CORROSION BY FOULING THE HEAT EXCHANGERS INSTALLATIONS

Lecturer PhD.Eng. FLORIN CIOFU
University "Constantin Brâncuși" of Târgu-Jiu, florin.ciofu@utgjiu.ro

Abstract: The origin of the corrosion may be the process fluid itself, or a constituent of it, or corrosion may be the result of the presence of impurities, perhaps in trace quantities carried in the fluid stream. In one sense corrosion may be regarded as reaction fouling, with the chemical reactions involving the surface rather than the constituents of the process fluid.

Key words: corrosion, transfer, electrochemical, oxidation

1. INTRODUCTION

Corrosion in process plant is an ever present problem and the engineers responsible for design, operation and maintenance need to be vigilant in the control of corrosion. Corrosion may be defined as the deterioration and loss of material due to some form of chemical attack. The origin of the corrosion may be the process fluid itself, or a constituent of it, or corrosion may be the result of the presence of impurities, perhaps in trace quantities carried in the fluid stream. In one sense corrosion may be regarded as reaction fouling, with the chemical reactions involving the surface rather than the constituents of the process fluid.

Corrosion is often accelerated by the presence of other deposits such as scale or biofilms. On the other hand corrosion protection is often afforded by the presence of metal oxides on surfaces. If the oxide layer is removed by chemical action or erosion then the underlying metal may be seriously affected. It is possible to limit corrosion or eliminate the problem altogether, by the correct choice of material of construction.

For products with a high added value however, the first cost (investment) may be entirely justified particularly where contamination from products of corrosion cannot be entertained. There is a wide variety of different materials of construction for the fabrication of corrosion resistant heat exchangers. Mild steel tubes are also used for low cost applications. In certain operating conditions a combination of environments involved on the inside and outside of the tubes may require the use of "duplex" or bimetal tubes.

2. LIQUID CORROSION THEORY

The well known brown rust (ferric hydroxide) is formed by the combination of metallic iron with oxygen and water. The overall relationship is:

\[ 4Fe + 3O_2 + 6H_2O \rightarrow 4Fe(OH)_3 \]  

Equation 1 illustrates the most common corrosion mechanism involving an electrochemical process essentially metal oxidation, and necessitates the removal of electrons from a metal.
Equations 2 and 3 illustrate the release of electrons from iron metal to produce first ferrous ions followed by conversion to ferric ions by further oxidation.

\[ \text{Fe} \rightarrow \text{Fe}^{2+} + 2e \]  \hspace{1cm} (2)

Ferrous ion and \( \text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + e \)  \hspace{1cm} (3)

The removal of a metal atom from an anodic site on the metal surface gives an ion in solution and an excess of electrons on the metal surface. Utilisation of the electrons on a nearby cathodic site gives a balancing reaction which in solutions that have a near neutral pH, usually involves the reduction of dissolved oxygen to hydroxyl ions according to

\[ \text{O}_2 + 2\text{H}_2\text{O} + 4e \rightarrow 4\text{OH}^- \]  \hspace{1cm} (4)

**Fig.1. The electrochemical corrosion cell**

Corrosion of heat transfer surfaces subject to gaseous environments can occur at almost any temperature. It is useful however to divide the discussion into two parts, namely low and high temperature corrosion, since in general, the mechanisms involved are different.

**Fig.2 Corrosion of a heat exchanger tube in association with the deposition of particulate matter**
As already described the presence of a metal oxide on a surface affords protection against further oxidation and metal wastage, but where corrosion occurs in gaseous atmospheres, the oxide layer may become involved in chemical reactions thereby removing the protection, and allow corrosion to proceed. The effects may be severe, even in the presence of an oxidising environment.

3. MATERIALS OF CONSTRUCTION TO RESIST CORROSION

The images in Figure 3 show the effects of pipe material deposits of the power plant heat changer Rovinari.

![Fig.3 Aspects of corrosion residue deposition](image)

Although glass and plastic materials have been used for the fabrication of heat exchangers there are limitations to their use. In the former the problem of fragility exists and in the latter there are temperature restrictions. At the present time the majority of heat exchangers are usually fabricated from metallic alloys where corrosion is anticipated.

In the following I will present the options open to the designers of chemical process plant, including heat exchangers. They give the following useful summary of advice on metallic alloys generally for use in liquid systems.
1. Standard austenitic stainless steels such as type 316 (18 Cr: 10 Ni: 3 Mo) have useful if limited resistance, to acids and reasonable resistance to pitting corrosion. Type 304 (18 Cr: 10 Ni) stainless steel has a good resistance to nitric acid. Austenitic stainless steels have relatively low strength, poor antierosion and abrasion properties and do not possess the ability to resist stress corrosion cracking.

2. Super austenitic stainless steels with relatively high nickel content (approx. 20 Cr: 29 - 34 Ni), sometimes referred to as "alloy 20" are more costly than standard austenitic steels but provide excellent resistance to acids and some acid chlorides.

3. Duplex stainless steels offer high strength, coupled with resistance to abrasion and erosion and to stress corrosion cracking. It is claimed that Ferralium alloy 255 (with 25% Cr), has excellent pitting and crevice corrosion with good resistance to acids.

4. Nickel based alloys, such as Hastelloy, have outstanding corrosion resistance in reducing acids, mixed acids and acids at high temperatures. The principal restriction in their use is the high cost.

5. Claddings the surfaces with corrosion-resistant materials, with the possibility of replacing elements add (fig.4).

Fig.4 Plated pipe

4. CONCLUSION

The final choice adopted for the relief of a particular fouling problem depends on many actors but the prime considerations will be that of cost and safety. Cost, not only for the leaning operation itself and the associated equipment requirement, but also for off-line cleaning, the down time involved, will usually dictate the method adopted. Safety not only of personnel involved in the cleaning operations, but also of the plant itself and the environment must be given serious consideration in relation to the techniques available. The cheapest may not be the safest.
REFERENCES

Ciofu Florin - "Studies evaluating and improving the corrosion resistance of metallic materials used for different types of heat exchangers", Contract research, 2014
Palade, V., Ștefănescu, I., - Tubular container and equipment, Ed. Semne, București, 2000