

Corrosion Never Sleeps- An Overview of Cathodic Protection in Pipes and Ships

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ABSTRACT:

This paper reviews the recent research and development in the area of corrosion management, cathodic protection in particular related to safety and reliability of ship structures. Corrosion is naturally occurring phenomenon commonly defined as the deterioration of a metallic substance or its properties because of a reaction with its environment. This corrosion can cause extremely dangerous and expensive damage to everything from automobiles, ships, home appliances and drinking water systems to pipelines, bridges and public buildings however this monster can be controlled by expending some bucks. The most commonly used methods for corrosion prevention include organic and metallic preventive coatings, corrosion resistant alloys, plastics and polymers, corrosion inhibitors and cathodic protection – a technique ships and offshore structures that creates an electrochemical shell in which the surface to be protected is cathode and corrosion reactions are mitigated. In conventional electrical theory current is considered to flow from anode to cathode and hence if in a structure current enters to the surface from the electrolyte (sea water) it gets protected from the metallic erosion. Conversely accelerated corrosion occurs if current passes from the metal to electrolyte (sea water).

Keywords: Cathodic protection, ships and offshore structures

INTRODUCTION

Effective corrosion control in hull structure is one of the most important features for the shipping industry to ensure reliability and minimize risk and major removal of hull structure [1]. The problem of hull corrosion has become a great concern for ship owners as they have increasingly recognized the need to protect their investment and demonstrate a commitment to safeguard the structural integrity of ships. Corrosion is an electrochemical process in which a current leaves a structure at the anode site, passes through an electrolyte, and re-enters the structure at the cathode site. For example, one small section of a pipeline may be anodic (positively charged) because it is in a soil with low resistivity compared to the rest of the line [2]. Current would leave the pipeline at that anode site, pass through the soil, and re-enter the pipeline at a cathode (negatively charged) site. Current flows because of a potential difference between the anode and cathode. That is, the anode potential is more negative than the cathode potential, and this difference is the driving force for the corrosion current. The total system – anode, cathode, electrolyte, and metallic connection between anode and cathode is termed a *corrosion cell* [3].

Cathodic Protection - Cathodic protection is a method to reduce corrosion by minimizing the difference in potential between anode and cathode. This is achieved by applying a current to the structure to be protected (such as a pipeline) from some outside source. When enough current is

applied, the whole structure will be at one potential; thus, anode and cathode sites will not exist. Cathodic protection is commonly used on many types of structures, such as pipelines, underground storage tanks, locks, and ship hulls [5].

TYPES OF CATHODIC PROTECTION SYSTEMS

There are two main types of cathodic protection systems: 1) Galvanic (or sacrificial anode) cathodic protection (SACP) and 2) Impressed current cathodic protection (ICCP). Figure 1 shows these two types. Note that both types have anodes (from which current flows into the electrolyte), a continuous electrolyte from the anode to the protected structure, and an external metallic connection (wire). These items are essential for all cathodic protection systems [4].

Cathodic protection has been widely used for protecting structures from corrosion. The design of cathodic Protection systems normally relies on a combination of experience, experimental data. However, problems and failures of cathodic protection systems not only have an economic cost; it can also present a threat to life and the environment.

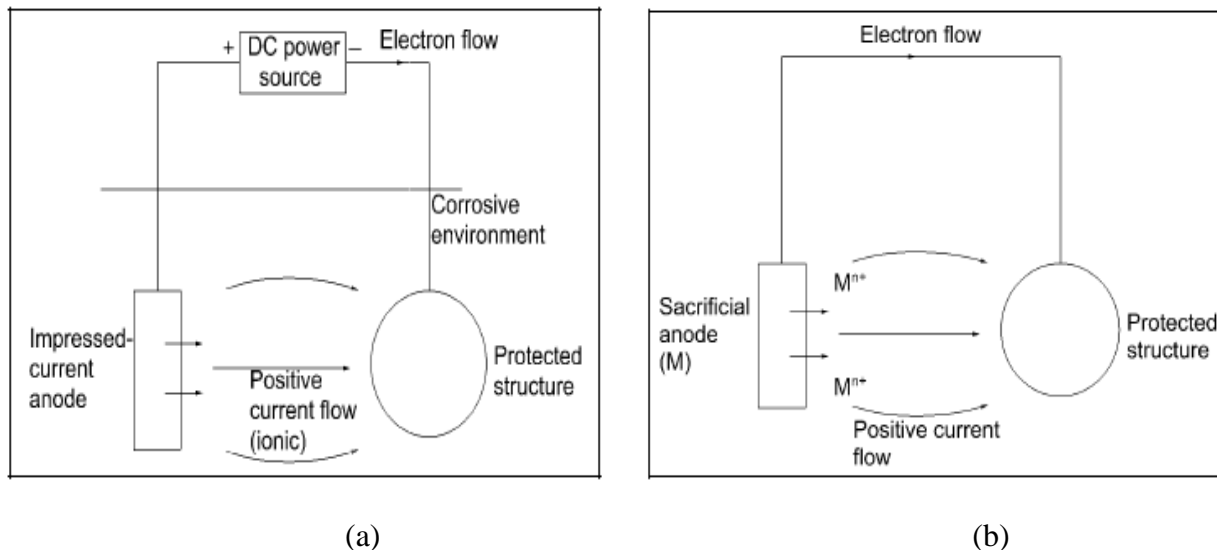


Fig 1: Schematic figure of; (a) ICCP, (b) SACP

There are two types of cathodic protection in use today, passive and active, the former depending on the use of “sacrificial anodes” which are attached to the ship’s hull, or inside ballast, providing the positive electrodes in an electrolytic process that protects the structure in its vicinity, which forms the cathode or negative electrode [8]. Gradually, the effect of sea water “sacrifices” the anodes, which are made of magnesium alloys, zinc or aluminium, rather than the structure itself, which remains protected as long as the anodes remain intact and doing their job.

Corrosion in aqueous solutions proceeds by an electrochemical process as shown in figure 2 (a) and (b), and anodic and cathodic electrochemical reactions must occur simultaneously [9].

PRINCIPLE OF CATHODIC PROTECTION

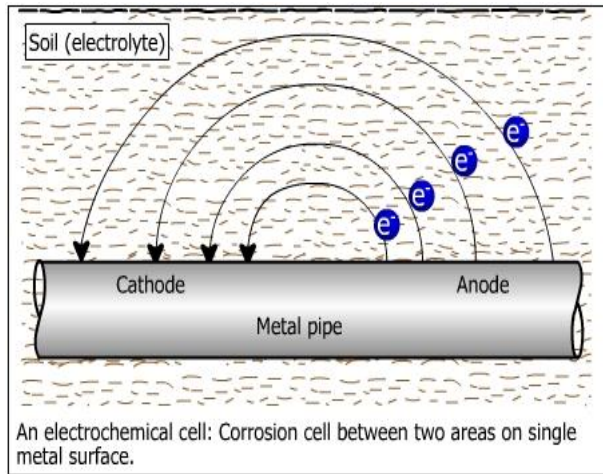


Fig 2. a Cathodic Protection Flow in pipes

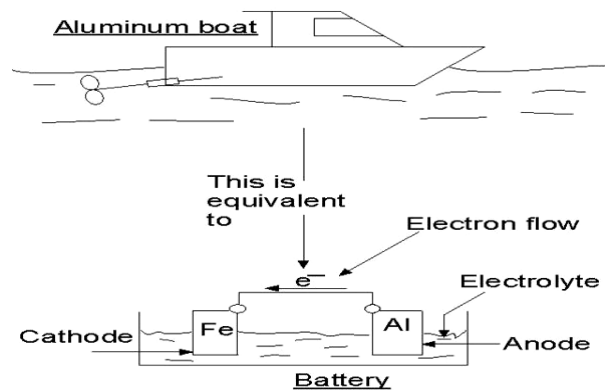


Fig 2.b: Cathodic Protection Flow in ships

No net overall charge builds up on the metal as a result of corrosion since the rate of the anodic and cathodic reactions are equal.

Anodic reactions involve oxidation of metal to its ions, e.g. for steel the following reaction occurs[12].



The cathodic process involves reduction and several reactions are possible. In acidic water, where hydrogen ions (H^+) are plentiful, the following reaction occurs.



In alkaline solutions, where hydrogen ions are rare, the reduction of water will occur to yield alkali and hydrogen.



However, unless the water is deaerated reduction of oxygen is the most likely process, again producing alkali at the surface of the metal.



SACRIFICIAL ANODE CATHODIC PROTECTION (SACP) SYSTEM

A sacrificial anode can be described as a metal which itself corrodes instead of another anode (metal). Sacrificial anodes are pure zinc, magnesium or aluminum. These anodes must be electrically connected to the surface to be cathodically protected and must be in contact with the conducting environment [10]. A voltage can be measured between the sacrificial anode and metal to be protected. Sacrificial anode system is used to protect the ship hull, ballast tanks, heat exchanger underground tanks and submerged pipelines network. Before a satisfactory cathodic protection design can be made using sacrificial anodes, the following information has to be

available or decided upon, 1) Information on the area of die steel work to be protected, 2) The type of coating, if any, that is to be used, 3) The length and frequency of time the steel work is in contact with the electrolyte. In ships, certain ballast tanks are only full of ballast water for certain periods of time and it is only in these periods of time that the sacrificial anodes operate, 4) The life required from the cathodic protection system, 5) The current density to be used to protect the structure has to be chosen and different situations require different current densities [11]. Figure 3 (a) and (b) describes the offshore corrosion control adopted for protecting the pipes and anode installation on ship hulls to facilitate the electrochemical reactions.



Fig 3. a: Alduco : Offshore Corrosion Control [7]

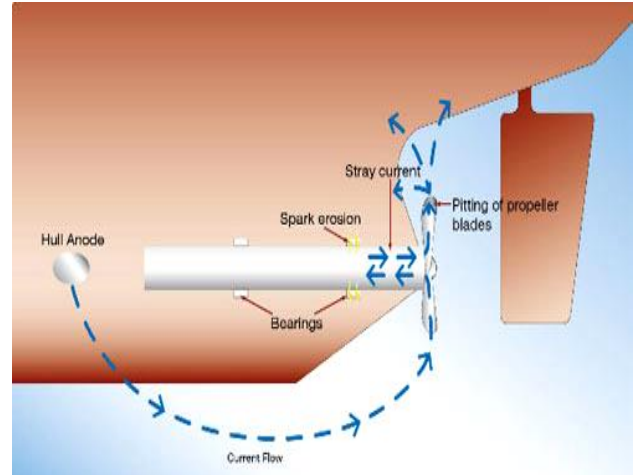


Fig 3.b: Partially corroded sacrificial anode on the hull of a ship [6]

ANODE LOCATION

All anodes are to be evenly distributed around the submerged hull near or just above bilge. Space the anodes up to 6m apart either welded or bolted to the hull and keel as each anode gives a protective radius of around 3m. Best sited on the lower curve of the hull in protected positions (from collision) and on the keel sides[6]. The anodes must be continually immersed to work. An increase in number of anodes in the stern area is recommended due to high current density demand caused by propeller. The SACP system is particularly very appropriate for internal use and complex structures since the protection of the entire structure is provided by distributing small anodes. For that reason, tanks in vessels are often protected using sacrificial anodes.

CONCLUSIONS

In this study, overview of cathodic protection methods has been executed. The two main methods are: ICCP and SACP, which has been discussed and the later one is found to be more efficient than the former. Coatings will provide the effective protection when they are used in combination with a proper CP system. The SACP system is easy to be installed and apparently very convenient for internal use such as in ballast and cargo tanks.

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