Energetically Efficient Heating Radiant Systems Using Advanced Composite Materials

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Abstract: - The paper presents heating radiant systems manufactured from advanced composite materials as well as two 3-D micro structural models of polymer matrix composites with conductive spherical particles and non-deformed flakes as fillers. The description of heating radiant systems for public and industrial buildings, including the heating principle, is also presented. These heating radiant systems provide clean and advantageous heat, are energetically efficient and lead to conformity with the procedures of IGEF-Internationale Gesellschaft für Elektrosmog-Forschung (International Society for Electronic Smog Research), regarding the electronic smog. The main feature of these heating radiant systems is that the energy transfer does not accomplish through air (convection), but through electromagnetic waves (radiation), namely the air between the heat bearer and its receiver does not heat.

Key-Words: - Percolation, conduction, convection, radiation, composites, heating, electronic smog, efficiency

1 Introduction

The phenomena of passing electric current through organic polymer matrix composites with powders and/or conductive fibres differs from the electronic conduction through metals and is described by the percolation theory [1], [2]. According to this theory, the electric conduction is accomplished through proximity, at micro level there are no homogeneous distribution of conductive phase in polymeric matrix. This conductive phase finds itself at micro level as a conglomerate of conductive micro zones. Between micro zones, the conduction occurs through mechanisms that are specific to insulated polymers. For instance, these conductive mechanisms can be the existence of loads in traps, the displacement of mobile carriers, etc., so that the electric conduction phenomenon in these materials is in general, more complex [3].

Attempts to accomplish some heating radiant systems made from composite materials have been made at COMPOZITE Ltd Brasov, Romania, since 1994 for different prototype applications. Thus, these were applied at the heating of 6 cleaning baths for syringe needles with ultrasounds, the heating of a pickling bath (8 m^3) with bimetal strips of bearing (customer ROMLAG SA Brasov, Romania), the heating of 20 shelters of electric generator group CONNEX (customer VODAFONE, Romania) in year 1998/1999 as well as the heating of different public buildings. At international level, there are some companies in Germany and Austria that produce THERMOCARB heating radiant systems, but they are based on other constructive principle of the resistive element, namely with special threads isolated with silica. The enameled steel is the result of melting steel and tough glass of a high value in a manufacturing process of high technology. The enameled steel can be labeled, is tough at scratches, acids, with lasting color and almost indestructible.

2 Problem Formulation

All systems that heat prevalent the air (convection) works according to the air circulation principle. The air heats, rises and takes cold air that heats itself, and so on. In this case, in the room it forms an air circuit through which become possible the room heating. As strong the air heats, as much stronger will be the moisture loss (the necessary air moisture) and the dust trouble from the room, pollen, bacteria and allergenic elements. These involve themselves in air and distribute themselves continuously in the whole room. The result: a high air temperature as well as dry and drossy air. This has an extreme injurious effect on the human body.

3 Solution of Heating Radiant Systems

The new generation of heating radiant systems made from advanced composite materials have as main purpose the heating of public buildings (restaurants, exhibitions, courses halls, schools, kindergartens, festive halls, sport halls, shops, etc.), residential buildings and at industrial consumers with accent on the increase of their energetic efficiency. That's why, the products will be with a high finishing degree, with pleasant aspect and of faultless quality. Some constructive architectures of heating radiant systems are presented in figs. 1 and 2.

Fig. 1. Heating radiant system for industrial applications

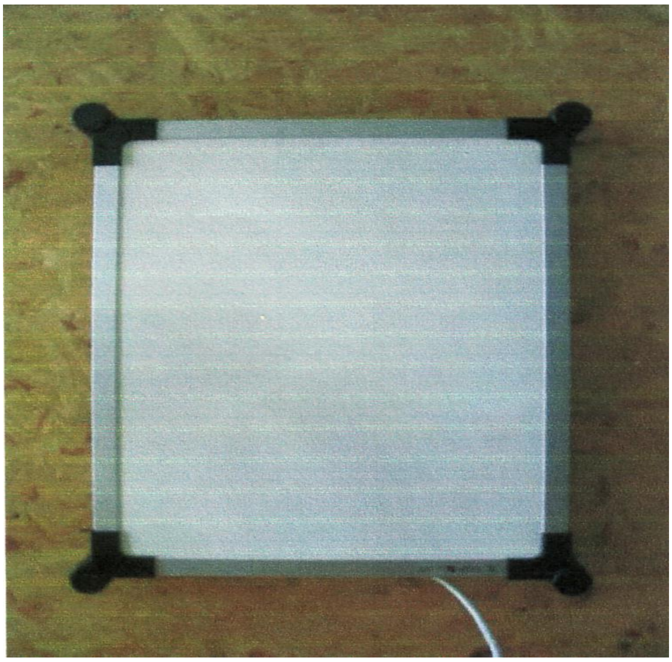

Fig. 2. Heating radiant system for residential and public buildings

In general, the heating radiant systems are composed from the following parts:

- Frame manufactured form steel that can be electrostatically painted or coated;
- Front side which can be manufactured from aluminium;
- Heating resistive element, 100% original, made from advanced composite materials;
- Thermal insulator;
- Rear side which can be manufactured from aluminium;
- Thermostat;
- Supports – 4 pieces;
- Power cable.

The frame can be from stainless steel, aluminium or painted in electrostatic field at the request colour. The front radiant side is also made from aluminium which can be natural or painted in electrostatic field. The heating radiant system works at 230 V and has a power of 1000 W.

Within a national project, the following types of experimental models of heating radiant systems made from advanced composite materials are intended to be manufactured:

- 300 x 500 x 32 mm – for a heating volume of up to 8 m^3;
- 1000 x 300 x 32 mm – for a heating volume of 20 m^3;
- 600 x 500 x 32 mm – for a heating volume of 20 m^3;
- 1000 x 600 x 32 mm – for a heating volume of 40 m^3;
- 1200 x 800 x 32 mm – for a heating volume of 80 m^3.

4 The Heating Principle

The electric energy is transformed in thermal energy produced by the heating resistive element. This transfers the heat to the environment through thermal radiation (thermal waves), the heating principle being similar to the sun. The heat transfer does not accomplish through air, but through walls-, objects from surroundings and through the human body heating. The air heats due to the objects- and wall heating and not due to the heat taking over by the air streams on the heating plate surface.

From the physiologic point of view, the heating through radiation is more natural for human beings also. Human body can take over, through skin, 99% from the thermal radiation at which is exposed by sun radiation, its body constitution being oriented to it. The warm and cold sensation does not depend on the environment air temperature. For instance: persons being in a room with warm air at 50°C and cold walls, almost "freeze", as well with an air at 10°C and warm walls, they "sweat".

5 3-D Models of Conductive Fillers

In general, the matrix of these materials is dielectric and provides mechanical adhesion, while the conductive

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fillers give electrical conductivity through connections accomplished between particles. The particles' arrangement and the way in which they connect each other are very important in determination of electric properties, respective electrical resistivity of conductive matrices.

To compute the resistance of polymer matrix composites with conductive fillers, one should know the position and the interconnections between filler's particles. To describe a micro structural 3-D model of a conductive matrix with spherical particles it is necessary to know some information about filler. First important information is that the shape of particles determines the microstructure and the interconnections betweens particles. Therefore, this shape must be chosen to facilitate the electric conduction. Usually, conductive fillers are flakes or spherical particles, since they present the lowest price and can be easily manufactured. Among these two types, flakes have wider applications due to their better connectivity as the spherical particles. However, since flakes present irregular shapes is difficult to accomplish a model. In case of spherical particles, the modelling is easier being necessary to take into account only the particle radius.

The second important information is that the filler's volume fraction must be above the percolation threshold [4]. For simplification, a polymeric matrix with conductive filler with uniform spherical particles is considered. If the spheres' radius and the filler's volume fraction are known, to accomplish the model is necessary to determine the particles position or the coordinates of spheres' centre in 3-D space. A very simple model is the Boolean one. Since the matrix presents a high viscosity and the conductive filler is completely mixed with the matrix, a uniform distribution of particles in matrix can be considered, so that the number of particles is the same in any volume unit of the conductive matrix. The easiest modelling method is the development of a set of coordinates of particles' centres randomly distributed in all volume (Boolean model). This is a simple model but not quite good since the superposition is allowed and many spheres intersect each other, which in reality this never happened. An example of micro structural model for a polymer matrix composite with conductive spherical particles as filler is presented in fig. 3.

The dimensions of the considered representative volume element (RVE) are 15 x 15 x 15 μm^3, the sphere's radius is 1 μm and filler's volume fraction is 25% [5]. Knowing the spatial arrangement of the particles, next steps in modelling are the computing of contact resistance and the connections analysis between them.

Some averaging methods in the micromechanics of composite materials with periodic structure can be used to model the resistive element [6].

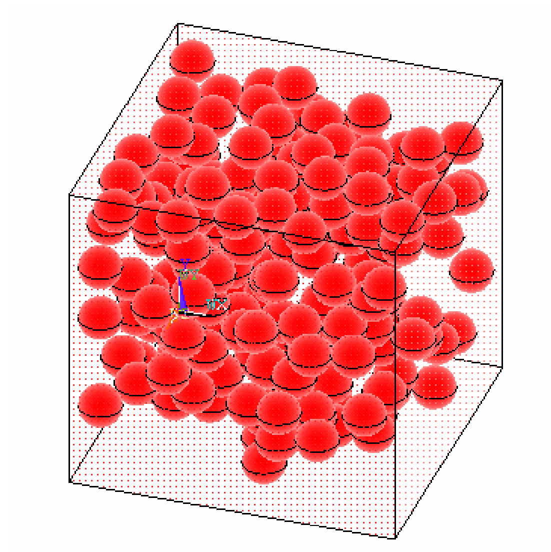

Fig. 3. Model of a polymer matrix composite with conductive spherical particles as filler [5]

Another type of micro structural model is for polymer matrix composites with conductive particles in form of flakes as filler. The majority conductive trading matrices include silver flakes due to their better conduction. To simplify the problem, the flakes have been considered in a configuration of rectangular elements having the thickness much smaller than the length and width of the considered matrix RVE. In fig. 4, a micro structural model of a polymer matrix composite with conductive flakes as filler is shown.

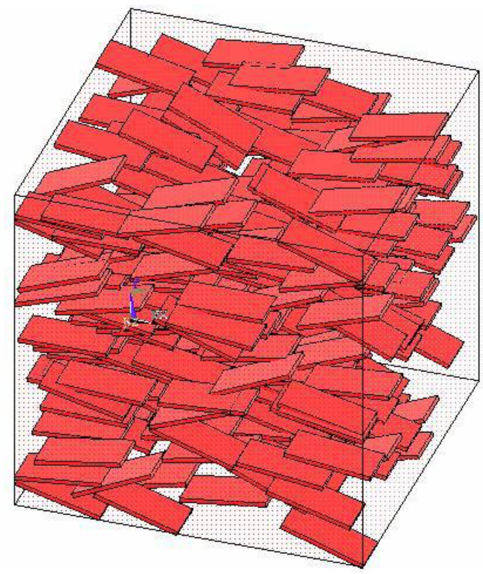

Fig. 4. Micro structural model of a PMC with conductive non-deformed flakes as filler [7]

In this model it is supposed that the flakes are stiff and they do not bend, so, no flakes' deformation occurs. Since the flakes' thickness is much smaller than their length and width, they can be easily deformed when they come in contact.

6 Conclusions

The novelty at the heating radiant systems with heat waves is the way and manner of this heat, namely by electricity. By help of the layers made from advanced composite materials, heat conductive, a more clean heat is obtained, more advantageous and spends more energy. Despite convection, at the heat radiation, the energy transfer does not accomplish through air, but through electromagnetic waves, namely the air between the heat bearer and its receiver does not heat.

The heating radiant systems made from advanced composite materials are extreme complex having an extraordinary know-how incorporated from the field of materials science (advanced composite materials based on synthetic resin reinforced with special fibres, powder materials, materials with remarkable electric properties), physics (the concept of thermal radiation through heat waves, radiation spectrum, etc.), thermodynamics and thermo technique. These products are also complex through their manufacturing technology of the composite resistive element, being necessary various manufacturing processes like: moulding at a well established pressure and temperature of the resistive stack in the hot mould press as well as the homogenization process of the powders in the matrix of the composite material.

The complexity of these heating radiant systems results from the researches to find complex constructive solutions that lead to the conformity with the stipulations of IGEF-Internationale Gesellschaft für Elektrosmog-Forschung (International Society for Electronic Smog Research). For more information see the web site www.elektrosmog.com.

The future researches will be carried out in the following areas:

- Measurements regarding the electromagnetic absorption of the advanced composite materials. The evaluation of electric permitivity and magnetic permeability of thesae materials used at the manufacturing of the resistive element, by the in line transmission method with a frequency less than 3 GHz;
- Measurements regarding the electromagnetic absorption of the advanced composite materials. The evaluation of electric permitivity and magnetic permeability of these materials used at the manufacturing of the resistive element, by the open end method with a frequency grater than 3 GHz;
- Measuring the electric and magnetic properties of the advanced composite materials used at the manufacturing of the resistive element using four conversion techniques:
  - o Nicolson-Ross-Weir technique;
  - o NIST iterative technique;
  - o A new non-iterative technique;
  - o In line shortcircuit technique.
- Decomposings, oxidizations and desiccatings determinations of the advanced composite materials used at the manufacturing of the resistive element using the thermogravimetric analysis;
- Determination of phase transitions and chemical reactions of different advanced composite materials using the differential thermal analysis of these materials;
- Thermal analysis of the advanced composite materials used at the manufacturing of the resistive element using the dynamic differential calorimetry (thermal capacity, phase transitions, chemical reactions, calorimetry);

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