Corrosion

Stainless Steels

The term “stainless steel” is applied to a group of Fe-Cr alloys, with or without nickel, which offers a good resistance to chemical corrosion.
Contrary to their name, stainless steels owe their "cleanliness" to a very thin superficial oxide layer, rich in chromium and oxygen. This layer, which acts as a protective film (passivation), exists due to the chromium, which is an easily oxidised element. It is very thin and inert in a large number of environments.

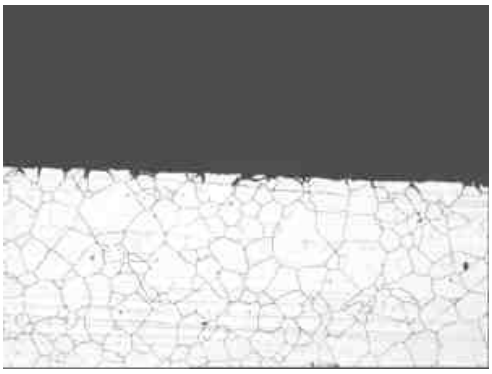
This property of Fe-Cr alloys is valid for Cr contents of approximately 12%, the minimum for all stainless steels.
Sometimes, it happens that this protective film is destroyed, either uniformly or locally – a status known as general- or localised corrosion (pitting, crevice, stress corrosion...).

General Corrosion

This term is used to describe a relatively uniform attack on the metal. This attack is due to the disappearance of the protective film.

The main factors causing the phenomenon are
- the surrounding environment
- the chemical composition of the steel or
- the temperature

There will be no protection against corrosion if the material is incapable of creating this film due to a too active environment.



Intergranular Corrosion

Intergranular Corrosion occurs when there is preferential attack of the grain boundaries. This results from depletion of chromium at the grain boundaries which occurs when stainless steel is heated to 500-900ºC.

Carbon tends to migrate to the grain boundaries where it bands together with the chromium to precipitate chromium carbides, thus tying up the chromium. Those regions next to the grain boundaries are therefore impoverished in chromium (dechromisation) and, consequently, are liable to corrosive attack.
To give the material these stainless qualities, chromium has to be made available. This is done by heating the material to above 1000ºC, followed by rapid cooling to prevent the formation of chromium carbide. This technique, applied to austenitic stainless steels, is called *quenching*.
In the case of ferritic stainless steels rehomogenisation of the chromium is obtained by holding the material at approximately 800ºC: the diffusion rate of the elements is much faster.
To reduce the susceptibility to intergranular corrosion, either the carbon level can be reduced (L series), or elements combining preferentially with carbon instead of chromium can be added, such as titanium or niobium (DMV 321; DMV 316Ti or DMV).

Crevice & Pitting Corrosion

These are particularly insidious types of corrosion: the attack is limited to a very small area of the metal, the remainder being free from attack. The depth of the attack can increase very rapidly.

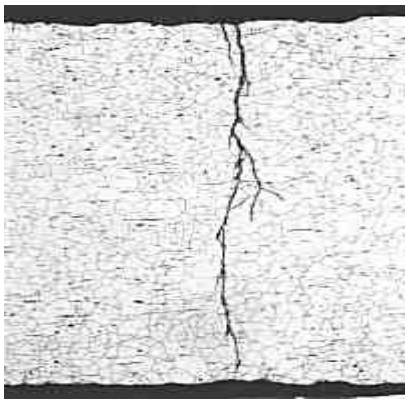
Pitting phenomenons can be separated into two stages:

- the initiation: occurs at a point where the protective film is accidentally damaged or weakened (by impurities, scratches, notches, rough surfaces)
- the progression: Will increase rapidly if the protective film has difficulty in re-establishing itself. This can occur when deposits become established on the material

Crevice corrosion is a particular from a pitting corrosion and occurs when the surrounding environment remains stagnant on the material, small defects gradually becoming depleted in oxygen. The corrosion products arising from this concentration pile are acid and, themselves, very corrosive. The following are the essential ingredients likely to lead to pitting and crevice corrosion:

- chlorides, particularly when associated with oxidising conditions (aeration, ferric iron etc...)
- deposits (rust etc...)
- structure anomalies (joints,threads, etc...)

The presence of molybdenum in the stainless steel can diminish or even prevent from crevice and pitting corrosion.



Stress Corrosion (Corrosion under tension)

Stress corrosion is associated with the simultaneous presence of corrosion and tension stress. In most cases it becomes apparent only at temperatures above 50-60ºC.

Tension stresses can be

- internal (residual stresses) or
- external (mechanical load, differential thermal expansion etc...)

A stress relieving heat treatment is the most usual method of reducing internal stresses.
Since this type of corrosion is initiated by local corrosion attack, an appropriate choice of the steel grade to be used is essential.

- The duplex stainless steels with a ferro-austenitic structure (DMV 22.5; DMV 25.7; etc.) are a lot less sensitive to stress corrosion and often represent an economical solution
- Very high nickel grades (DMV 928; DMV 825; DMV 600; DMV 625 etc...) are necessary to be applied in severe corrosive environments