**The Eurasia Proceedings of Science, Technology,
Engineering & Mathematics (EPSTEM)
ISSN: 2602-3199**

The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM), 2018

Volume 4, Pages 259-262

IConTES 2018: International Conference on Technology, Engineering and Science

Galvanic Corrosion

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Abstract: Corrosion can be defined as the deteoration of metals and alloys due to a interaction with their environments. There are several types of corrosion such as general corrosion , galvanic corrosion, pitting corrosion, intergranular corrosion, atmospheric corrosion. Galvanic corrosion, also known as bimetallic corrosion, is an electrochemical process which occurs when two different metals are immersed in electrolytic solution due the difference of electrode potentials of dissimilar metals. One of the metals is anode and other is cathode in the couple. Metals and alloys have different electrode potentials. The less noble metal is anode tends to corrode faster than cathode. The electrolyte acts as a conductive noble metal is protected. Several factors affect galvanic corrosion rate, such as potential difference between metals, cathode efficiency, surface areas of the connected metals , electric resistance difference of the connected metals and electrolyte. When a metal is in contact with a metal which is close in galvanic series. For example, zinc aluminum couple shows 300mV potential in sodium chloride solution whereas zinc copper couple indicates 700 mV. The greater the potential difference, the greater the power to conduct galvanic corrosion.

Keywords: Alkaline, Media

Definition of Galvanic Corrosion

Galvanic corrosion, called also bimetallic corrosion occurs when two different metals immerse in the same electrolytic solution. For example when zinc (Zn) is immersed in copper sulphate ($CuSO_4$) solution, Fig.1a. Zn dissolves and its mass decreases. Copper ions (Cu^{+2}) reduce to metallic copper. Fig.1.b

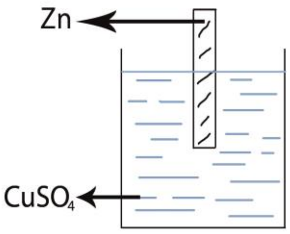


Figure 1.a. Zn is immersed in CuSO$_4$

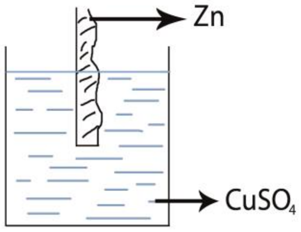


Figure1.b. Zn dissolves and its mass decreases

Anodic, cathodic and total reactions are as follows:

Anodic reaction : $Zn_{(s)} \longrightarrow Zn^{2+}_{(aq)} + 2e^-$

Cathodic reaction : $Cu^{2+}_{(aq)} + 2\,e^- \longrightarrow Cu_{(s)}$

Total reaction: $Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$

The resulting Cu forms a porous layer on the Zn surface. As the experiment progresses, there remains porous Cu piece and ZnSO4. This is the exchange of Zn with Cu. Another example can be seen in Figure 2. The formation mechanism of galvanic corrosion is as follows [1].

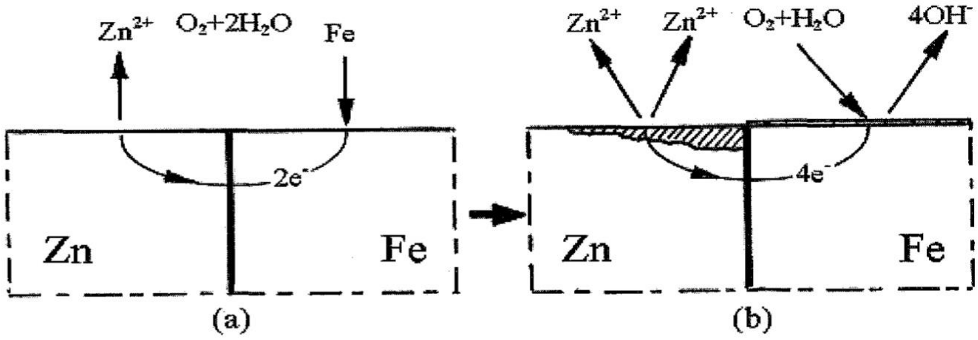


Figure 2.a. Short term start level Figure 2.b. Continuos situation

The Factors Which Determine the Rate of Galvanic Corrosion

1. Electromotor force (EMF) for corrosion reaction,
2. The variation of anode and cathode polarizations with time,
3. The dependence of polarization on current density,
4. The difference between the polarization of metals,
5. The magnitude of cathode,

If these effects are examined sequentially;
1. A chart based on the experiments is used in examining the galvanic effects. In this chart, galvanic effects of many metals and alloys are given in skudded sea water. If any two metals are joined together with a conductor, the metal that is close to the top of the chart becomes the anode and is rapidly corroded. The metal that is close to the bottom of the chart is the cathode and is galvanically protected. Magnesium (Mg) which is at the top of the chart is the most active metal, and when combined with a metal below itself, Mg is galvanically corroded. The electrical potential difference between the two metals is an important factor that affects the rate of galvanic corrosion. When a metal is in contact with a metal that is close to it in the chart, it is subject to slower corrosion than a metal that is far from it. For example, a Zn-Al pair in a sodium chloride solution exhibits a potential of 300 mV, while a Zn-Cu pair in the same solution has a potential above 700 mV. The larger the potential, the faster the galvanic corrosion.

2. As the galvanic corrosion reaction progresses, corrosion products are generally deposited at the anode and hydrogen is released at the cathode, and this causes a decrease by changing the initial potential. The potential of anode shifts toward cathode, and the potential of anode shifts toward the anode. This potential change is called polarization. If polarization is on the anode it is called as anodic polarization; if polarization is on the cathode it is called as cathodic polarization.Fig 3.

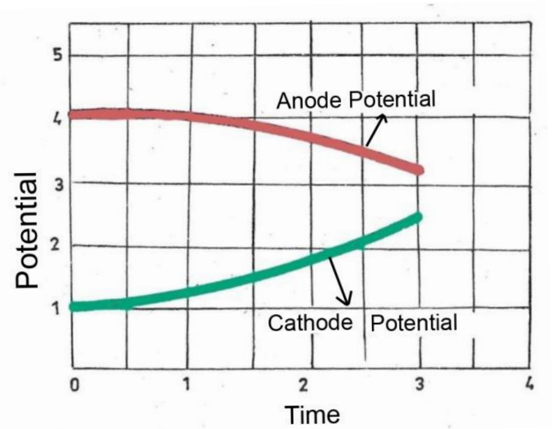


Figure 3.The variation of anode and cathode potentials with time

3. The potential change, called polarization, is not only a function of current magnitude but also a function of current density.

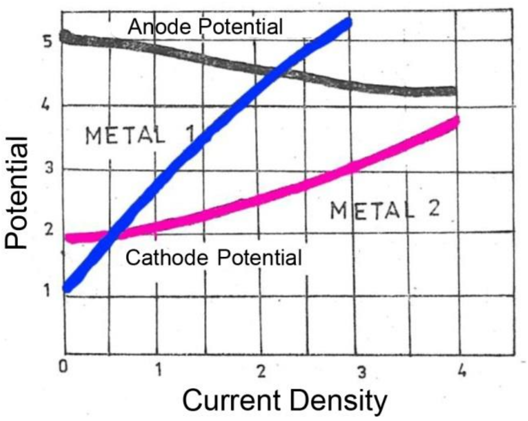


Figure 4. The variation of anode and cathode potentials with current density

When Fig. 4 is examined, the cathodic polarizations of 1 and 2 metals increase as the density increases, but this increase is more in metal 1. The galvanic corrosion rate is determined by the current density corresponding to the intersection point of the anode and cathode polarization curves. At the figure above, the intersection point of galvanic corrosion for metal 1 is smaller than that of metal 2, thus its corrosion rate is less [2].

4. Depending on the polarization, an oxidation at the anode and a reduction and hydrogen accumulation at the cathode can occur. Cathodic reactions do not occur on all metals with the same ease [4]. As a result, some metals are more easily polarized than the others. In order to be able to make an estimate of the galvanic corrosion of a metal pair. In this condition metal ion which has a high concentration the side of metal is called as cathode, respectively metal ion which has low concentration the side of metal is called as anode . The current flows between these two regions anode side is corroded. Two cups are separated by porous walls. One of them is filled by concentrated $CuSO_4$ and the other is filled by diluted $CuSO_4$. If we immerse Cu electrodes in both of them. There will be 50 mV potential difference and about 400 μA current is observed between these two electrodes. This condition is given in Fig. 4. In the left side of the cup, Cu electrode is cathode and other Cu electrode is anode (the right Cu electrode). In the anode side Cu electrode dissolves and in the cathode side Cu electrode reduces.

Anodic reaction: $Cu \longrightarrow Cu^{2+} + 2e^-$ (in low $CuSO_4$ concentration)
Cathodic reaction: $Cu^{2+} + 2e^- \longrightarrow Cu$ (in high $CuSO_4$ concentration)

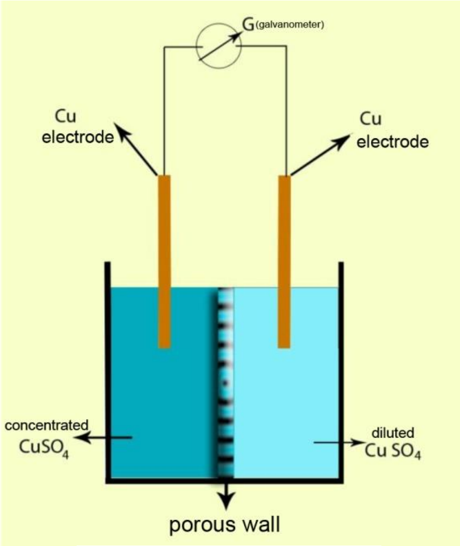
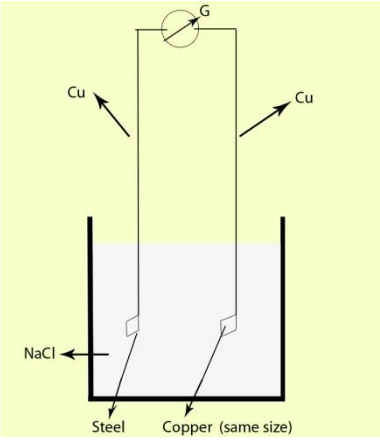


Figure 5. Two Cu electrodes

One of them is immersed in concentrated $CuSO_{4.}$ The other of them is immersed in diluted $CuSO_{4.}$

5. The size of the cathode also affects the corrosion rate. If copper and steel electrodes of the same size are immersed in one of the two beakers with the same salt solution, and a copper plate of 5 times larger than the steel anode into the other beaker, and if both of them is exposed to oxygen, it is observed that a larger current

flows through the cell, which is has a larger cathode. This is due to more current is needed to provide the same current density at the larger cathode. This situation is seen in Fig. 6a and 6b.



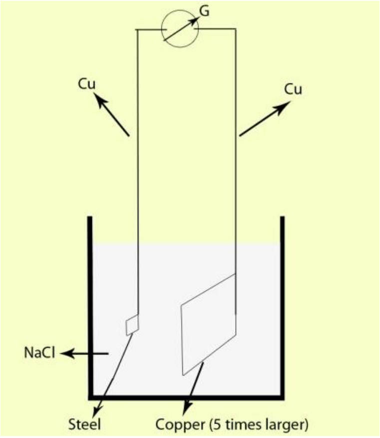


Figure 6.a. Steel and copper foils have the same size   Fig. 6.b. Steel and 5 times larger copper foil

The current to polarize smaller cathode is small. Accordingly, larger cathode is more dangerous than the anode. Therefore, the corrosion of the steel is also small. A cell structure just like between two metals can also be formed on a single metal surface. There could be a potential difference between two points of the same metal surface, and this potential difference causes galvanic corrosion. Potential differences may occur on the same surface due to irregular impurities present on the surface, the defect of crystal structure, local tension and the adjacent environment. In this case there is a local influence.

Prevention of Galvanic Corrosion

To prevent or at least reduce galvanic corrosion, various measures can be taken. They can be listed as follows:

i. The use of metals and alloys which are far from each other in the galvanic series should be avoided to as possible.
ii. Care should be taken when pairing metals and alloys that those with small surface area should be more noble (inert).
iii. Combining the more active metal in the galvanic pair can reduce or even stop the galvanic activity. In this case, more noble metallic parts of the system are protected against corrosion.
iv. The corroded parts of the galvanic pairs should be designed with greater corrosion rate (rust rate) than the other parts.
v. The corrosion rate can be slowed down by the addition of inhibitors into the medium and by surface coatings.

References

Deshipande, Be Kiran, (2010). *Corros Sci*, 52 p.2819.
Doruk, M., (2014). *Metalik Malzemeler ve Korozyon* 1. Baskı Korozyon Derneği, Ankara
Erbil, M., (2012). *Korozyon: İlkeler ve Önlemler* 1. Baskı Korozyon Derneği
Üneri, S., (2011). *Korozyon ve Önlenmesi* 3. Baskı, Korozyon Derneği

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