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Corrosion protection of ship structures

Zaštita od korozije brodskih konstrukcija

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Abstract

Hull maintenance is one of the most important aspect in ships lifetime. Ship maintenance represents prevention of ship system failures, dealing with them and extending ships lifetime. Corrosion has been a common cause of damage in ships for years. The most widely used method for protecting ship structures is application of coatings. Ships age, size and navigation area all influence in choosing the right protective coating system. Hull protective coating can be applied either during navigation or during ship repair works in shipyard.

Keywords: *corrosion protection, protective coatings, ship's hull*

Izvod

Održavanje broda jedan je od najvažnijih aspekata u životnom veku broda. Pod pojmom održavanja broda podrazumeva se sprečavanje kvarova na brodskim sistemima, otklanjanje nastalih kvarova te produženje životnog veka broda i njegovih sistema. Korozija je godinama čest uzrok oštećenja na brodovima. Najraširenija tehnologija zaštite brodskih konstrukcija od korozije je zaštita premazima. Starost broda, veličina i područje njegove plovidbe su samo neki od aspekata koji utiču na odabir odgovarajućeg sistema zaštitnih premaza. Zaštita brodskog trupa premazima može se vršiti tokom pomorsko plovidbenog procesa, ali najefikasnije je u remontnim brodogradilištima.

Ključne reči: *zaštita od korozije, zaštitni premazi, brodski trup*

Introduction

Hull maintenance represents big cost for ship owner, especially in modern bussiness trends. Purpose of this paper is showing the influence of protective coatings in protection of the ships hull against corrosion, fig. 1. Ships age, size and navigation area all influence in choosing the right protective coating system. Throughout history there were numerous methods of protective coatings, but modern coating are more and more quality and eco-friendly. Surface preparation, environmental conditions and correct application of quality coating are equaly important in antifouling technology. Corrosion damage can allow major problems on the ship's structure, which, in addition to material damage, can also reach human victims, environmental problems and the like. Corrosion protection if carried out technologically correctly, significantly affects the extension of ship's lifetime. The most widely used method for protecting steel is application of coatings, but other methods such as cathodic protection are also applied.

Protection of ship's hull

Construction materials are expected to have excellent mechanical properties and workability properties at the lowest possible price, while at the same time ensure corrosion resistance. These properties, except in the case of use high-corrosion-resistant materials such as stainless steels and nickel alloys in practical application, can rarely be met by the construction material itself. Due to its good strength properties, steel is the dominant construction material for shipbuilding [1]. It is a

metal of heterogeneous composition which, in its microscopic particles, generates a galvanic cell by the influence of water (moisture) and oxygen from the air.

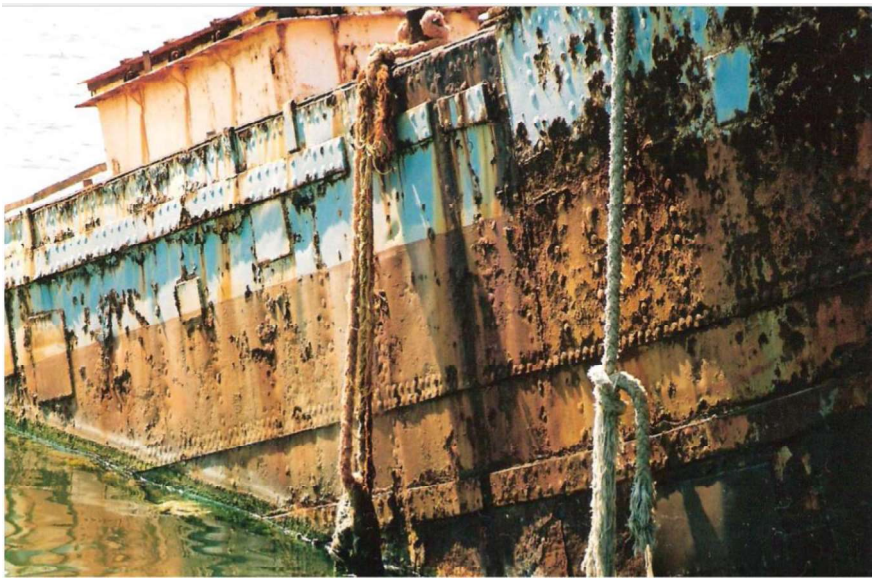

Figure 1. *Corrosion of ship's hull*

Corrosion is the gradual deterioration of a material or its properties through a chemical reaction with its environment. Therefore, different corrosion protection methods/technologies are applied. Cathodic protection and coatings are very popular methods for corrosion protection. Each individual method has its own benefits and drawbacks, whereas experience has shown that the most effective method of corrosion prevention is a combination of both cathodic protection and coatings. This combination can provide very good protection over a long period of time. An illustration of the influence of using cathodic protection (CP) as a support for the coating is shown in fig. 2.

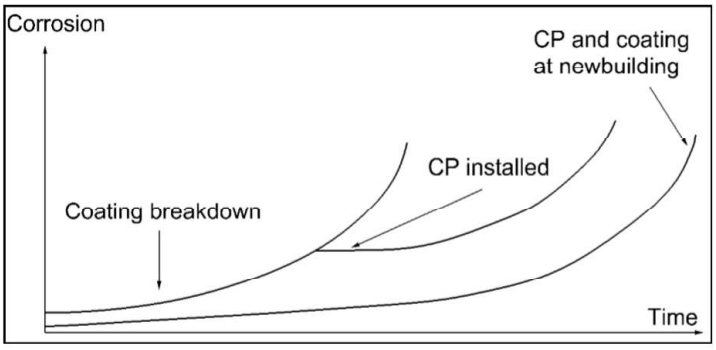

Figure 2. *Corrosion vs. time curves in different corrosion protection technologies [2]*

The most common technology for corrosion protection of ship's hull is coating protection. The application of protective coatings is probably one of the oldest and most universal methods of corrosion protection. The characteristics of this method are simplicity and speed of application and relatively low cost. When performing protection, it is important to prepare the surface properly, apply the coating correctly, and ensure good working conditions (lighting, surface availability, ventilation) with an appropriate microclimate (ambient temperature, relative humidity). Protective coatings from the group of organic coatings are most often used in shipbuilding, fig. 3.

Figure 3. *Corrosion protection with coatings*

The correct choice of painting method greatly affects the overall protection of surfaces both the speed of protection and the quality of the performed operation.
The following coating methods are most commonly used in shipbuilding [3]:

- brush application (brush application is a relatively slow method and is generally used for the coating of small complicated or complex areas or where the need for 'clean' working with no overspray precludes the use of spray application. Brushes are also used for applying surface tolerant primers, where good penetration of rusty steel surfaces can be achieved with operator persistence. Brushes are a commonly used method for "touch up" of coatings during service)
- roller application (application by roller is faster than with a brush on large, flat surfaces, such as walkways and deck areas, but it is not so good for complex shapes [3]. It is hard to control film thickness and high film build is generally attained by applying multiple coats. The correct choice of roller pile is dependent on the type of coating and the roughness and irregularity of the surface being coated and is essential for a good finish, fig.4.)

Figure 4. *Application by roller*

- conventional spray (this is a method commonly used for applying zinc silicates to large surfaces. The equipment is relatively simple and inexpensive and is usually confined to fairly low-viscosity paints. Paint under pressure and air are fed separately to the spray gun and mixed at the nozzle. The paint is atomized and air is mixed with these droplets forming a fine mist of paint which is carried by the air pressure to the work surface)

- airless spray (this is the method that is most common in shipbuilding because it allows rapid application of paint on wide surfaces, very high performance and the ability to apply thicker layers, good penetration [4]; compared to conventional spray methods, overspray and bounce back are reduced, fig. 5)

Figure 5. *Airless spray application of paint onto the vessel's topsides*

Cathodic protection, along with coating protection is the most common method of corrosion protection in shipbuilding. It gives the best results in combination with coating systems, where the protective coating layer separates the material from the environment, and the cathodic protection changes the external damaging factors by reducing the moving force of the damage. The cathodic protection system is the most widely used method of protecting a material from corrosion, aside from coatings, in a marine environment [5]. Today, many ships and offshore platforms are protected from corrosion by the aid of a cathodic protection system. Cathodic protection may be used as a single protection method, or it may be used in conjunction with other protective systems. The specific combination of cathodic protection and coatings can be regarded as the most effective way of corrosion prevention from both practical and economical aspects [6].
Cathodic protection is defined as the reduction or removal of corrosion of metal structures, and is achieved by making the structure electrically negative in relation to the corrosive medium, ie. to make it a cathode. The second electrode in the circuit becomes electrically positive and represents the counter electrode-anode.
There are two cathodic protection techniques:

- cathodic protection with sacrificial anodes
- impressed current cathodic protection

Sacrificial anodes

Cathodic protection using sacrificial anodes produces a decrease in the potential of the ship by connecting the vessel to a metal which takes up a reversible potential of less than –850mV and allowing the sacrificial metal to produce the electrons rather than the corrosion reaction of the steel [4,7]. Common choices for the sacrificial anodes are zinc, aluminum and their alloys. Both zinc and aluminum produce potentials of less than -1000mV (SCE). Aluminum has to be alloyed with other metals such as tin in order to make it corrode freely in service, fig. 6.
In addition to protection via an electrochemical potential change, sacrificial anodes also protect by forcing the cathodic reaction to occur on the steel.

Figure 6. *Cathodic protection using sacrificial anodes (zinc)*

Impressed current cathodic protection

On exterior hulls, it is also possible to use an Impressed Current Cathodic Protection system in the same way that coupling mild steel to zinc results in a flow of electrons to the mild steel to prevent metal loss. In the Current Cathodic Protection system, an auxiliary anode made from a non-consumable material, such as platinized titanium or mixed metal oxides, replaces the zinc or aluminum anode of the sacrificial system [4].

A reference electrode is also required to monitor the polarization voltage produced on the hull by the current flowing from the anode. It allows feedback control in the voltage rectifier that is used to produce the current, as shown in fig.7.

Figure 7. *An example of a zinc reference electrode on a ship's hull*

Conclusion

Despite the great damage that occurs as a result of corrosion, corrosion protection is still not given much importance. This is evidenced by the large number of accidents caused by corrosion destruction. Hull corrosion protection is a big part of ship maintenance. Anti-corrosion coatings represent a barrier between the metal hull of the ship and the sea.

The application of corrosion protection technology ensures the ship's ability to perform its function for many years. The planned durability and functionality of the ship are achieved through the proper use of modern corrosion protection technologies.

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