$$Al(OH)_3 + OH^- \longrightarrow Al(OH)_4^- + SS \qquad (1.8)$$

at the same time, water is reduced on the aluminium surface according to Volmer-Heyrovsky⁽⁷⁾ mechanism:

$$SS + H_2O + e^- \longrightarrow H_{ads} + OH^- \qquad (1.9)$$

$$H_{ads} + H_2O + e^- \longrightarrow H_2 + OH^- + SS \qquad (1.10)$$

The cathodic reaction, which occurs when aluminium corrodes in weakly alkaline solutions, has been investigated by Burstein and Liu(8).It was found that the rate of cathodic reaction occurs on aluminium electrode independent of the thickness of the passive layer during repassivation. The cathodic reaction is primarily the reduction of water to hydrogen, i.e.,

$$H_2O + e^- \longrightarrow {}^1/_2\, H_2 + OH^- \qquad (1.11)$$

The overall anodic reaction in the corrosion of aluminium in weakly alkaline solutions is

$$Al + 4\,OH^- \longrightarrow Al\,(OH)_4^- + 3\,e^- \qquad (1.12)$$

1.2- Forms of Corrosion

Almost all corrosion problems and failures encountered in service can be associated with one or more of the eight basic forms of corrosion: general corrosion, galvanic corrosion, concentration cell (crevice) corrosion, pitting corrosion, intergranular corrosion, stress corrosion cracking, dealloying, and erosion corrosion.

a. General corrosion. With general corrosion (sometimes called uniform corrosion), anodic dissolution is uniformly distributed over the entire metallic surface. The corrosion rate is nearly constant at all locations. Microscopic anodes and cathodes are continuously changing their electrochemical behavior from anode to cathode cells for a uniform attack. The general corrosion rates for metals in a wide variety of environments are known, and common practice is to select materials with rates that are acceptable for the application.

b. Galvanic corrosion. Galvanic (dissimilar metals) corrosion occurs when two electrochemically dissimilar metals are metallically connected and exposed to a corrosive environment. The less noble metal (anode) suffers accelerated attack and the more noble metal (cathode) is cathodically protected by the galvanic current.

c. Concentration-cell corrosion. Concentration-cell corrosion occurs because of differences in the environment surrounding the metal. This form of corrosion is sometimes referred to as "crevice corrosion," "gasket corrosion," and "deposit corrosion" because it commonly occurs in localized areas where small volumes of stagnant solution exist. Normal mechanical construction can create crevices at sharp corners, spot welds, lap joints, fasteners, flanged fittings, couplings, threaded joints, and tube sheet supports. At least five types of concentration cells exist; the most common are the "oxygen" and "metal ion" cells. Areas on a surface in contact with an electrolyte having a high oxygen concentration generally will be cathodic relative to those areas where less oxygen is present (oxygen cell). Areas on a surface where the electrolyte contains an appreciable quantity of the metal's ions will be cathodic compared to locations where the metal ion concentration is lower (metal ion cell).

d. Pitting corrosion. Pitting corrosion is a randomly occurring, highly localized form of attack on a metal surface, characterized by the fact that the depth of penetration is much greater than the diameter of the area affected. Pitting is one of the most destructive forms of corrosion, yet its mechanism is not completely understood. Steel and galvanized steel pipes and storage tanks are susceptible to pitting corrosion and tuberculation by many potable waters. Various grades of stainless steel are susceptible to pitting corrosion when exposed to saline environments.

e. Intergranular corrosion. Intergranular corrosion is a localized condition that occurs at, or in narrow zones immediately adjacent to, the grain boundaries of an alloy. Although a number of alloy systems are susceptible to intergranular corrosion, most problems encountered in service involve austenitic stainless steels (such as 304 and 316) and the 2000 and 7000 series aluminium alloys. Welding, stress relief annealing, improper heat treating, or overheating in service generally establish the microscopic, compositional inhomogeneities that make a material susceptible to intergranular corrosion.

f. Stress corrosion cracking. Stress corrosion cracking (environmentally induced-delayed failure) describes the phenomenon that can occur when many alloys are subjected to static, surface tensile stresses and are exposed to certain corrosive environments. Cracks are initiated and propagated by the combined effect of a surface tensile stress and the environment. When stress corrosion cracking occurs, the tensile stress involved is often much less than the yield strength of the material; the environment is usually one in which the material exhibits good resistance to general corrosion.

g. Dealloying. Dealloying is a corrosion process in which one element is preferentially removed from an alloy. This occurs without appreciable change in the size or shape of the component; but the affected area becomes weak, brittle, and porous. The two most important examples of dealloying are the preferential removal of zinc from copper-zinc alloys (dezincification), and the preferential removal of iron from gray-cast iron (graphitic corrosion). Graphitic corrosion sometimes occurs on underground cast iron water mains and leads to splitting of the pipe when the water pressure is suddenly increased.

h. Erosion corrosion. Erosion corrosion refers to the repetitive formation (a corrosion process) and destruction (a mechanical process) of the metal's protective surface film. This typically occurs in a moving liquid. Erosion may be impinging (in the case of a pipe cell) or sliding (pipe wall) when it occurs. An example is the erosion corrosion of copper water tubes in a hot, high velocity, soft water environment. Cavitation is a special form of erosion corrosion.

1.3- Corrosion Mitigation

Corrosion mitigation can be accomplished by design considerations, by employing corrosion-resistant materials of construction, by employing cathodic protection, by using protective coatings, or by using inhibitors.

a. Design considerations. The use of acceptable engineering practices to minimize corrosion is fundamental to corrosion control. This is accomplished by engineering design. One of the most important factors in designing for corrosion control is to avoid crevices where deposits of water-soluble compounds and moisture can accumulate and are not accessible for maintenance. Any region where two surfaces are loosely joined, or come into proximity, also qualifies as a crevice site. Joining geometries also present various crevice corrosion problems. Examples include: bolting, back-to-back angles, rough welds, weld spatter, sharp edges, corners, discontinuities, and intermittent welding.

b. Cathodic protection. Cathodic protection is an electrical method of mitigating corrosion on metallic structures that are exposed to electrolytes such as soils and waters. Corrosion control is achieved by forcing a defined quantity of direct current to flow from auxiliary anodes,