Mitigating Corrosion by Sacrificial Protection

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Abstract: **Corrosion wastes material pollutes our environment. It affects every person, business and industry, directly or indirectly. Damages on account of Corrosion can be measured in terms of monitory losses, adverse impact on human life and quality of life. Corrosion affects all industries, such as oil and gas and resources sector and almost all aspects of human activities. When Corrosion is considered across the entire value change, implementation of optimal corrosion management practices can maximize efficiency, ensure safe and environment compliant operations and reduce costs. Understanding corrosion is the first step to develop and ensure that effective mitigation policies are in place.**

Keywords: **Corrosion, Sacrificial Anode, Cathodic Protection**

Introduction

Alterations in the properties of materials caused by the environment is called corrosion. The threat from the degradation of materials in the engineered products that drive our economy, keep our citizens healthy and safe from terrorism and belligerent threats have been well documented over the years. To combat this problem number of short and long term recommendations to the Government agencies, educational institutions, industries and communities have been made to increase awareness, thereby giving the workforce the knowledge needed to deal with this menace.

Importance of corrosion studies is manifolds. The first area of significance is economic; losses are incurred by corrosion of piping, tanks, metal components of machines, ships, bridges, marine structures etc. In 1986 not so long ago, the bridge built across Mandovi River collapsed resulting in great loss which could have been prevented had the scientists and engineers worked together on it prior to its construction. The second area is improved safety of operating equipments. Examples are pressure vessels, boilers, metallic containers of radioactive materials, turbine blades and rotors, bridge cables, aero-plane components etc. Our health is affected by corrosion of body implants and cardiac pacemakers. These are subjected to attack by corrosive body fluids. Personnet et al has reported corrosion in most of the explanted body implants. For the purpose of safety, the underground cables are enveloped by a neutral ground wire called concentric neutral. This concentric neutral is subjected to corrosion by soil and also by currents induced by the alternating current in the cable. This can result in open circuit in concentric neutral and the induced current may find another path to ground such as nearby cable or pipe. This may result into an accident thus a safety hazard.

The third area is conservation. The world supply of metal resources is limited and wastage of metal includes corresponding losses of energy and water reserves associated with production and fabrication of metal structures. US Bureauof Mines have reported that at the present rate of consumption resources of chromium will be exhausted in little less than a century, whereas iron and steel in 93 years, Nickel in 53 years and mercury in next 13 years. Even if it is assumed that undiscovered resources might yield fourfold increase, the resources are available for a limited period of time.

Last but certainly not the least is the problems associated with hurdles in research and development. Development of technologies is obstructed by corrosion. Research is on to find solution to corrosion of solar cell batteries etc. And also to develop techniques and materials which could limit the corrosion of magnets, hydrodynamic energy generators to work in the environment of hot gases that drive the system.

Cathodic Protection

Much before the science of electro chemistry developed, the technique of cathodic protection was employed by SirHumphrey Davyin 1824. He reported that copper could be successfully protected from corrosion by coupling it with iron or zinc. On his recommendation, British navy shipshaving coppersheathing were protected by attaching to their hull iron blocks in the ratio of 100:1. It was observed that copper corrosion was considerably reduced. But the drawback faced was that copper which was cathodically protected started fouling due to the presence of marine organisms, which was not observed in unprotected copper. This was due to the fact that unprotected copper produced copper ions which were toxic to the organisms creating corrosion. This fouling reduced the speed of the ships, and thereby this technique was aborted. After a long gap this technique of sacrificial protection was researched and again adopted in 1950 by Canadian navy on a large scale basis. However the first patent on cathodic protection is reported in France in 1836. In recent times the use of cathodic protection has spread rapidly and now miles of buried pipelines and cables are being efficiently protected by this technique against corrosion.

In the technique of cathodic protection coupling is done of a less noble metal i.e. more electronegative metal in galvanic series with the structure to be protected. The more noble metal structure in the galvanic couple is cathodically polarized while the less noble metal is anodically dissolved. Sacrificial anodes serve as a source of electric energy. Anodes maybe madeof zinc, aluminium or magnesium are of high purity grade to avoid significant anode polarization and accumulation of insulating reaction products. A backfill is used for packaging consisting of 75%gypsum, 20%betonite and 5%sodium sulphate. The backfill used absorbs corrosion products from soil and water which keeps the anode active. Sacrificial anodes provide their own power and do not require an outside power source, hence are low maintenance. Few of the points to be noted for selection of sacrificial anodes are listed here:

A) The potential between the anode and the corroding structure must be large so that the formation of anode cathode cell on corroding structure is overcome.

B) The polarization of anode should be under control when current is drawn.

C) The current produced by metal dissolution must easily available for cathodic protection so that high anode efficiency is maintained.

Magnesium and zinc are readily used as anodes for cathodic protection. The corrosion potential difference of magnesium in coupling with steel is approximately 1V which limits the length of the structure under protection. Due to the economic considerations, use of aluminium and its alloys have come up. But it was observed current output is decreased as aluminium passivates easily. To avoid this passivation of aluminium, it is alloyed with tin, indium, gallium or mercury.

Design consideration for buried pipelines and other marine structures is very important and needs a lot of deliberations. For designing this system, knowledge and awareness is must about if the system should have sacrificial anode or an impressed current passed or mixture of the two systems. Sacrificial systems are preferred as they are easy to install, do not require any source of electricity, are suited for localized protection and do not cause interaction on neighboring structures. The limitation of sacrificial anodes is that the small driving force restricts its use to conductive environments or well coated systems. To protect a large system in a linear way e.g. pipelines etc it can provide protection to large even with sacrificial anodes, number of these would be required to be distributed along it and also would need multiplicity of electrical connections and considerable installation work.

The benefits of impressed current system are that it can provide protection to large even uncoated structuresin high resistivity environments because of large driving force; moreover the number of electrodes needed are less. Also added advantage is that voltage can be adjusted to allow for environmental and coating changes. The impressed current system allows considerable overprotection, but at the same time considerable variation of potential over the structure is unavoidable.

Casting of sacrificial anodes is usually done in three basic shapes -.a) long slender stand-off type, b) Flush mount type which are like flat plates and c) Bracelet type. The selection is done based on the usage and considering factors like sea current drag and sub-sea interventions, net anode mass to be installed, available space for installation of anode etc. The correct choice of anode affects anode utilization factor and anode current output obtained is better. For offshore structures usually long slender type or circular cross-section shapes of anodes are used. The main benefit of long slender type of anode is high current output and good current distribution for a given mass, if flush anode having the same mass is used it results in low anode current output n also lower utilization factor. Fabrication and casting of long slender anodes is simpler than other two. Recent innovation for stand- off anodes is to put the anode in sled which is a steel frame and then to connect it with a special clamp to steel structure. Net anode mass of hundreds of kilograms are used as drag force of ocean currents is high. Formerlybracelet anodes were used pipeline protection, later also put in use in the upper zone of platform legs to obtain a high current output to weight ratio combined with low drag .For flush mounted anodes a suitable coating needs to be applied on the surface facing the projection structure. This is done to avoid building up of anode corrosion products that could cause further corrosion and may also fracture anode’s fastening devices.Bracelet type anode structures are better suited for submarine pipelines as wrap around construction is feasible. These are also sometimes used in retrofitting on used structures.

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