NEW COMPOSITE MATERIALS FOR ELECTROMAGNETIC PROTECTION

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Abstract : *The paper shows up the research results on processing and characterization of composite materials with polymeric matrix (silicone rubber). The materials obtained in laboratory contain metallized nettling like reinforcement material and powdery graphite as filling agent. Measurements were conducted to determine the transmision diminishing carried out.*
Key words: *polymeric composite on de basis of silicone rubber, plated nettling, filling additions, shielding effectiveness, electromagnetic shields*

1. INTRODUCTION

At present, all over the world, concerns in absorbents field of electromagnetic waves are directed to directon of new materials with low cost and maximum efficiency both by designing of shieldind means **as diverse** and also for **specific** applications.

Therefore, the Materials Research Laboratory of Building of US Army has **ongoing** a complex program of research with the following goals:

- development of new materials: conductive polymers and covering for the shielding componnets; The materials comprise amorphous materials and inserted graphite
- shielding of standard building materials: foils of aluminium, copper**, nettling of metallic threads** and ceilings of metallic layers;

The first papers and practical achievement of **reflectants** and absorbents of electromagnetic field before the World War II, following diferently insurance of military security. USA, Germany and England give an important **volume** of **work** and big **funds** to vary these materials.

The United States of America tries to obtain light absorbent materials with low cost usable both at marine vessels and **airships.** The most recent achievements are:

- HARP Cloth Material made by MIT Radiation laboratory on the basis of conductive **sparkles** (aluminium, copper or ferromagnetic materials) scattered in a polymeric binder (rubber/plastic) **sprayed** on surfaces, especially used to reduce the electromagnetic interface;
– "Salisbury Screen material", as multilayer consisting in a layer of glass fibres impregnated with graphite, a foam layer and a conductive **counter face.**

England was also active in the absorbent field. Since 1947, British Radar, Signal Research Establishment have sponsored research and experiments about these materials and British Navy used the first materials resulted in the field of **resonant** absorbents to reduce the false echoes and perturbations made at the **reflection** of **radar energy** of **masts.** The recent results refer to materials on the basis of composite rubber with ferrite and carbonyl iron, carrying out absorbents of 20-30dB in a large range of frequency (1-18 GHz).

2. SOURCES FOR ELECTROMAGNETIC POLLUTION

Accurately Art 2, Directive 2004/108/EC of the European Parliament and Council the following issues are defined: [1]

-"electromagnetic compatibility": equipments ability to operate in their electromagnetic medium satisfyingly without to make themselves the insufferable electromagnetic perturbations for other equipments from this medium;

-"electromagnetic perturbation": any electromagnetic phenomenon susceptibly to make operating disturbances of equipment. An electromagnetic perturbation can be an electromagnetic noise, an undesirable signal or an altering of propagation medium itself;

-"immunity": equipment ability to operate accurately stipulations without degradation in the face of electromagnetic perturbations;

If in the equipments range the effects of electromagnetic radiations can be somehow quantified as regards interactions between the electromagnetic field and living creatures these will be variable and depend on the frequency field, amplitude of state sizes of electromagnetic field and density of electromagnetic energy on human body in due time.

At present, literature consists in a plenty of articles about the influence of electromagnetic fields on living systems. The sources generating the electromagnetic radiation are mainly represented by electric and electronic equipments (the electronic and communication equipments, electric mains, electric boards of command) that generate electromagnetic radiation both in near field and the far one. [2]

The main sources of pollution are such as:

–Natural electric field of the Earth that depends on latitude and altitude;

– Artificial static electric field (that arises in processing some plastics in the usage some woven of synthetic materials etc.);
–Terrestrial magnetic field (that has a variable component named magnetic storm depending on astronomical phenomena such as due to solar blast);
–Natural electromagnetic fields (such as lightening);
–Artificial electromagnetic fields (such as, radio waves in the range $3x10^5 – 3x10^7$ Hz, industrial electric – power – supply network at frequency of 50 Hz etc.[3]

At present, on the world plane, actions for limiting effects of electromagnetic fields on living creatures are undertaken of which the most important are:

- Standardization admissible intensity of electromagnetic fields for industrial activities and form dwellings in the civil and rural centres. This differentiation is necessary because the exposure time of a person differs in an industrial activity and also in the dwelling space. For example, in USA density of maximum power of electromagnetic field of 10 mW/cm^2, in the frequencies range of 10- 10^5 MHz is requested.
- Putting protection measures into force for development of some activities with sources of electromagnetic fields of which it may be mentioned: (Protection against high magnetic fields constantly and low frequency carrying out the shields of ferromagnetic materials that has a high permeability such as iron-nickel alloys;

Protection by limiting exposure time using device of acoustic or optical warning).

– Protection by development of distances activities calculated from the source of electromagnetic field is made using empirical relations which occur parameters of radiant source.

– Protection by usage some shields at the work place such as rooms made of metallic nets.

– Protection by usage some robes or other protection clothes made of cotton, silk, etc. whose structure is made of thin metallic fibers that form meshes of 0.5x0.5mm.[4]

The latest research about the influence of electromagnetic fields on living creatures have demonstrated that these particularly complex act on intracellular phenomena, on cells and organs and organism overall. At present, the research in this field are moved to elaboration of new standards on the pollution sources and for carrying out of new techniques of human protection against influence of electromagnetic fields.

The materials properties used for the reduction of electromagnetic pollution have to contribute to counteract the undersirable influences of electromagnetic field. The claims required to materials used for the reduction perturbations radiated depend on the shielding necessities. It can be considered electromagnetic shields also even the metallic nettings, iron armatures respective of buildings if the shielding requires are very reduced.

In the future, it is foreseen the integration in the building walls of some shielding materials to reduce the effect of disruptive electromagnetic field on indoor equipment.

These materials have to be cheap and to have an efficiency of shielding as reduces perturbations but not to affect the mobile communications.

The goal of present paper consits in the realization a composit material with polymeric matrix. The synthetic polymeric matrix used at the obtaining composite is represented by a bicomponent silicone elastomer that strengthens itself at the room temperature by means of a poly condensation reaction.

3. EXPERIMENTAL PROCEDURE

To achieve materials was used composite materials with polymeric matrix silicone rubber **(siloxanic)** as polymeric matrix of RHODOSIL RTV 3325 type that has a **beige-colored viscous aspect** have been used.

The best **reticular** is achieved **at** a temperature of 23^0C in humidity conditions of about 50%. Catalyst 60 is on base of $C_6H_{12}N_2O_4$ (dinytrohexan), this hurries the polymerization reaction **(strengthening)** of polymer. A ratio of (between **catalyst** and **silicone rubber**) = 5:100 PARTS is used.

As reinforcer, it is used plated netting **(PN).**

The metallized texture are obtained by **metallic coating/plating** (galvanizing coating) of fibers or polymers textures, basalt, glass, silica, graphite, etc. and are designed for making screens, protection of building , various devices, protective clothing.

The **plated nettling** helps to improve screening against the electric, magnetic, electromagnetic fields, infrared emissions and the biologic protection against their negative effects on **living creatures.**

Fig. 1 Plated nettling

Using materials as particles has known a great extension since performs some important advantage such as: Low cost, Simple technologies of introduction particles into matrix, Possibility to obtain **isotropic** materials.

The filling materials are used to induce some properties, such as increasing capacity of electromagnetic shielding different as their nature and configuration.

The preparing the raw materials of filling in essence consists in the eliminating **hygroscopic** humidity. This is carried out by drying the raw materials. The operation is very important as from the bad dried raw materials cannot be obtained products of quality.

The powdery fillings graphite – G , have been dispersed into polymeric matrix – silicone rubber, abbreviation

SG. Mixing has been made at the room temperature. Carrying out composites has been made by the laying mixtures on the plated nettling (PN) by means of doctor blade technique. The following abbreviations/acronyms, such as PNSG means polymeric mixture of silicone and graphite laid on the plated nettling and SG is polymeric mixture with silicone rubber and graphite without plated nettling will be used.
The composite materials have been polymerized in open atmosphere at a temperature of about 22 – 25^{0}C, for 24 hours. Materials with dimensions of 35x35 cm^{2} adequately to **screening** measures have been obtained

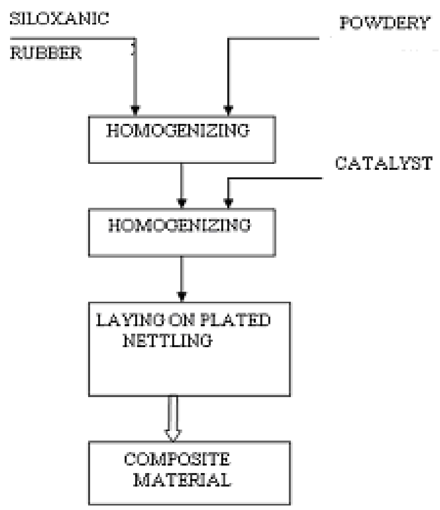

Fig. 2 Technological flux of composite composite materials

4. MEASUREMENTS OF TRANSMISSION DIMINISHING IN FREQUENCIES RANGE 1-18 GHZ.

The analysis goal is to determine the radio transmission diminishing in frequencies range 1-18GHz, with a view to establishing applicability field of composite materials with polymeric matrix obtained. [5]
The method principle consists in the diminishing measurement of radio transmission chain in two situation: without material and with the material inserted on the transmission chain. The transmission chain can be free space or waves guide.
The (emission and receiving) antennas are set up in the shielded room sitting face to face. The distance between antennas remains the same during measurements. By means of signal generator (Frequency range: 250kHz – 40GHz) a amplitude signal constant in the frequency range 1-18GHz is generated and this signal captured by receiver antenna noting the obtained values is measured. The sample is set up between antennas then an identical signal of the same amplitude as at measurement without sample and measure again the signal noting the obtained values is generated. The diminishing is calculated and plots of diminishing graph depending on frequency.

Fig.3. E8257D signal generator type (250kHz - 40GHz)

Fig. 4. Analyzer type 7405ª spectrum(100kHz-26GHz)

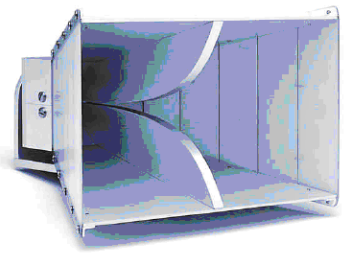

Fig.5. Model 3115 Horn Antenna (1 – 18GHz)

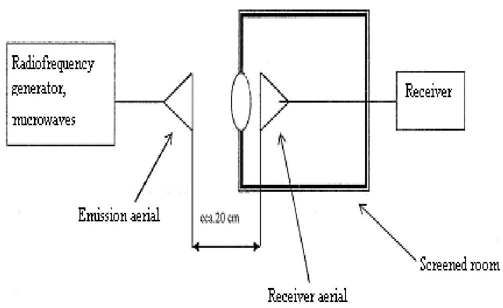

Fig. 6 General scheme for determination of transmission diminishing of materials ("method in free space")

As the listing is in tables 1-3, the experimental results of transmission diminishing measurements in the range 1-18 GHz made on composite polymeric materials, PN, PNS, PNSG, and SG are performed.
On based tables 1-3, using the Origin program were drawn the following graphs of variation of diminishing transmission.
As a material can be considered efficiently in point of radio diminishing, this must perform a minimum diminishing of 20 dB in band of work frequency.

Table 1

Frequency (GHz)	1	1,6	2	2,6	3	3,6	4	4,6	5	5,6	6
Reference [dBm]	11.49	10.38	6.827	4.345	-0.327	-3.456	-4.525	-1.471	-4.672	-0.146	0.969
Attenuation PM [dBm]	5.859	19.532	14.692	18.385	24.633	22.044	28.505	27.639	32.128	34.324	39.899
Attenuation PMS[dBm]	5.703	17.221	15.843	16.285	18.183	17.404	22.895	23.149	25.608	31.214	29.419
Attenuation PMSG[dBm]	1.75	8,.7	2.71	-6.12	2.84	7.36	2.4	7.99	11.8	18.16	20.79
Attenuation SG[dBm]	-2.84	-1.99	-5.51	4.26	5.96	4.01	8.23	8.72	2.86	2.58	3.11

Table 2

Frequency (GHz)	6,6	7	7,6	8	8,6	9	9,6	10	10,6	11	11,6	12
Reference [dBm]	1.71	1.133	1.99	1.161	1.941	1.722	0.399	-2.345	-3.595	-4.658	-4.744	-5.611
Attenuation PM [dBm]	35.9	38.163	39.52	41.711	40.101	43.322	51.079	46.135	38.195	41.092	46.186	50.159
Attenuation PMS[dBm]	30.28	32.023	33.01	32.391	32.831	33.202	34.009	36.625	41.985	40.082	46.276	39.109
Attenuation PMSG[dm]	21.26	22.05	22.83	26.56	27.07	25.85	26.05	24.93	26.64	25.77	25.33	28.97
Attenuation SG[dBm]	2.94	2.88	2.81	1.01	0.73	1.08	-0.98	1.15	1.06	0.83	1.15	2.29

Table 3

Frequency (GHz)	12,6	13	13,6	14	14,6	15	15,6	16	16,6	17	17,6	18
Reference [dBm]	-7.264	-7.529	-14.58	-11.57	-13.71	-16.06	-15.22	-20.47	-23.68	-27.02	-34.67	-38.33
Attenuation PM [dBm]	46.226	42.601	44.72	40.19	50.86	52.91	49.01	40.28	42.52	45.4	39.81	34.63
Attenuation PMS[dBm]	38.956	41.691	39.27	38.02	38.82	40.92	45.54	43.64	45.87	37.77	35.52	35.05
Attenuation PMSG[dm]	24	24.77	21.11	18.77	18.62	17.53	17.57	7.51	8.58	7.2	5..51	1.81
Attenuation SG[dBm]	3.28	4.65	4.96	4.21	5.04	6.09	7.76	6.95	5.89	5.75	4.51	2.17

– The behaviour composite system with polymeric matrix PN, as tables 1-3, performs minim values of radio diminishing (maximum of transparency) of (5.89)dB at a frequency of 1 GHz for system and the maxim value of radio diminishing is presented by the same composite material at a frequency of 16.5 GHz corresponding to value of (52,91) dB.
– The behaviour composite system with polymeric matrix PNS, as tables 1-3, performs minim values of radio diminishing (maximum of transparency) of (5.703)dB at a frequency of 1 GHz for system and the maxim value of radio diminishing is presented by the same composite material at a frequency of 11.6 GHz corresponding to value of (46.271) dB.

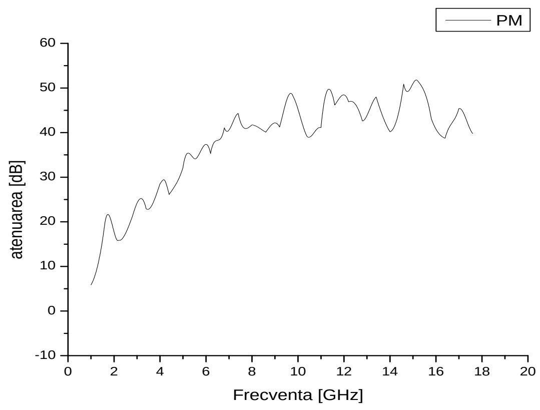

Fig. 7 Variation of transmission diminishing (dB) depending on material sample, PN

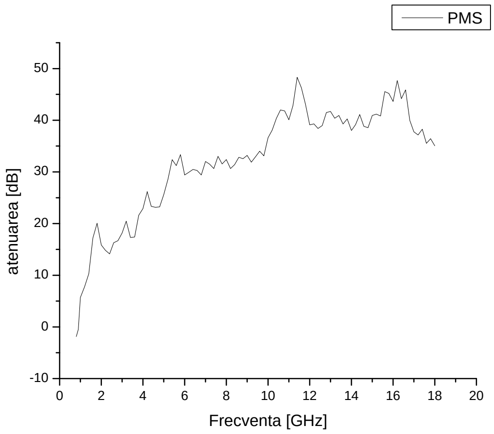

Fig. 8 Variation of transmission diminishing (dB) depending on material sample, PNS

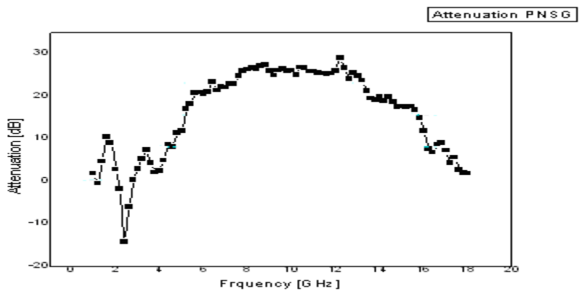

Fig. 9 Variation of transmission diminishing (dB) depending on material sample, PNSG

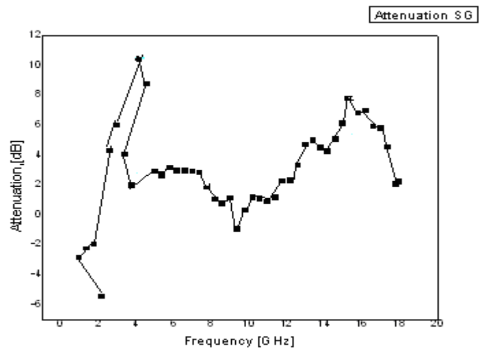

Fig. 10 Variation of transmission diminishing (dB) depending on material sample, SG

The behaviour composite system with polymeric matrix PNSG, as tables 1-3, performs minim values of radio diminishing (maximum of transparency) of (-6.12)dB at a frequency of 2.6 GHz for system and the maxim value of radio diminishing is presented by the same composite material at a frequency of 8.6 GHz corresponding to value of (27.07) dB.
The simple material without plated nettling, namely only silicone rubber and filling agent like nanocarbon SG, is performed, the diminishing values are covered between (-3.75) dB and 8,72 dB with an average only 2.98 dB

According to the diminishing graphs (7-10), it is observed that for systems which have as reinforce wire nettling, the diminishing decreases with increase of frequency and systems that have not reinforce the values of diminishing increase with the frequency increasing.
The composite systems developed in this research perform, generally, low values of diminishing for samples without plated nettling.

Table 4 Evaluation of transmission diminishing of composite systems obtained on frequencies range covered between 1-18 GHz

Sample	Diminishing (dB) measured on frequencies range		
	1-6 GHz	6,6-12 GHz	12,6-18 GHz
PN	24.32	42.63	46.98
PNS	20.26	38.68	40.088
PNSG	7,17	25,25	14,39
SG	2,54	1,47	4,94

5. CONCLUSIONS

– The obtained materials ensures an electromagnetic diminishing covered between (-6.12) dB şi (52.91) dB.
– The value of radio transmission diminishing on frequency range 1-6GHZ according to 4 and for the system PN of (24.32) dB and for PNS only (20.26) dB, PNSG of (7.17)dB and for SG (2.54)dB, on the frequencies range 6.6 – 12 GHz are met high values for three systems with plated nettling, and for the system without plated nettling the diminishing decreases to (1.47)dB . On the frequency range 12.6 – 18 GHz it is seen that the value of transmission diminishing performs values increasing for systems PN,PNS, SG and for PNSG values are given decreasing up to (14.39) dB.
– As we say that, the electromagnetic screens classification the materials obtained and characterized to ICPE-CA Bucharest, in the Electromagnetic Compatibility Laboratory , ensure a good attenuation [6], compared to composites with pyrite as filling agent providing a mean attenuation. [7]