Study of the Effect of the Film-Forming Substance on the Corrosion Resistance of Intumescent Paints

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Abstract. One of the simplest and most effective fire protection methods for building structures is the application of a fire retardant intumescent coating on the surface of a structure. These swelling (intumescent) type coatings are widely used today. Intumescent coatings can increase the fire resistance of polymer compositions, but they have insufficient chemical resistance, resistance to high humidity. As a result, corrosion pockets appear on the surface of the steel structure and under the coating during long-term operation, the coating peels off, and cracks appear on it, and adhesion decreases. The purpose of this work was to determine the effect of a film-forming substance (binder) on the resistance of intumescent paints to the action of a corrosive atmosphere. For this, intumescent compositions with three different binders were made. The paint composition was applied with a brush to metal plates. For the experiments, samples of St 3 were used. The problem was solved, which was aimed at studying the heat-insulating properties of the studied coatings and the microhardness of metal samples under it. As the main criterion for evaluating the fire retardant properties, the heating time of the metal substrate of the sample was used. It was revealed that three paints obtained satisfactory results and can be used in industry. But epoxy binder paint got better results.

1. Introduction
The greatest losses from fires are noted in the sectors of the fuel and energy complex [1-9]. One of the methods of fire protection is the application of a fire retardant intumescent coating on the surface of the structure [2]. Such swelling (intumescent) type coatings are widely used today. An intumescent technology for protecting structures from burning consists in expanding and turning into a coke the surface layer of the coating that is exposed to fire. The foamed coke layer, which is formed in this case, protects the metal surface for some time from the effects of flame and high temperatures.

Due to the fact that intumescent coatings have insufficient chemical resistance and are also vulnerable to the effects of high humidity, corrosion pockets appear on the surface of the steel structure and under the coating during long-term operation, which leads to a decrease in adhesion. Peeling of the coating and the appearance of cracks on it can also be observed. This ultimately leads to a reduction in fire protection time. Such coatings are used for equipment that operates in difficult operating conditions at oil refineries and the oil and gas industry [10-21].
2. Experimental procedures

2.1. Materials

The object of the study are intumescent compositions with three different binders: epoxy resin ED 20 with hardener polyethylene polyamine; acrylic dispersion heat resistant; silicon varnish brand KO-85. The system of ammonium polyphosphate-pentaerythritol-melamine in the ratio 2: 1: 1 was selected as the foaming component. To increase the foam coke layer, intercalated graphite was used. For the experiments used samples of St 3. As a result of the preparation of the compositions with various polymer binders were obtained: styrene-acrylic dispersion, silicon varnish and epoxy resin. The paint composition was applied with a brush to metal plates. For testing, 15 samples of St. 3, having the shape of a square, with a side of 165 millimeters. The thickness of the samples was not more than 10 millimeters. The tests were carried out on three samples. Before the test, the samples were conditioned until a constant weight was reached at a temperature of (23 ± 2) °C and relative humidity (50 ± 5)%.

2.2. Experiment Techniques

Intumescent coatings can increase the fire resistance of polymer compositions. As a result of the experiment, intumescent compositions with various polymer binders were applied to the metal samples: styrene-acrylic dispersion, silicon varnish and epoxy resin. After complete curing of the paint material, a measurement of its thickness was carried out. For this, the magnetic thickness gauge MT-201M (MT-201-01) was used. It was revealed that the coating thickness met the requirements.

The heat-insulating properties of the studied coatings were determined according to ST SEV 1000-88 “Fire safety standards for building design. Fire test method for building structures”. As the main criterion for evaluating the fire-retardant properties, the time of heating the metal substrate of the sample (a metal plate with a fire-retardant coating) to a critical temperature (500°C for steel) was used at the appropriate temperature of the “standard fire” due to the thermal effect on it from the fire-retardant coating in the experimental chamber. The design of the installation provides stable conditions of heat exposure, eliminating significant temperature and heat flux gradients in the working area of the furnace, where the fire retardant coating is expanded. The essence of the method allows you to determine the time of heating the unheated side of the sample to a critical temperature (for steel - 500°C) during the tests, which are carried out according to the temperature regime specified in accordance with table 1.

| Time from start of test $\tau$, min | Oven temperature corresponding to time $\tau$, $t ^\circ C.$ | Time from start of test $\tau$, min | Oven temperature corresponding to time $\tau$, $t ^\circ C.$ |
|-----------------------------------|-------------------------------------------------|-----------------------------------|-------------------------------------------------|
| 1                                 | 2                                               | 3                                 | 4                                               |
| 5                                 | 550–590                                         | 30                                | 810–840                                         |
| 10                                | 650–690                                         | 35                                | 840–870                                         |
| 15                                | 710–750                                         | 40                                | 860–890                                         |
| 20                                | 755–795                                         | 45                                | 870–900                                         |
| 25                                | 790–820                                         | -                                 | -                                               |

The microhardness of metal samples under coating was determined using a MET-UDA Hardness Tester. The hardness tester implements the principle of ultrasonic contact impedance when working with an ultrasonic sensor.
3. Results and discussion

The heating dynamics of metal plate samples and the temperature change in front of the sample (furnace temperature) were controlled and recorded automatically using control units, the results are shown in Figure 1.

![Figure 1](image_url)

**Figure 1.** Change in temperature of steel samples during heating according to the standard fire.

The heat-insulating properties of the coatings were estimated by the heating time to a temperature of 500 °C, which was: - with acrylic dispersion: 40 min; - with epoxy paint: 90 min; - with silicone varnish: 50 min.

The microhardness of metal samples under coating was determined using a MET-UDA Hardness Tester. The results of microhardness measurements are presented in Figure 2.

![Figure 2](image_url)

1 - coating with an epoxy binder; 2 - coating with silicone varnish; 3 - coating with acrylic dispersion

**Figure 2.** Results of microhardness measurements.

4. Conclusion

In the course of the experiments, three compositions of the intumescent composition with various binders were prepared: an epoxy two-component composition, acrylic dispersion, and also with an
silicone varnish. All three paints obtained satisfactory results and can be used in industry. But paint with an epoxy binder got the best results.

The exposure time for heating a sample with epoxy paint was 90 min. This suggests that this coating has the best heat-insulating properties, which means that it can protect the metal structure from heating for a long time.

According to microhardness measurements, a sample that was coated with an epoxy binder paint showed the best results, namely 1336 HV. This suggests that the temperature under this type of coating, when exposed to fire, was lower due to good insulation.

Thus, an epoxy-based coating has high durability, good heat-insulating properties, and also resistance to the action of a corrosive atmosphere.

5. References

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