PROTECTION OF SHIPS FROM CORROSION

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Abstract. Corrosion of steel hulls of ships and vessels is the main cause of vessel wear, reducing the strength of hull structures and navigation safety. To ensure the protection of housings from corrosion, to achieve the required level of reduction or prevention of corrosion, an integrated approach is necessary. This approach should be based on the rational use of various methods of protection and control, taking into account the design features of the hulls and the technical operating conditions of ships and vessels.

Key words: corrosion prevention, metal erosion prevention, cathodic protection, sacrificial protection, body fouling.

Due to corrosion-mechanical destruction, a large number of hull structures of ships and floating technical structures fail. In addition to the environmental hazard in such accidents (environmental pollution, loss of energy resources), significant economic losses arise: loss of equipment, repair costs, downtime. 10% of the metal is lost irretrievably, dissipating in the form of oxidation products.

Corrosion is the enemy of metals, especially those in contact with water. Marine equipment, ships, oil and gas complex facilities require reliable and long-term anti-corrosion protection. Today this is a very important problem that they are trying to solve [1].

To prevent any corrosion process, the following basic methods can be used:

- eliminate the cause of corrosion (contact with electrolyte);
- apply passive protection that impedes the occurrence and development of corrosion processes, but does not eliminate their causes (painting);
- use active protection, which consists of influencing the cause of corrosion (cathodic protection, in which a mode is established that reduces the destruction of the ship’s hull);
- use anodic protection.

In shipbuilding, the last three methods of combating corrosion are used, since it is impossible to exclude contact of the ship’s hull with the electrolyte (sea water).

Passive protection can be achieved by applying a protective coating to the ship's hull, hull structure or product: metallic, organic or inorganic. Metal coatings can be anodic or cathodic. Zinc coatings, classified as anodic, not only isolate the metal from the influence of the external environment, but also protect it electrochemically.

Organic coatings include liquid, paste, solvent-free or powder coatings. Inorganic protective coatings are obtained by chemical processing of metal. Due to significant porosity, oxide or phosphate films themselves cannot serve as a reliable protective coating for metal. Such films only improve the adhesion of the paint coating to the surface being painted, which increases the anti-corrosion protection of the metal.

Active protection is based on electrochemical methods of combating corrosion processes. With the cathodic protection method, the ship's hull is connected to an external source of direct current, and it serves as a cathode [2, 3]. Additional electrodes are used as anodes, specially installed on the outer surface of the housing, which are destroyed in the process (Fig. 1).

Figure 1 – Scheme of cathodic protection of ships

This is the most reliable and cost-effective way to protect the underwater part of the hulls of marine infrastructure facilities from corrosion. Benefits of cathodic protection for platform protection:

• complete suppression of corrosion of casings and welds
• reducing the margin of thickness of the skins for corrosive wear
• does not require replacement during the entire service life of the vessel
• remote monitoring and control.

Anodic, or sacrificial, protection consists of the following: a plate of metal that is less noble than the metal being protected is attached to the structure being protected, i.e., having a lower electrode potential. Such a plate (protector) becomes an anode on which corrosion is artificially concentrated. The destroyed protector is replaced with a new one (Fig. 2).

Figure 2 – Placement of protectors on the ship's hull

Tread protection is economical, simple and straightforward. The protectors slowly dissolve, protecting the structure to which they are attached [4].

In shipbuilding, protectors made of zinc, aluminum, magnesium, alloys of aluminum with zinc, magnesium with aluminum, zinc, etc. are used. Protective protection is most effective in combination with paint and varnish coatings.

To protect against corrosion, paint and varnish coatings are most often used, which, compared to other types of protective coatings serving the same purposes, have the following advantages:

- low cost (compared, for example, with the cost of galvanic, powder, glass-enamel and other coatings);
- high manufacturability (painting is less complicated than applying other types of protective coatings; products of any configuration and size can be painted, in whole or in part);
- long period of action with the correct choice of paints and varnishes, their application technology and painting scheme;
- the ability to quickly renew the coating in case of damage or destruction, even on a vessel in operation.

In addition, by appropriate selection of paints and their application technology, it is possible to obtain coatings with almost any required properties (non-flammable, heat-resistant, oil-resistant, acid-resistant, non-slip, anti-fouling, chemically resistant, etc.), as well as any specified color and desired texture (glossy, matte, semi-matte, rough, etc.).

When choosing a protection method, it is necessary to take into account the conditions in which the product will be located during operation. Therefore, for painting ships, coatings with good water resistance, hardness and wear resistance should be used. In order to reliably protect the surface being painted, it is necessary to use paints that contain pigments that can slow down metal corrosion. This property of pigments is called inhibitory ability.

All pigments used for the manufacture of paints can be divided into inert (aluminum powder, titanium white, chrome yellow pigment, etc.), corrosion inhibitors (lead and zinc crown, red lead, zinc dust, etc.) and corrosion promoting (mummy , soot, red lead from pyrite cinders, etc.).

The retarding effect on corrosion of paints, including those containing aluminum powder, cannot always be explained only by electrochemical protective protection. The high anti-corrosion properties of such paints largely depend on their low swelling and permeability due to the scaly structure of aluminum powder particles.

Zinc crown is one of the universal corrosion inhibitors for steel and light alloys, but only in a neutral or alkaline environment. In an acidic environment, on the contrary, it increases corrosion.

Observations have established that paint coatings containing pigments, which are corrosion inhibitors, have a protective effect on the painted metal surface even after damage to the coating.

The fight against fouling of the underwater part of ship hulls is a complex problem that has not been completely solved at the present time. Although there are now several ways to combat fouling, the simplest and most commonly used is to paint surfaces with special anti-fouling paints.

Antifouling paints can be liquid (containing a fairly large amount of solvents), paste-like (with a low solvent content or even without it) and solid [4].

Toxic substances in anti-fouling paints dissolve in seawater. As a result, a layer of water is formed on the painted surface containing toxic components that repel fouling larvae trying to attach to the ship's hull, structures, structures, or, if attachment has occurred, cause their rapid death. There are two types of such paints. In paints of the first type, the film-forming base, together with pigments and inert fillers, remains in its original form, toxic components are released from the film (Fig. 3, a and b), in paints of the second type, the paint film is gradually destroyed due to friction with water, as a result of which new ones are discovered areas of the coating that also contain soluble toxic components (Fig. 4, a and b). Such paints, applied even in a relatively thin layer, protect against fouling for 20-24 months.

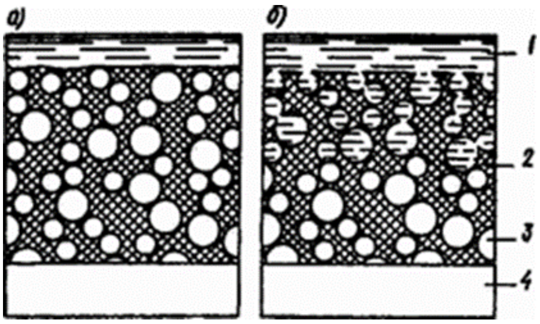

Figure 3 — Isolation of toxic components from anti-fouling paint with an insoluble base: a - paint before use; b - paint after a year of operation. 1 - sea water; 2 - paint base; 3 - toxic components; 4 - anti-corrosion coating.

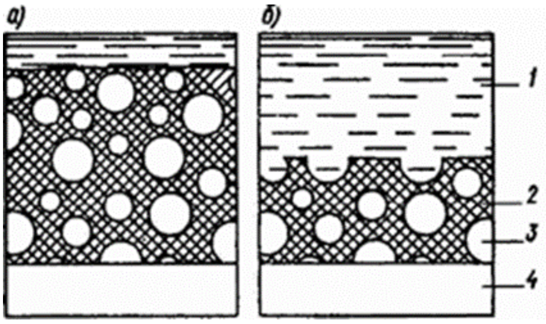

Figure 4 — Isolation of toxic components from antifouling paint with a soluble base. The designations are similar to those adopted in Fig. 4.

Anti-fouling paints containing a polymer base chemically bonded to organotin derivatives are characterized by high toxicity and good protective properties. Upon contact with water, hydrolysis of the film-forming base occurs with the release of toxic compounds that saturate the laminar layer.

If anti-fouling paint is applied directly to metal, the compounds of copper, mercury and other metals contained in it can cause intense corrosion of the ship's hull. Therefore, such paints can only be applied to metal surfaces that have a layer of good anti-corrosion coating.

The fairings are protected from fouling on the outside by painting them according to the scheme adopted for the underwater part of the hull.

It is better to paint the hulls of fishing vessels that stay away from bases for a long time and undergo docking once every two to three years with thermoplastic anti-fouling paints.

The results of this study should be used in anti-corrosion protection of the ship hull to improve the performance of the ship and in order to maximize the allocated service life of the ship structure.

This study is very useful for shipbuilders and ship owners to understand the corrosion reactions, activity on metal and also for taking control measures.

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