Sacrificial Anode

Sacrificial Anodes are highly active metals that are used to prevent a less active material surface from corroding. Sacrificial Anodes are created from a metal alloy with a more negative electrochemical potential than the other metal it will be used to protect. The sacrificial anode will be consumed in place of the metal it is protecting, which is why it is referred to as a "sacrificial" anode.

Cathode Protection

When metal surfaces come into contact with electrolytes, they undergo an electrochemical reaction known as corrosion. Corrosion is the process of returning a metal to its natural state as an ore and in this process, causing the metal to disintegrate and its structure to grow weak. These metal surfaces are used all around us -- from pipelines to buildings to ships. It is important to ensure that these metals last as long as they can and thus necessitates what is known as cathode protection.

Sacrificial anodes are among several forms of cathode protection. Other forms of cathode protection are plating, galvanization, and the formation of alloys.

Metal in seawater is one such example with the iron metal coming into contact with electrolytes. Under normal circumstances, the iron metal would react with the electrolytes and begin to corrode, growing weaker in structure and disintegrating. The addition of zinc, a sacrificial anode, would prevent the iron metal from "corroding". According to the table of Standard Reduction Potentials, the standard reduction potential of zinc is about -0.76 volts. The standard reduction potential of iron is about -0.44 volts. This difference in reduction potential means that Zinc would oxidize much faster than iron would. In fact, zinc would oxidize completely before iron would begin to react.

What materials are used for sacrificial anodes?

The materials used for sacrificial anodes are either relatively pure active metals, such as zinc or magnesium, or are magnesium or aluminum alloys that have been specifically developed for use as sacrificial anodes. In applications where the anodes are buried, a special backfill material surrounds the anode in order to insure that the anode will produce the desired output.

Since the sacrificial anode works by introducing another metal surface with a more negative electronegative and much more anodic surface. The current will flow from the newly introduced anode and the protected metal becomes cathodic creating a galvanic cell. The oxidation reactions are transferred from the metal surface to the galvanic anode and will be sacrificed in favor of the protected metal structure.

Figure 1. Partially corroded sacrificial anode on the hull of a ship. Figures courtesy of Wikipedia

How are sacrificial anodes put on?

Sacrificial anodes are normally supplied with either lead wires or cast-m straps to facilitate their connection to the structure being protected. The lead wires may be attached to the structure by welding or mechanical connections. These should have a low resistance and should be insulated to prevent increased resistance or damage due to corrosion. When anodes with cast-in straps are used, the straps can either be welded directly to the structure or the straps can be used as locations for attachment.

A low resistance mechanically adequate attachment is required for good protection and resistance to mechanical damage. In the process of providing electrons for the cathodic protection of a less active metal the more active metal corrodes. The more active metal (anode) is sacrificed to protect the less active metal (cathode). The amount of corrosion depends on the metal being used as an anode but is directly proportional to the amount of current supplied.

Applications

Sacrificial Anodes are used to protect the hulls of ships, water heaters, pipelines, distribution systems, above-ground tanks, underground tanks, and refineries. The anodes in sacrificial anode cathodic protection systems must be periodically inspected and replaced when consumed.

References

1. "Corrosion Control" NAVFAC MO-307 September 1992
2. Petrucci, Ralph H., William S. Harwood, Geoffrey Herring, and Jeffry D. Madura. *General Chemistry: Principles & Modern Applications.* Ninth ed. Upper Saddle River, N.J.: Pearson Education, 2007. 848. Print.

Problems

1. What are the purposes of using sacrificial anodes?
2. How do sacrificial anodes function?
3. What other forms of cathode protection?
4. What different metals can be used as sacrificial anodes? (name three)

Answers

1. Sacrificial anodes are used to protect metal structures from corroding.
2. Sacrificial anodes work by oxidizing more quickly than the metal it is protecting, being consumed completely before the other metal reacts with the electrolytes.
3. Several different forms of cathode protection are forming alloys, plating, and galvanizing the metal.
4. Three metals that can be used as sacrificial anodes are zinc, aluminum, and magnesium.

Source: http://chemwiki.ucdavis.edu/Analytical_Chemistry/Electrochemistry/Case_Studies/Corrosion/Sacrificial_Anode