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RESEARCH OF NEW FIREPROOF SUPPLIED POLYMER COMPOSITES BASED ON EPOXY RESIN FOR METAL STRUCTURES

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Abstract. *In the article proposes new compositions based on fire retardant expanded polymer composites of epoxy resin ED-20 and phosphorus-containing oligomers, catalysts, aluminum hydroxide and nitrogen-containing compounds.*

The obtained sample of fire retardant expanded polymer composites based on epoxy resin, as well as the initial substances, were investigated by IR spectroscopy (Nicolet 5700), thermogravimetric analysis (TG) (SDT Q600) of physical and chemical properties and determination of fire retardant efficiency according to GOST R 53295-2009.

Infrared spectroscopy has been used to determine the bends and epoxy groups that characterize composites, as well as to determine the frequencies of phosphorus, nitrogen, and metal-containing groups. At the same time, a thermal analysis of the obtained composites was carried out. The TG analysis analyzed temperatures in the range 150-500 oC and a weight loss of 3% was determined at 150 oC, weight at 430 oC, weight at 430 oC, 430 oC orat at 150 oC. 50%.

Composites DTA derivatograms are protective expanded polymer composites based on epoxy tar, four endothermic effects at 175, 186, 200 and 430 ops and three exothermic effects of 250 or 300 and more than 400 effects were found. According to the results of a study of the fire resistance of polymer composite coatings obtained on the basis of GOST R 53295-2009, it was found that they meet the requirements of GOST. It has been established that, in contrast to polymer composites, they have the property of protection against three different types of impacts in the same time.

Keywords: *fire resistance of building structures, intumescent (intumescent), polymer composites, blowing agent, phosphorus-containing compounds, catalyst, coke formation, filler.*

Introduction. Increasing the limits of fire resistance of building structures due to various methods of passive fire protection is one of the main factors in increasing their operational reliability [1; 2; 3; 4; 5; 6; 7; 8]. At present, both abroad for these purposes, a wide range of intumescent (intumescent) fire retardants based on water, based on organic solvents and solvent-free (100% dry residue) epoxy compositions are produced [9; 10; 11; 12; 13; 14].

Epoxy resins belong to the group of thermosetting polymers and have high adhesion, chemical resistance, water resistance, good mechanical and electrical properties, due to which they are widely used in industry, including as adhesives and coatings. The disadvantage of epoxy polymers is their increased flammability. To reduce combustibility, combustion retarders of organic and inorganic nature are introduced into polymers [15; 16; 17; 16; 17]. Finely dispersed metal powders (aluminum, copper, iron, tungsten) are used as fillers for epoxy glue to increase its thermal conductivity and provide heat removal in the case of structural elements of heating equipment [18; 19; 20; 21; 22; 23].

Material and methods. The preparation and research of fire retardant expanded polymer composites used epoxy resin ED-20, curing was carried out using polyethylene polyamine, and as intumescent (intumescent) flame retardants, phosphorus-containing compounds (usually ammonium polyphosphates) were catalysts for the coke formation process, and the filler was nano-sized aluminum hydroxides, and the filler was nano-sized aluminum hydroxides. foaming agents (blowing agents). The obtained sample of fire retardant expanded polymer composites based on epoxy resin, as well as the initial substances, were investigated by IR spectroscopy (Nicolet 5700), thermogravimetric analysis (TG) (SDT Q600) of physical and chemical properties and determination of fire retardant efficiency according to GOST R 53295-2009.

In our Republic, it is urgent to create effective oligomeric fire retardants based on local raw materials, as well as from waste and by-products of chemical and mining and metallurgical industries. Obtaining new polyfunctional fire retardant expanded polymer composites based on epoxy resin ED-20, with the joint introduction of which into oligomeric binders, a synergistic effect is observed.

The obtaining new fire retardant was expanded polymer composites for fire resistance of metal structures, with the high fire retardant efficiency, environmentally friendly and economical is an urgent task today.

It has been studied, IR spectroscopy (Nicolet 5700), thermogravimetric analysis (TG) (SDT Q600) and physic mechanical physicochemical properties of flame retardant expanded polymer composites.

The preparation and study of the process of fire retardant expanded polymer composites used epoxy resin ED-20, curing was carried out using polyethylene polyamine, and as intumescent (intumescent) flame retardants, phosphorus-containing compounds (usually ammonium polyphosphates) were catalysts for the coke formation process, filler, nanosized aluminum hydroxides - foaming agents (blowing agents).

In the comparison, some data from the results obtained are given. Table 1 shows that, under optimal conditions, fire retardant expanded polymer composites. These polymer composites are characterized by physical and chemical properties. (1-greedy).

Table-1.

Physical properties of refractory convex polymer composite coatings

Indicator	Flammable convex polymer composite
Density g/sm3	1,09
Water solubility	Insoluble in water
Color and appearance	A viscous white polymer composite in the oligomeric state

Infrared spectroscopy with Fourier transform (UR-20 and UR-75) of the obtained composite based on ED-20 epoxy resin and phosphorus, nitrogen and metal-containing additives is shown in Figure 1. IR spectra of the composition based on epoxy resin in the presence of a wide band at ≈3400 cm-1 are associated with the stretching of the O-H hydroxyl grouP. Signals in the range of wavenumbers 2922–2817 cm–1 and around 1457 cm–1 are due to –CH2– symmetric and asymmetric stretching and banding, respectively. Moreover, the signals located in the range 1295-1060 cm-1 can be attributed to the stretching of C-C and C-O. The IR spectrum contains absorption bands in the region of 3000-3300 cm-1, corresponding to the epoxy ring and absorption bands in the region of 750 -950 cm-1, asymmetric stretching vibrations of the ring. The absorption bands at 800 and 1600 cm-1 confirm the presence of –NH2 groups. The presence of groups containing phosphorus P=O and P–O–C in the range 1000-1250 cm-1 is confirmed by a broad intense band. In addition, narrow low-intensity bands containing aluminum bonds appear in the IR spectrum in the 800cm-1 and 1460cm-1 regions. (Figure-2)

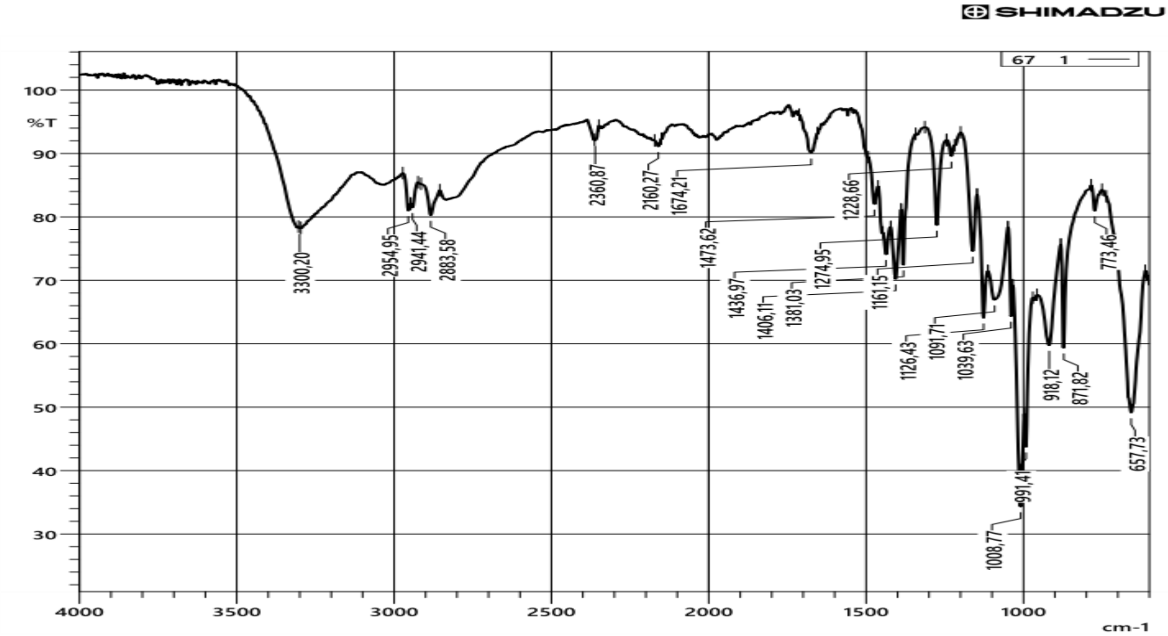

Figure 1. IR spectroscopy of flame retardant was expanded polymer composites based on epoxy resins.

The thermal stability of the obtained samples was investigated in the mode of linear heating at a rate of 10 °C/min in an air atmosphere in the temperature range 50–800 °C. Thermal analysis results are shown in Fig. 2. On the DTA curve of the derivatogram of the sample of fire retardant expanded polymer composites based on epoxy resins, four endothermic effects were found at 175, 186, 200 and 430 oC and three exothermic effects at 250, 300 and 400 oC. (fig. 2).

Thermal destruction of the studied samples occurs in three stages. In the first two stages, the formation of the carbonized residue occurs, in the third stage, it is oxidized [8]. The temperature of the onset of destruction, which was taken as the temperature at which a 3% weight loss of the samples (T5%) occurs, for all fire retardant expanded additives in the samples is lower than that of the original epoxy polymer (Table 2). From the analysis of the dependence of the change in the mass of the samples on temperature (Fig. 2), it can be seen that the introduction of fire retardant expanded additives into the epoxy resin leads to an increase in the weight loss when the samples are heated to 150 °C as a result of the release and evaporation of water and sorbet gases. epoxy resin ED-20, curing was carried out using polyethylene polyamine, and as intumescent (intumescent) flame retardants, phosphorus-containing compounds (usually ammonium polyphosphates) are catalysts for the coke formation process, the filler is nanosized aluminum hydroxides, nitrogen-containing compounds are blowing agents. When heating nanosized aluminum hydroxides of metals, desorption of water and gas vapors occurs [4, 7]. Evaporation of water lowers the temperature of the samples, which slows down the destruction process and increases their thermal stability at temperatures above 150 °C.

The weight loss of fire retardant coatings of 6% was 24 min at 200 °C. At a temperature of 430 °C and 50%, this process was carried out for 40 min.

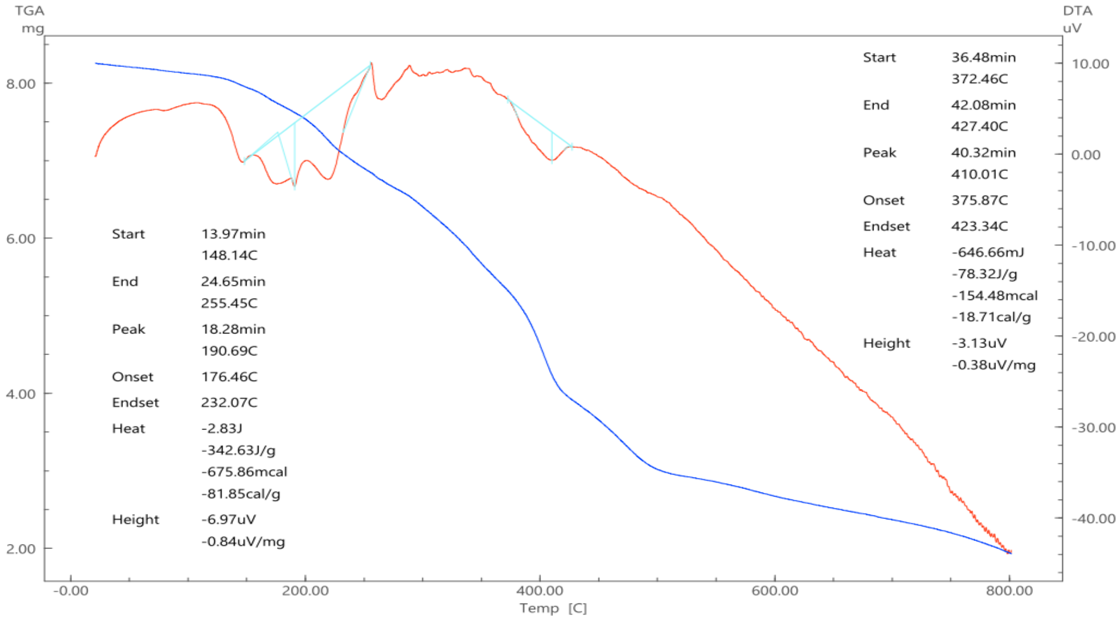

Figure 2. Results of thermal analysis of fire retardant was expanded polymer composites based on epoxy resins.

Studies of fire retardant expanded polymer composites used epoxy resin ED-20 exhibit a fire retardant effect by two mechanisms: it initiates the formation of a thin film and promotes the formation of a "coke cap", which has a porous structure and low thermal conductivity.

The main advantages of this type of fire retardant materials: provision of a fairly large range of values of fire resistance limits; small thickness of coatings - up to 4 mm, low consumption and, accordingly, low loads on structures; high decorative qualities.

For comparison, fire retardant expanded polymer composites used epoxy resin ED-20 were tested samples of a metal structure coated with a thickness of 0.7 mm (additive content 10%).

In the study of the intumescent coating, the destruction of the porous structure occurs (50-60 seconds) and a rapid increase in the heating temperature of the samples to 280-500 °C is noted. In this case, the limiting state of the sample sets in and the test is terminated. As a result, the thickness of the expanded layer is 0.6-0.9 mm.

So, with the introduction of fire retardant expanded polymer composites in an amount of 0.5-7.5%, the adhesive strength of the bond between the coating and the substrate increases two to four times. The best performance is achieved when the content of the modifying additive in the amount of 5.0% transformations (foamed layer) and a layer of coke foam (Fig. 3).

The transformation zone is a black foam mass with large pores (up to 3 mm) formed in the process of intense gas formation. Foam coke is a gray foam with a large number of small pores evenly distributed over the volume of the expanded mass. It can be assumed that the pores are filled with a foaming mass. On the basis of literature data and experimental studies, it has been established that such coke should have the high fire, and heat protection properties.

An important indicator for fire heat-protective coatings is their ability to coke formation, which is significantly influenced by the amount of fire-retardant expanded polymer composites as an effective catalyst for coke formation. Fig. 3.

Figure 3. Results of fire retardant expanded polymer composites based on epoxy resins.

In the process of production of the obtained polymer composites, have been tested experiments were carried out and the results were obtained. The metal surface was cleaned before covering the external load-bearing metal structures with flammable convex polymer composite coatings. The polymer composite intended for the outer surface was then thoroughly mixed (Figure 4.A). The finished polymer coating was applied to the surface of the cleaned metal structure as shown in Figure 4.B. The appearance of these polymer coatings for exterior surfaces after 6 months in Figure 4.S, weather resistance (from -20 oC to +110 oC), wide range of application temperatures and protection from fire, corrosion caused by chemicals are similar to other similar polymer composites. the relative difference was found to have the property of protecting against three different types of effects at the same time. This leads to economic and environmental efficiency in the application of polymer composite materials in metal structures of buildings and structures.

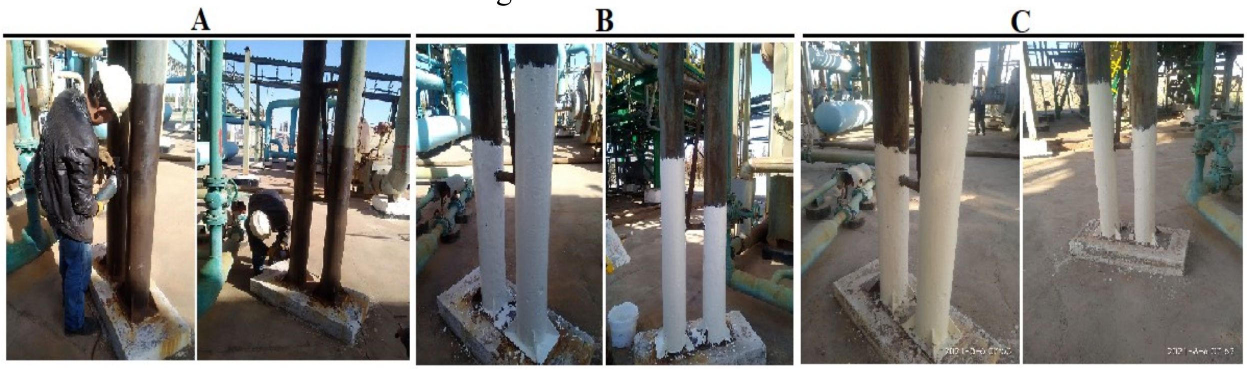

Figure 4. Application to the surface of metal structures in the production of refractory polymer composite coatings.

Conclusion. In this work, fire retardant expanded polymer composites were obtained on the basis of epoxy resin, their physicochemical properties were analyzed, and the main characteristic bonds of epoxy groups and groups containing phosphorus and metals were identified using IR spectroscopy. In addition, the heat resistance of flame retardant expanded polymer composites was analyzed and a weight loss of 50% was determined at a temperature of 430 oC. GOST R 53295-2009. The results of a study of the fire resistance of polymer composite coatings were obtained, on the basis of which it was determined that the results meet the requirements of GOST.

Based on these test experiments, the use of flame retardant expanded polymer composites can be used to protect metal structures from fire, high temperatures, and exposure to chemicals.

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