EVEN STAINLESS STEELS CAN CORRODE

Carlo Cozzi

Recently we received a request to perform a NSS neutral corrosion resistance test in accordance with EN ISO 9227 on a sample of stainless steel product classified AISI 316.
The defect complained by the customer was a rapid rust formation: a phenomenon that was not acceptable in consideration of the final use of the element.

The test confirmed the behavior exposed by the customer: shortly after 200 hours of exposure, the rust began to cover the product.
Generally, stainless steel does not present any sign of decay before 1000-1500 hours when exposed to neutral salt spray.
The Department of Science and Chemical Technologies at the University of Udine was able to explain this phenomenon (decisive was the analysis of the production cycle of the product in question).
A SEM analysis firstly showed that the material did not have a microstructure suitable for high corrosion resistance; furthermore, the product was obtained through a forging process processing which favor the phenomenon of stress-corrosion as it weaken the passivation layer typical of stainless steels.

Stainless steels are ferrous alloys that combine mechanical properties, typical of steels, to the intrinsic characteristics of noble materials, such as corrosion resistance.

In reality these materials are "oxidable", and have the ability to auto-passivate by covering themselves with an invisible (with the naked eye) oxide layer that protects the underlying material from corrosive attacks. All this by virtue of a quantity of chromium in the alloy composition not less than 10.5%, as required by standard EN 10020.
Another important element for the passivation film formation is the presence of an oxidizing environment (such as air) that promotes the process of formation or restoring this when it is damaged.

Therefore it is essential that the material, both during the manufacturing process and the installation, can be exposed to air-oxigene so that it can be considered in the optimum passivation conditions. The passivation film may be more or less resistant and more or less anchored to the material depending on the chromium concentration in the alloy and depending on the presence of other elements.

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It is therefore clear that there are several grades of stainless property and consequent corrosion resistance.
However, there are many cases where a stainless component is chosen only because people trust in the "stainless" adjective, claiming its resistance to any type of environment and any type of use.
The causes that can trigger the corrosion process are many and depend on the type of environment in which the product will be used and the type of use to which it will be subject.
In particular, the main factors are:
- the nature of the aggressive agent (typology, concentration, pH);
- the aggressive agent temperature;
- the surface finish;
- the fluid speed on the walls of the material.

In general, the "enemies" of stainless steel are chlorides (Cl) as they are able to "break" the passivation film and hinder its reformation. The knowledge of the type, concentration, pH and temperature of the environment to which the stainless steel will be exposed, are very important for the final choice.
Another fundamental aspect is the finishing. It is intuitive that the "smoother" is the surface, the lower is the possibility of anchoring by an aggressive element. It is also important to remember that stainless steels are able to "protect themselves" through the passivation film that covers them. This will be able to reform more easily and steadily as the substrate is finer.

A rough finish will give result to major stagnant areas that slow down the fluid speed on the surface and allow the corrosive agent to create a corrosion-friendly environment.
The most common "wet" corrosion forms on stainless steel are: pitting, crevice-corrosion, intergranular corrosion, stress corrosion cracking, galvanic corrosion and hot oxidation (heat treatments, soldering, operating range, etc.)
To conclude, our suggestion is to choose the material carefully, considering all the variables and the existing technical standards. In addition, an appropriate set of tests designed before installation can prevent unpleasant problems.

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