

6.17 CORROSION CONTROL (PROTECTION AGAINST CORROSION)

Some of the *corrosion control methods* are described as follows :

1. Proper designing : *The design of the material should be such that "corrosion, even if it occurs, is **uniform** and does not result in intense and localized corrosion". Important design principles are :*

(i) *"Avoid the contact of dissimilar metals in the presence of a corroding solution : If this principle is not followed, then corrosion is localized on the more active metal (in the immediate vicinity of contact); while the less active metal remains protected.*

Amph

(ii) When two dissimilar metals are to be in contact, the **anodic material** should have as large area as possible ; whereas the cathodic metal should have as much smaller area as possible.

(iii) If two dissimilar metals in contact have to be used, **they should be as close as possible to each other in the electrochemical series.**

(iv) Whenever the direct joining of dissimilar metals, is unavoidable, an **insulating fitting** may be applied in-between them to avoid direct metal-metal electrical contact.

(v) **The anodic metal should not be painted or coated**, when in contact with a dissimilar cathodic metal, because any *break* in coating would lead to rapid localized corrosion.

(vi) **Prevent the occurrence of inhomogeneities, both in the metal and in the corrosive environment.** Thus, a proper design should avoid the presence of crevices between adjacent parts of the structure, even in the case of the same metal, since crevices permit concentration differences. Bolts and rivets are, therefore, undesirable for this reason and these should preferably be replaced by a *butt-weld* (see Fig. 18). When it is impractical to avoid crevices in a given design, their harmful effects can be minimized, if the corroding medium is denied access to crevices with an **impervious material** or by **painting**.

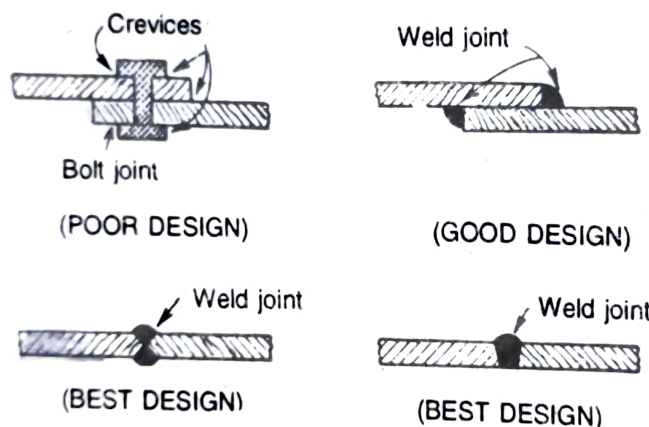


Fig. 18. Different types of joints

(vii) It is desirable that the design allows for adequate cleaning and flushing of the critical parts (i.e., susceptible to dirt, deposition, etc.) of the equipment. **Sharp corners and recesses should be avoided**, because they favour the formation of stagnant areas and accumulation of solids, etc. (see Fig. 19).

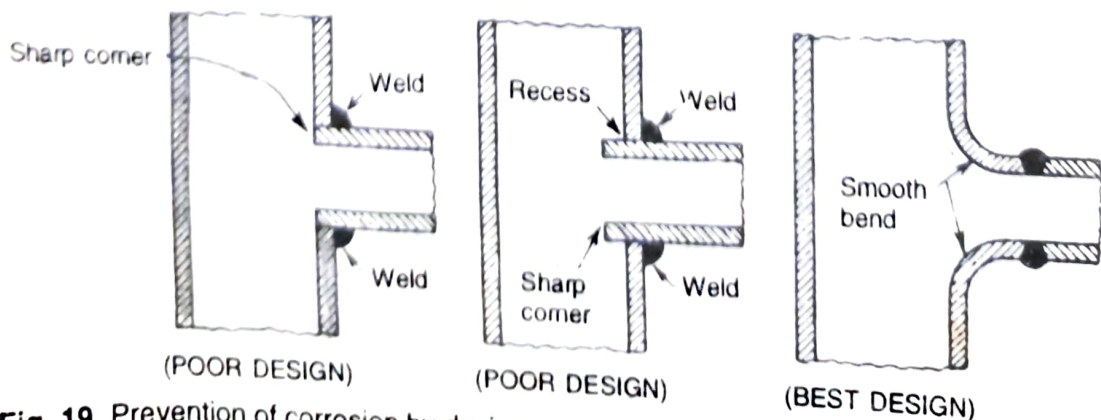


Fig. 19. Prevention of corrosion by design – elimination of sharp corners and stresses.

(viii) Whenever possible, the equipment should be supported on legs to allow free circulation of air and prevent the formation of stagnant pools or damp areas (see Fig. 20).

(ix) *Uniform flow of a corrosion liquid is desirable, since both stagnant areas and highly turbulent flow and high velocities can cause accelerated corrosion. So, highly impingement conditions of flowing liquid should be avoided as much as practically possible.*

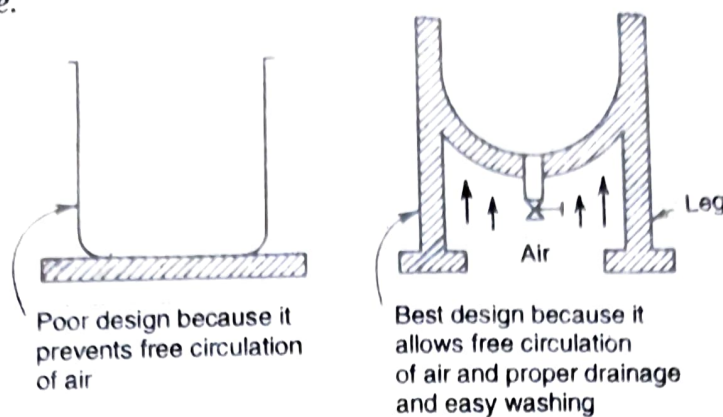


Fig. 20. Prevention of corrosion by design.

(x) A proper design should prevent condition subjecting some areas of structure to stress (cold-worked part). Such an area could set up a galvanic couple with a non-stressed (not worked) areas of the metal (see Fig. 20).

2. Using pure metal : Impurities in a metal cause **heterogeneity**, which decreases corrosion-resistance of the metal. Thus, the corrosion-resistance of a given metal may be improved by **increasing** its purity. Purification of metals like Al, Mg, etc., provides a coherent and impervious protective oxide film on their surfaces, when exposed to environment. However, corrosion-resistance of a purified metal depends on the **nature** of corrosive environment. For example, the corrosion resistance of Al depends on its oxide film formation, which is highly protective only on the high purity metal. However, nothing is gained by purifying Al, if it is to be used in **alkaline** environment, in which both the oxide film and the Al are destroyed.

In many cases, it is not practical to produce a metal of high chemical purity, because : (1) of **cost consideration** in some cases, and (2) very pure metal often possesses the disadvantages of **inadequate mechanical properties** like softness and low strength. Thus, the greater thickness of pure metal is required for a proper strength. Generally, purification of metals is of use only under conditions in which **corrosion by a purely electrochemical mechanism** and not by direct chemical attack.

3. Using metal alloys : Noble, but precious metals such as platinum and gold are corrosion-resistant. Corrosion-resistance of most metals is best increased by alloying them with suitable elements, but for maximum corrosion-resistance, **alloy should be completely homogeneous**. Chromium is the best suitable alloying metal for iron or steel. Its film is self-healing. Thus, steel containing up to 13% Cr are used in cutlery, surgical instruments, springs, etc. Iron alloys containing 13 to 25% Cr (called "**ferrite stainless steels**") are used in turbine brackets, heat-resisting parts, etc.

4. Cathodic protection : The principle involved in this method is to force the metal to be protected to behave like a **cathode**, thereby corrosion does not occur. There are two types of cathodic protections :

(i) **Sacrificial anodic protection method :** In this protection method, the metallic structure (to be protected) is connected by a wire to a **more anodic metal**, so that all the corrosion is concentrated at this more active metal. The more active metal itself gets **corroded slowly** ; while the parent structure (cathodic) is protected. The more active metal so-employed is called "**sacrificial anode**". The corroded

sacrificial anode block is *replaced* by a fresh one, when consumed completely. Metals commonly employed as sacrificial anodes are *magnesium, zinc, aluminium and their alloys*. Important applications of sacrificial anodic method include protection of buried pipelines, underground cables, marine structures, ship-hulls, water-tanks, piers, etc. (see Fig. 21).

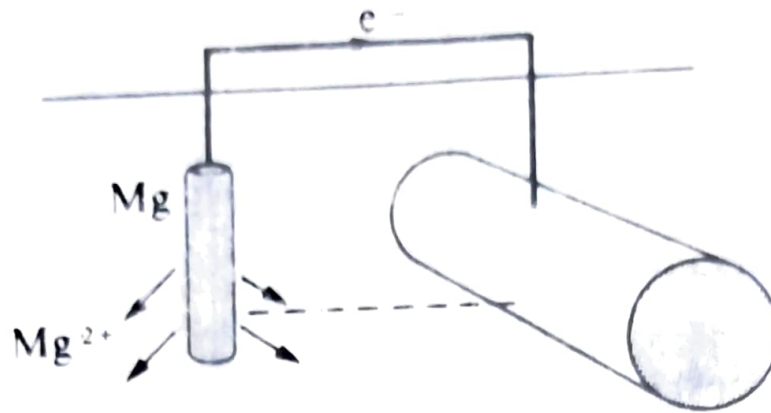


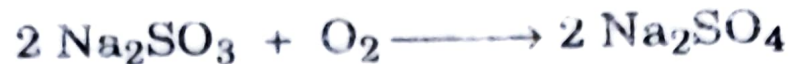
Fig. 21. In cathodic protection, an anode of a more strongly reducing metal is sacrificed to maintain the integrity of the protected object (e.g. a pipeline, bridge, ship hull or boat).

(ii) **Impressed cathodic protection:** In this method *an impressed*

external cell so that the ...
5. Modifying the environment : The corrosive nature of the environment can be reduced either : (i) by the removal of harmful constituents, or (ii) by the addition of specific substances, which neutralize the effect of corrosive constituents of the environment.

(a) **Deaeration.** In oxygen concentration type of corrosion, exclusion of oxygen from aqueous environment reduces metal corrosion. Expulsion of dissolved oxygen is done by adjustment of temperature, together with "mechanical agitation". The method also reduces the CO_2 - content of water, thereby decreasing the corrosion rate of steel pipelines carrying steam condensates from boilers.

(b) **Deactivation** involves the addition of chemicals, capable of combining rapidly with the oxygen in aqueous solution. For example, sodium sulphite (Na_2SO_3).



Hydrazine hydrate ($\text{NH}_2 \cdot \text{NH}_2 \cdot \text{H}_2\text{O}$) is advantageous over the sodium sulphite, because the reaction products are N_2 (g) and water.



(c) **Dehumidification** reduces the moisture content of air to such an extent that the amount of water condensed on metal is too small to cause corrosion. Alumina or silica gels, which adsorb moisture preferentially on their surfaces, are used only in closed areas like air-conditioning shop.

(d) **Alkaline neutralization** is prevention of corrosion by neutralizing the acidic character of corrosive environment (due to the presence of H_2S , HCl , CO_2 , SO_2 , etc.). Such alkaline neutralizers (like NH_3 , NaOH , lime, naphthenic soaps, etc.) are, generally, injected either in vapour or liquid form to the corroding system or to its parts. This method has been widely used in controlling the corrosion of refinery equipments.

6. Use of inhibitors. A corrosion inhibitor is a substance which is added in small