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MECHANICAL AND ELECTRICAL PROPERTIES OF COMPOSITE MATERIALS BASED ON POLYESTER REZINS AND GIPSYMFIBER

Рассмотрены композиционные материалы на основе полиестерных резин и гипсфибер. Исследованы механические и электрические свойства в зависимости от содержания гипсфибра.

The composite materials developed from unsaturated polyester resins and gypsumfiber filler show relatively good strength characteristics. The adding gypsumfiber does not effect negatively the properties of the unsaturated polyester resins. The materials obtained have good electrical-insulation characteristics.

Introduction

In the development of new materials, except the properties of the materials, the economical and ecological aspects are also of considerable importance. More and more frequently, the traditional metal materials, the production of which requires expensive raw materials, are being replaced with composite materials with alternative properties, which, in some relations, are even better. The composite materials are obtained from much cheaper components, and are with significantly lower relative weight at that [1].

In KNAUF-Gipsfaser, in the production of gypsumfiber plates, gypsumfiber powder is obtained as waste material. The usage of both gypsum and fiber as fillers of polymer composite materials is well known. The usage of waste material as a component of a composite material results in reduction of its cost, and in a positive environmental effect in view of the ecological problems [3, 4].

All these facts brought forth the idea for the usage of the gypsumfiber powder as filler of composite materials.

In industry, composite materials on the basis of non-saturated polyester and epoxy resins have found the widest field of application [2, 5, 6].

The polyester resins have a series of valuable properties: suitable viscosity, ability to solidify at both room and high temperatures, high strength and dielectric ratings, high chemical stability and the do not release volatile substances. The coefficient of light refraction of the unsaturated polyester resins is close to that of the glass; therefore the obtained polymer materials are transparent [2, 7].

The main objective in the creation of composite polymer materials is to combine the properties of the separate components in view of the optimization of the design, technological, electrical and operational features of the end product – the composite material [1].

The aim of this paper is the development and research of the electrical and mechanical characteristics of composite polymer materials from unsaturated polyester resins with gypsumfiber powder filler, as well as to determine the influence of the filler quantity upon these characteristics.

Experimental Part

For the preparation of the composite materials the following output components are used:

- Unsaturated polyester resin UP-PS5323;
- Accelerator Pitt-Consol 640;
- Hardener Arrcoper 20;
- Fiber-gypsum power –technological scrap.

The fiber-gypsum power is sifted through a laboratory sieve 0,5 mm in order to homogenize it and to remove the mechanical impurities. The following operation is heating up to 50^{o}C within 10 hours, aiming at removing the absorbed moisture.

The necessary quantities of the resin, accelerator and fiber-gypsum are homogenized in a glass container within 10 minutes and then the hardener is added. The following homogenization lasts 2-4 minutes only as its continuation is defined by the moment when the resin start to jelly. The composite obtained is poured in moulds from metal and PVC, which have been preliminary oiled with separating grease.

The polycondensation of the composite materials is carried out at two stages. The first is effected at temperature of 80^{o}C for 10 minutes and the samples are out of the moulds. The second polycondensation stage is performed at 100^{o}C for 30 minutes. The test samples are then machined to obtain the necessary geometrical sizes and roughness.

As the most suitable component ration for obtaining quality materials the value of 100:2:1 has been selected, of the relevant substances: resin: hardener: accelerator.

In order to establish the influence of the quantity upon the composite materials properties the following mixtures are prepared: No 1 contains 0% filler, No 2 - 5%, No 3 – 7,5%, No 4 - 10%, No 5 - 15%, No 6 - 20%.

In order to perform the various types of tests samples with different shapes and sizes are prepared in accordance with the requirements of the regulation documents.

The prepared samples represent disks of diameter 50 mm and thickness of 3÷4 mm for measurement of relative dielectric permeability, the tangent of the dielectric losses angel and electric strength.

In order to find out the hardness as per the Brinell method cylindrical samples are used, which serve also to define the pressure strength.

The hardness is defined by means of sphere with diameter D=2,5 mm, loading F=309 kN and duration – 20 s.

The tensile strength is defined on short five-fold cylindrical sample bodies with calculated L_0=40 mm.

The sample bodies, used for the measurement of the pressure strength, are cylindrical, with diameter D=12 mm and height 18 mm, as the height is determined by the diameter and the slenderness coefficient of the sample body. The break stress under pressure is defined as a relation of the break effort F_{Src} and the initial cross section of the sample S_0.

The impact resilience is defined by means of standard sample bodies with sizes 10x10x55 mm.

Results and comments

The maximum quantity of gypsumfiber powder has been defined. The percentage contents of the filler should not exceed 20%. The gypsumfiber powder is of low relative weight and in the presence of great quantities of filler, quality materials cannot be produced. A great number of air pores and high level of non-uniformity are observed.

Fig.1 shows the dependence of the density of the obtained composite materials from the quantity of gypsumfiber powder. Increasing the filler contents results in increasing the density of the composite materials with 8-10%.

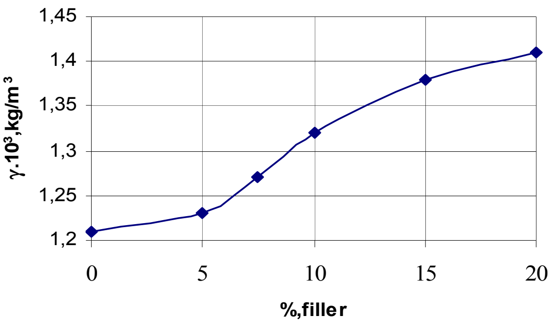

Fig.1 The dependence of the density from the quantity of filler

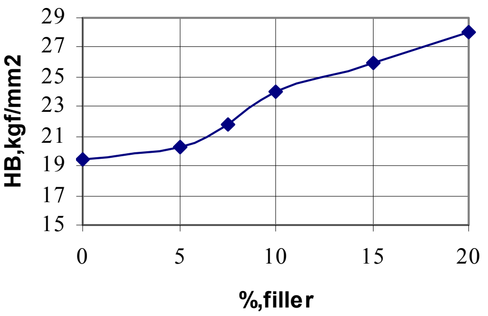

Fig.2 The dependence of the hardness from the quantity of filler

Fig.2 show the alteration of the hardness of the material in dependence of the filler contents. Increasing the filler quantity increases the hardness of the material, measured with Brinell methods. When the gypsumfiber powder contents is 20% the hardness is by about 70% higher than the hardness of the pure resin.

When researching the tensile strength of the samples, a maximum value is observed for the pure unsaturated polyester resin (fig.3). While increasing the filler contents, it decreases sharply with about 25% for gyosumfiber contents of 7,5%. A further increase of the gypsumfiber powder contents results in a slight decrease of the strength. The tensile strength reaches its minimum when the gypsumfiber powder is 20%.

The dependence of the pressure strength from the percentage contents of gypsumfiber is given in fig.4. After a series of pressure tests with the samples, the break stress proved to be greatest for the pure resin (242,5 N/mm^2). When the filler quantity is 5% the break stress decreases and remains stable about this limit when the filler quantity is further increased.

When determining the influence of the filler quantity upon the impact resilience the results show that the impact resilience increases for filler contents up to 10%, then it gradually decreases while the gypsumfiber content increases (fig.5).

The type of alteration of the strength characteristics of the composite material should be related first to the properties of its components (polyester resin and gypsumfiber powder) on the one hand, and to the forces of adhesion along the inter-phase borders of the two phases, on the other hand. The presence of microscopic parts of gypsumfiber powder hinders the development of the dislocation planes of skidding in the process of determination and research of strength characteristics, influencing the process of destruction of the sample bodies. The tests performed evidence the complicated influence of the gypsumfiber quantity upon the different characteristics.

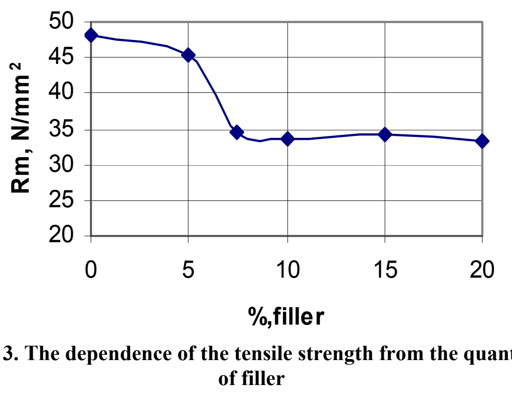

Fig. 3. The dependence of the tensile strength from the quantity of filler

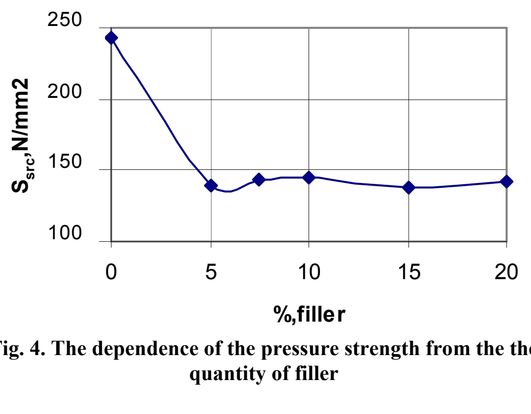

Fig. 4. The dependence of the pressure strength from the the quantity of filler

Fig.6 shows the alteration of the relative dielectric permeability as a function of the filler concentration for frequency values 1 kHz, 10 MHz and 30 MHz. When the frequency increases a reduction of ε_r.is observed, which is a result of the disappearance of the relaxation polarizations, which are typical for the polar dielectrics. Increasing the gypsumfiber quantity results in an increase of ε_r. This is logical, as ε_r.of the gypsumfiber is several times greater than the value for the pure polyester resin. On the other hand, the density of the composite material also increases when the filler content increases.

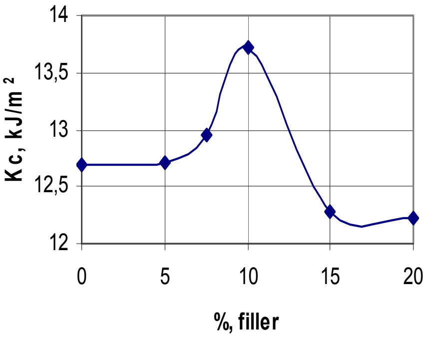

Fig. 5. The dependence of the impact quantity of filler

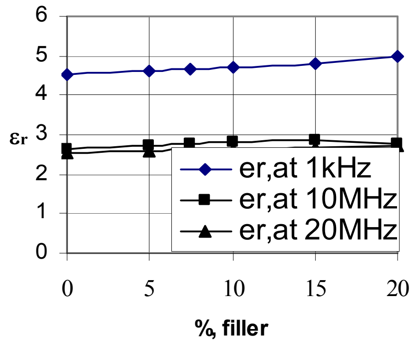

Fig. 6. The dependence of the dielectric resilience from the permeability from the the quantity of filler

The investigation of the tangent of the dielectric losses angle shows and increase of its value when the filler quantity increases. This is explained with the increase of both the losses from polarization and electric conductivity. When the frequency increases, tgδ decreases because the slow polarizations disappear.

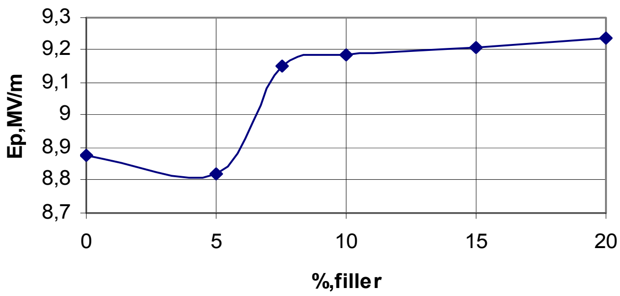

Fig.7. The dependence of the electric strength from the the quantity of filler

Fig.7 illustrates the electric strength. It changes only slightly when the filler contents increases up to 20%, as the obtained composite materials are relatively homogenous and the electric field in the dielectric is homogenous too.

Conclusion

In conclusion to the analysis of the results it can be noted that the composite materials developed from unsaturated polyester resins and gypsumfiber filler show relatively good strength characteristics. They can find application in the machine-building industry for the production of housings and other parts, replacing other materials with similar parameters, but of higher cost.

It should be noted that adding gypsumfiber does not effect negatively the properties of the unsaturated polyester resins. The materials obtained have good electrical-insulation characteristics. They will enrich the range of electrical-insulation compounds, which are widely used to pour on electrical machines, radio-electronics schemes and other types of electrical equipment and appliances.

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