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Assignment 3.

1) Define corrosion & explain cathode protection method to minimize the rate of corrosion.

→ a) Corrosion : i) Corrosion is the destruction of metal of alloy by chemical or electrochemical reaction with its environment.

ii) Corrosion is natural and electrochemical process.

iii) It leads to lost, it can't be eliminated but can be minimized.

b) Cathode Protection : i) Cathodic protection is also called as electrical protection method.

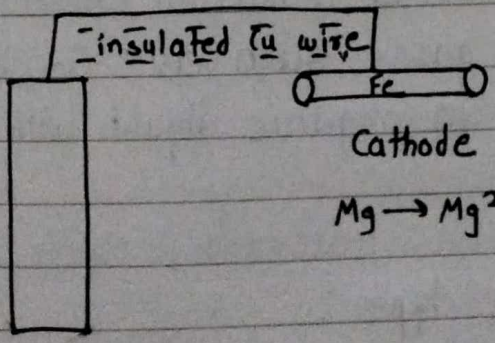
ii) Principles of Cathod protection:

① The principle envolved in this method is to force the metal to be protected to behave like cathode.

② Thereby, corrosion doesn't.

③ It can be done by 2 methods.

a) Sacrificial Anodic Protection



b) Impress Current Cathodic protection method :-

i) The flow of electron takes place from anode → cathode and the flow of current takes place from cathode → anode.

ii) Anode is forced to act as cathode by applying externa current source i.e. D.C. current.

iii) It help to prevent the corrosion of underground pipelines, tanks, vessels in the oil and gas industries. Due to oxidation of metal, which is loosing electron and metal get corrode.

iv) Positive supply is connected to anode and negative supply is connected to protective structure. Due to voltage difference, positive current flows from anode to cathode then the metal structure completely act like -ve charged cathode & due to that it will not get corrode.

2) Discuss direct corrosion (dry corrosion) due to oxygen.

→ Dry corrosion is known as direct chemical corrosion or direct chemical attack. This type of corrosion occurs mainly through the direct chemical action of environment in the dry state, atmospheric gases such as O_2, H_2, halogen H_2S, SO_2, etc on unhydrous in organic liquid with metal surface.

Dry corrosion are of three types:

① Liquid Metal Corrosion : (i) When liquid metal allow to flow ove solid metal at high temperature corrosion occurs & it is known a liquid metal corrosion

(ii) It leads weakning the solid metal
a) Its dissolution in liquid metal
b) Penetration of liquid metal into solid metal ex. sodium metal leads to corrosion to cadmium in nuclear reactor.

(2) Corrosion by Other Gases : (i) Some gases like Cl_2, H_2S, CO_2, etc. have corrosive effect on metal which depends mainly on the chemical affinity between metal and gas.
(ii) The degree of attack depends on the formation of protective and non-protective layers on metal surface.
(iii) Ex. (1) If the layer is formed is protective or non porous, the intensity of attack decreases because the layer from protect the metal from further attack.
(2) If the layer is non protective or porous, the surface of metal is gradully destroyed.

(3) Oxidation Corrosion : i) Oxidation Corrosion is brought about by the action of oxygen at low or high temp on metal in absence of moisture
ii) Alkaline metal : Li, Na, K, Rb, Fr
Alkaline earth metal : Be, Mg, Ca, Sr, Ba, etc are oxidised rapidly at low temp where as all metal except Au, Ag, Pt oxidised at high temp

iii) Direct attack of oxygen on metal doesn't take place at ~~high~~ atmospheric temperature. When it does takes place, a thin film of the solid corrosion forms.

iv) When oxidation occurs, a thin layer of oxide is formed on the surface of metal. A layer is called film when its thickness is less than 300A° and its called as scale when its thickness is more than 300 A°.

3) Write note on Galvonic Corrosion.

→

① On a corrodic surface galvonic cell may be form in several base.

② The principle of there working explained by considering Danial cell. which consist of Zn & Cu plates dipping in solution having Zn^{++} & Cu^{++}.

③ The solution being separated by porous partition.

④ The plates are connected by metallic conductor, the e.m.f develop is due to 2 separate reaction taking place at electrode.

⑤ Zn atom have tendency to go into sol^n as Zn^{++} making $2e^-$ available, this is oxidation reaction.

$$Zn(s) \rightarrow Zn^{++}(aq) + 2e^-$$

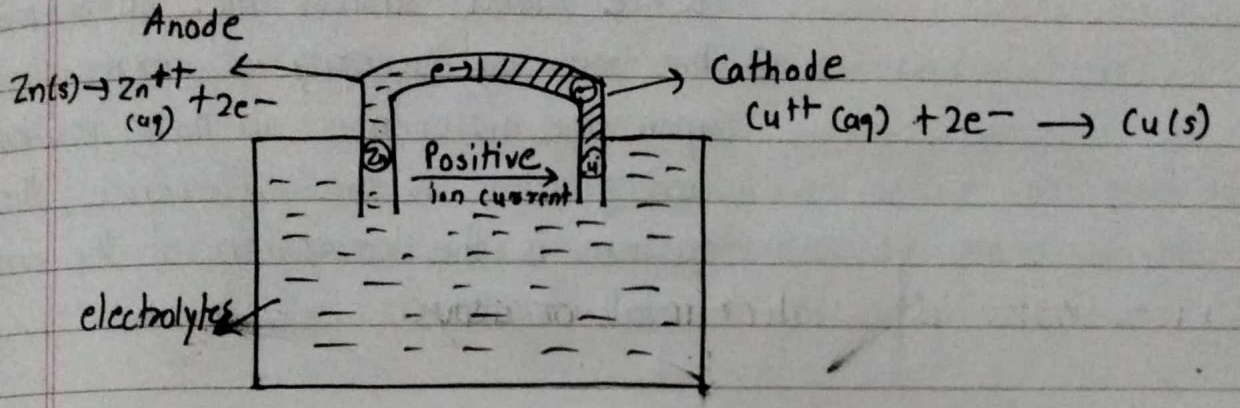
⑥ The eletrodes move along the conductor and are respons for the reduction reaction at the Cu plate.

$$Cu^{++}(aq) + 2e^{\ominus} \rightarrow Cu(s)$$

⑦ Thus, Zn dissolve and Cu is deposited. Exactly similar reaction occur in corrosion.

⑧ In this cell, zinc plate is called as anode because oxidation reaction takes place at the zinc plate. Similarly, because reduction reaction takes place at Zn/Cu plate is called cathode.

⑨ The greater is the em.f, the faster will be corrosion.



⑩ When 2 dissimilar metals like Zn & Cu are electrically connected and exposed to an electrolyte, the metal hiring electrochemical series undergoes corrosion.

⑪ In above example, Zn highering in electrochemical series forms the anode and is attacked and get dissolved, where as, Cu lowering electrochemical act as cathode.

4) Discuss factors which influence the corrosion rate in detail.

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i) There are many factors which affects the rate of corrosion, it can be nature of metal either nature of environment.

ii) Physical State of the metal: ① The smaller the grain size of metal or alloy, the greater will be the solubility and hence greater will be its corrosion.

iii) Purity of metal : ① Pure metals are generally corrosion resistant.
② Lesser is the percentage purity of a metal, faster is the rate of corrosion.

iv) Position in Galvonic Series : ① When two metals are in electrical contact in the presence of an electrolyte, the more active metal suffers the corrosion
② The rate and severity of corrosion depends upon the difference in their positions and greater is the difference, the faster is the corrosion of the anodic metal or alloy.

v) Volatility of corrosion product : ① If the corrosion volume is more volatile, then metal surface is exposed for further attack. i.e corrosion rate will be more.

vi) pH : ① Acidic media are generally more corrosive than alkaline & neutral
② The amphoteric metals such as Al, Zd, Pb, etc in alkaline solution
③ The corrosion rate of Fe in oxygen free water is slow, until pH is below 5.
④ Zn is rapidly corroded, even in weakly acidic sol^n such as carbonic acid suffers minimum corrosion at pH = 11.

vii) Temperature : ① With increase of temperature of environment the reaction as well as diffusion rate increases, thereby corrosion rate is generally increased.

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5) State & explain pilling bed worth rule :

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a) Pilling Bed Worth Rule : The ratio of the volume of oxide to the volume of metal consumed is known as Pilling Bed Worth Rule.

b) i) $PBR = \frac{\text{Volume of metal oxide}}{\text{Volume of metal consumed.}}$

ii) According to this rule, we can define an oxide is protective (non-porus) or non-protective by means of the volume of the oxide

iii) Oxide layer will be porous when
Volume of oxide < volume of metal consumed

iv) Oxide layer will be non-porous when
Volume of oxide > volume of metal consumed

v) For example, alkali and alkaline earth metals on oxidation produce oxide deposits of smaller volume than the respective metals from which they were ~~found~~ formed, this result in the formation of porous layer through which oxygen can diffuse to bring about further attack on the metal, thus corrosion continues non-stop.

vi) In case of heavy metals like Al form oxides of greater volume than the metal from which they were produced. These non-porous continuous oxide films prevent the diffusion of oxygen and hence the role of further attack on the metal decreases with increase in the thickness of the oxide film.

6) What is Anodic & Cathodic protection for controlling the corrosion & discuss there merits & de-merits.

→

a) Anodic Protection :

i) Anodic protection is a technique to control the corrosion of a metal surface by making it the anode of an electrochemical cell and controlling the electrode potential in a zone where the metal is passive.

ii) To anodically protect the structure, potentiostat is required
iii) Potentiostat is an electronic device that maintains a metal at a constant potential.
iv) The use of potentiostat is to shift corrosion potential into passive potential so that the corrosion of the metal is stopped.

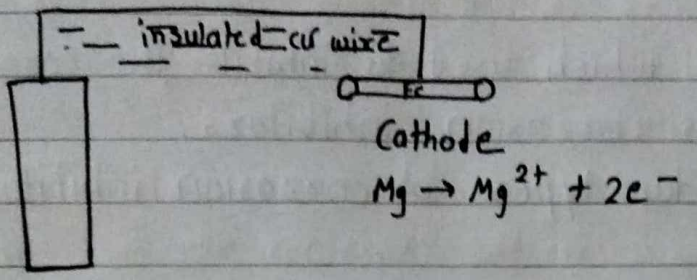
Merits : i) Protects embedded reinforcement against present and potential corrosion by means of anodes which are embedded in repair patches.
ii) No need for wiring or external equipment

Demerits : i) Monitoring is difficult and impractical.
ii) Unknown lifespan.

b) Cathodic Protection : Cathodic protection is also called as electrical protection method.
i) The principle envolved in this method is to force the metal to be protected to behave like a cathode.
ii) Thereby, corrosion doesn't occur.

iii) It can be done by 2 methods.

a) Sacrificial Anodic Protection



b) Impress Current Cathodic protection method:

- The flow of electron takes place from anode → cathode and the flow of current takes place from cathode → anode
- Anode is forced to act as cathode by applying external current source i.e. D.C. current.
- It help to prevent the corrosion of underground pipelines, tanks, vessels in the oil & gas industries. Due to oxidation of metal, which is loosing e^- and metal get corrode
- Positive supply is connected to anode and negative supply is connected to protective structure. Due to voltage difference, positive current flows from anode to cathode then the metal structure completely act like -ve charged cathode & due to that it will not get corrode.

7) Discuss any 4 method of corrosion control.

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a) By using corrosion Inhibitors :

i) The substance which used to inhibit the corrosion rate or known as corrosion inhibitors.

ii) There are two types of corrosion inhibitors :

① Cathodic Corrosion : The substance which reduce the rate of cathodic reaction is known as Cathodic corrosion inhibitors.
Ex. Na_2SO_3, Ni salts, etc.

② Anodic Corrosion : The substance which reduce the rate anodic reaction is known as Anodic Corrosion Inhibitors.
Ex. Alkalies, phosphates, molybdates, etc.

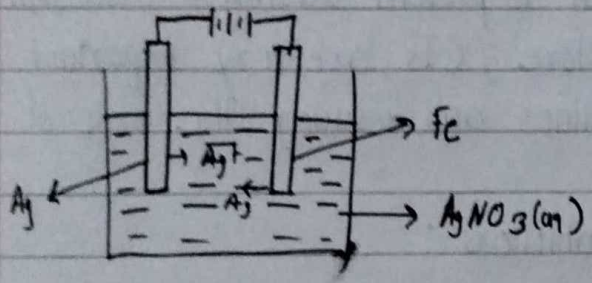
b) By Cathodic Protection : Cathodic protection is also called as electrical protection method.
The principle envolved in this method is to force the metal to be protected to behave like a cathode.
It can be done by 2 methods
a) Sacrificial Anodic Protection
b) Impress Current Cathodic protection

c) Anodic Protection Method:

i) It is applicable to metal which can be passification by deposition of oxide film.
Ex. Steel, Aluminium, Chromium, etc.

~~ii) It is applicable to metal which can~~

D) Electroplating



i) In this process, the coating metal is deposited on the base metal by passing a direct current through an electrolytic solution containing the soluble salt of the coating metal.
ii) This is the most widely used method coating and the commonly electron deposited metal include, Au, Ag, Cu, Sn, Ni, Zn, etc.

8) Discuss briefly corrosion inhibitors.

→ A chemical compound that can be added to liquids or gases and used to decrease the corrosion rate of a given material (usually a metal) can be referred to as a corrosion inhibitor. One method for the inhibition of corrosion would be the addition of a coating on surface of the metal which acts as passivation layer & disallows access to the surface of the metal.

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Uses of Corrosion Inhibitors:

Corrosion Inhibitors have a wide range of uses in commercial, process and industrial environments.

i) Corrosion Inhibitors are used to stop rusting and anodic corrosion of metals.

ii) Oxygen scavengers can be used as CIs to react with dissolved oxygen in the environment and can help in preventing cathodic corrosion.

iii) It is very important to prevent rusting & corrosion of fuel pipelines. Therefore, CIs are very important in securing these pipelines and reducing the risk of accidents.

Types of Corrosion Inhibitors:

a) Cathodic Inhibitor:

i) Cathodic inhibitors can work to slow the cathodic reaction down or they can work to selectively precipitate on cathodic regions of the metal inorder to restrict the diffusion to the metal surface of elements that are eroded.

ii) Ex. Cathodic inhibitor is a catalyzed redox reaction by nickel.

b) Anodic Inhibitor:

i) These types of corrosion inhibitors form a thin preventive oxide layer on surface of metal.

ii) This reaction leads to a big anodic shift, turning the metallic surface into a passivation area. This passivation area helps in reducing the corrosion of metal.

iii) Ex. Anodic Inhibitors include chromates, nitrates, orthophosphates & molybdates.