	13
7,9 – 8,5	16,5	15,5	16,5	20	12

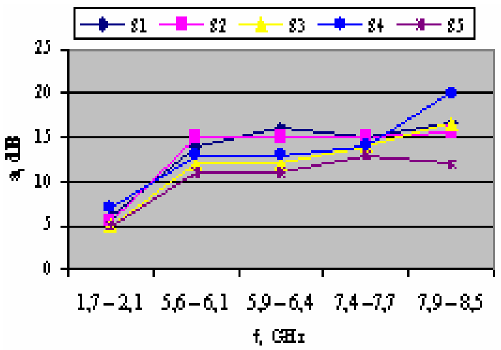

Fig.3. Attenuation coefficient frequency dependence for five samples

For the same five samples on Fig. 3 it can be seen the attenuation coefficient frequency dependence. In a common case, the attenuation coefficient grows up with the increasing of the frequency.

Fibrous absorbing planes position toward the transmitter of the parabolic antenna discounts the possibility of a perpendicular fall of electromagnetic energy on their surfaces. This can lead to an eventual returning of a part of the energy (reflection). This fact and the absorbing mechanism of electromagnetic energy in this kind of materials (mainly diffusion, because of their specific structure and uneven surface), explain why we do not have to measure the reflection coefficient. In the beginning of our experiments, we measured the coefficient of a standing wave on an initial plane (before the deposition of absorbing compound). The corresponding value was 1.1-1.3 for a frequency of 8-8.5 GHz. It showed an almost ideal matching on the border surface free space – fibrous material and an absence of electromagnetic energy reflection.

The absorbing material was put to a climatic test – resistance to cold and heat on standard methods. It was evaluated that AM had the same parameters from minus 55^0 C to plus 55^0 C.

In order to get information for the reliability of the absorbing material it was tested in an extreme conditions – repeating cycles with a sudden change of temperature (minus 40^0 C – plus 70^0 C). On the next parameters' check, it was proved that the parameters suited the requirements.

V. CONCLUSION

A technology and styrene butadiene latex based compound for obtaining of fibre broadband microwave absorbers are developed. The absorbers obtained may be used to reduce the side lobes in the radiation pattern of the parabolic antennas high-quality production, used for radio-relay lines, for equipment of anechoic chambers used in the measuring microwave antennas techniques, etc.

The mass of a fibrous absorbing plane (dimensions 1000x600x30 mm) is not greater than 1.450 kg, absorption coefficient is not less than 5 dB in the range 1,7 – 5,6 GHz and not less than 10 dB in the range 5,6 – 8,5 GHz.

Fibre based microwave absorbers keep its parameters in the temperature range from minus 55^0 C to plus 55^0 C.

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