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Studying the Influence of Inhibitors on Physical-Chemical and Mechanical Properties Epoxy Coating EP-750

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ABSTRACT: The article, using electrochemical research methods, shows the effectiveness of increasing the service life of EP-750 enamel using organic compounds to protect metals from corrosion in a humid atmosphere containing H_2S, NO_2, CO_2, SO_2.

I. INTRODUCTION.

In the chemical industry, metal structures are often corroded by substances such as: H_2S, SO_2, NO_2, CO_2 and acid vapors H_2SO_4, HCl and others. An effective method of protecting metal structures and equipment from corrosion is the use of paint and varnish coatings. Sometimes these coatings do not effectively protect metal structures from corrosion, due to an increase in the concentration of chemicals in the atmosphere, which leads to cracking of steel, as a result of which emergency situations may arise, the results of which can be absolutely unpredictable.

II. LITERATURE SURVEY

To extend the service life of coatings, paint and varnish coatings on the metal surface are regularly renewed. Annual application of coatings on the surfaces of structures and equipment presents certain difficulties, cleaning the metal surface, applying several layers of coatings by drying each layer for 1 hour, etc. An effective way to extend the service life of paints and varnishes is the use of inhibited paint and varnish coatings. This paper presents a study of the effect of inhibited epoxy coatings EP-750 on the protective properties of metal structures and equipment of drilling rigs.

Previously, we studied the protective properties of the epoxy coating EP-750 in an atmosphere containing H_2S, NO_2, CO_2, SO_2 [1-3].

III. RESEARCH METHODS

In this regard, the purpose of this work is: 1) To study the effect of inhibitors on the physicochemical properties of EP-750 enamel in the studied environments; 2) To study the manufacturability and mechanism of action of the developed inhibitors by determining their diffusion through the coating on steel, the effect on the kinetics of electrode processes.

Study of the effect of inhibitors on the physicochemical and mechanical properties of EP-750 enamel using the method described in TU and GOST [4-6]. Nitrobenzene and captax were used as inhibitor additives. Nitrobenzene and captax were introduced into the composition of EP-750 enamel in an amount of 1.0 wt.%. Samples coated with inhibited and non-inhibited EP-750 enamel were placed in a special vessel and the physicochemical and mechanical properties of the coatings were determined.

IV. EXEPERIMENTAL RESULTS

The conditional viscosity of the coatings, which is based on free flow, was determined by the time of continuous flow in seconds of a certain volume of the test material through a calibrated nozzle of a VZ-246 viscometer.

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The test material sample, selected in accordance with GOST 9980-20, was thoroughly mixed before determining the conditional viscosity, avoiding the formation of air bubbles in it, while the test paint and varnish material must be homogeneous. To eliminate foreign substances, the sample was mixed, filtered through a sieve and thoroughly mixed again immediately before the measurement. At least two parallel determinations were carried out simultaneously. The test was carried out at an air temperature of (20 ± 2)°C. The viscometer and the test material were brought to a temperature of (20 ± 0.5)°C immediately before the test. Before the test, the viscometer and especially the nozzle were thoroughly cleaned with a solvent. The viscometer was filled with the sample so that air bubbles did not form. Excess material and formed air bubbles were removed using a glass plate moved along the upper edge of the funnel in a horizontal direction so that an air gap did not form. The nozzle opening is opened and the stopwatch is started simultaneously with the appearance of the test material from the nozzle. At the moment of the first interruption of the stream of the test material, the stopwatch is stopped and the flow time is counted. The test was carried out three times and the arithmetic mean value was taken. The conditional viscosity (X) is calculated using the formula:

$$X = t \cdot K,$$

where: t - arithmetic mean value of the expiration time of the test material, s; K - viscometer correction factor.

The mass fraction of volatile and non-volatile, solid and film-forming substances was determined as follows: before weighing, the cups, previously wiped with acetone, were kept in a drying cabinet at the test temperature for at least 10 minutes. After that, the cups were placed in a desiccator, cooled to room temperature and weighed. Then the test material, thoroughly mixed to a homogeneous consistency, was placed in the cups and weighed. To avoid the loss of volatile substances during weighing, the cups were covered with a watch glass. After weighing, the cups are opened and, rotating them, the contents are distributed in a thin layer over the entire surface of the bottom, after which they are placed in a drying cabinet in a horizontal position and heated. After heating, they are transferred to a desiccator, cooled to room temperature and weighed. If heating is carried out to a constant mass, the first weighing is carried out after 30 minutes, and then every 30 minutes. The discrepancy between the results of the last two weighings should not exceed 0.01 g. The mass fraction of volatile (X) and non-volatile (X_1) substances in percent is calculated using the formulas: $X = ((m_1-m_2)/m_1)\ 100$ (1) $X_1 = (m_2/m_1)\ 100$ (2) where: m_1 is the mass of the test material before heating, g; m_2 is the mass of the test material after heating, g. The arithmetic mean of the results of parallel determinations is taken as the test result, the discrepancy between which should not exceed 1%.

To determine the degree of dilution of the enamel, 120 g of the test enamel was weighed and diluted with a solvent to a working viscosity of 28÷30 using a VZ-246 viscometer with a nozzle diameter of 4 mm at a temperature of (20 ± 0.5) °C. The degree of dilution (X) in percent was calculated using the formula:

$$X = (m_1 \cdot 100)/m,$$

Where, m_1 – mass of solvent used to dilute enamel, g; m – mass of enamel, g.

The time and degree of drying were determined according to the method described **in** [3]. The degree of drying characterizes the condition of the surface of the paint and varnish material applied to the plate at a certain drying time and temperature. Drying time is the period of time during which a certain degree of drying is achieved at a given thickness of the paint and varnish layer and under certain drying conditions. The drying time and degree were determined at (20±2)°C and relative air humidity of (65±5)% on three samples at a distance of at least 20 mm from the edge of the image after natural or hot drying of the applied layer of paint and varnish material. The plates with a naturally dried paint and varnish layer were kept horizontally in a room protected from dust, drafts and direct sunlight at (20±2)°C and relative air humidity of (65±5)% for the time specified in the normative technical documentation for the material being tested, and then the test was carried out. During the test, a sheet of paper is placed on the painted plate with clean hands or tweezers, taking it by one of the free corners. A rubber plate is placed on the sheet of paper, in the middle of which a 20 g weight is placed; the weight and rubber plate are removed through (60±2), and the painted plate with the sheet of paper is freely dropped edgewise from a height of 28…32 mm onto a wooden surface. If the sheet of paper does not stick to the film, then drying degree 3 has been achieved. The drying time is calculated as the arithmetic mean of three parallel determinations, the permissible differences between which do not exceed +15%.

The elasticity of the film during bending was determined using the following method [7]. The method consists of determining the minimum diameter of a metal cylindrical rod, on which bending a painted metal plate does not cause mechanical destruction or peeling of a single-layer or multi-layer paint film. The film's bending elasticity on a metal rod is assessed after testing three plates on the same rod.

The strength of the film upon impact was determined by a method based on determining the maximum height from which a load of a certain mass does not cause visible mechanical damage on the surface of a plate with a paint coating. The test paint and varnish material was applied to the plate in accordance with GOST 8832-76. Before testing, the samples were kept at (20±2)°C and a relative air humidity of (65±5)% for 48 hours. Test procedure: The test was

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carried out at (20±2)°C and a relative air humidity of (65±5)%. The plate was placed on the anvil under the striker with the coating facing down (reverse impact), ensuring that it fit tightly to the anvil surface. The section of the plate onto which the load would fall was installed at a distance of at least 20 mm from the edge of the plate and at least 40 mm from the center of other sections previously subjected to impact. The test result is taken as the value of the maximum height at which three positive test determinations are obtained.

The adhesion of the paint and varnish coating of the lattice cuts was carried out by visually assessing the coating condition using a four-point system. Two samples were prepared for the test. The test was carried out on two samples and at least on three sections of the surface of each sample. On each test section of the sample surface, at least six parallel cuts were made to the metal at a distance of at least 10 mm from the edge using a cutting tool along a ruler, at least 20 mm long, at a distance of 1, 2 or 3 mm from each other. Cuts were made in a similar way in the perpendicular direction. As a result, a grid of squares of the same size is formed on the coating. The distance between adjacent grids should be at least 20 mm. A grid with a single square measuring 1x1 mm was applied to coatings less than 60 µm thick, 2x2 mm to coatings from 60 to 120 µm thick, and 3x3 mm to coatings from 120 to 200 µm thick. The control of the coating cut to the metal was carried out using a magnifying glass. The results of testing the inhibited and non-inhibited coating EP-750 are given in Table 1.

Table 1.

Physico-chemical, mechanical and technical characteristics
inhibited and non-inhibited enamel EP-750

Name of the indicator		Standard according to TU 2312-216-00209711-2007	
		EP-750 without inhibitor	EP-750 with captax
Appearance		homogeneous matte surface without foreign inclusions	homogeneous matte surface without foreign inclusions
Mass fraction of non-volatile substances, % (depending on color)		37-45	37-45
Conditional viscosity according to viscometer VZ-246(4), s,		60-110	60-105
Drying time to degree 3 at a temperature of (20±2) °C, h, no more than		3	3
Shelf life (when mixed with hardener), h, not less than (in tightly closed container)		72	72
Adhesion, points, no more than		1	0,8
Film elasticity when bending, mm, no more than		1	0,9
Film strength upon impact on the U-1A device, cm		50	50
Film hardness according to pendulum device TML2124, rel., units, not less than		0,3	0,32
Resistance to static impact at a	Water -	72	72

temperature of (20±2)°C, h, not less than	mineral oil -	24	25
	Gasoline -	24	25
	3% sodium chloride solution	24	30
Grinding degree, μm		18	20
Film coverage, g/m2		243	249
Drying time to degree 3, hours		20	11
Film color		Grey	Grey

V. CONCLUSIONS

As can be seen from Table 1, the introduction of an inhibitor into the coating composition has almost no effect on the main physical, chemical and mechanical properties of the coatings, and in some cases even slightly exceeds the properties without an inhibitor, which contributes to an increase in the service life of EP-750 epoxy coatings in the studied environments.

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