

MICROSTRUCTURE AND PROPERTIES OF DUPLEX STAINLESS STEELS

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Duplex stainless steels unite an interesting combination of mechanical properties, corrosion resistance, wear resistance and weldability, which led to the selection of these steels in numerous applications. The particular advantage of duplex steels lies in their high resistance to chlorine and hydrogen induced stress corrosion cracking together with their high resistance to pitting-, crevice- and general corrosion and their higher yield strength compared with the austenitic and ferritic stainless steels.

These steels were introduced into the market during the thirties, and there has been an accentuated development and spreading mainly for the last 15 years. Today, duplex stainless steels are in competition with single phase austenitic and ferritic steel grades. They are obtainable as forgings and castings (including centrifugal castings), cold and hot-rolled plates, tubes, wires, etc. Areas of application are chemical, petrochemical and desulphurization (pollution control) plants, off-shore techniques as well as the acetic acid, photo, pulp, dyeing and food industries.

On the other hand, these steels are subject to four types of brittleness: 475°C-embrittlement of ferrite, sigma-phase embrittlement, nitrides embrittlement and reduction of ductility which is due to a network of carbides in alloys containing a high concentration of carbon.¹

This paper reports the occurrence of these four types of brittleness, their consequences and the different types of fracture appearance.

The ferritic-austenitic stainless steels with a duplex microstructure can be divided into two groups: i) low carbon wrought and cast alloys and ii) higher carbon cast alloys. In the case of the carbon-rich variants, carbides of the type $M_{23}C_6$ are also formed.²

The existence of two-phase (ferritic-austenitic) structures in corrosion-resistant CrNi-steels is mainly determined by the alloy mass portions of iron, chromium and nickel. Duplex stainless steels with ca. 20-27 wt.-% chromium and 4-8 wt.-% nickel have a ferritic-austenitic microstructure. If the carbon content is higher, they have a ferritic-austenitic-carbide microstructure. In addition to chromium and nickel they often contain 2-5 wt.-% molybdenum and up to 0.25% wt.-% nitrogen, to increase their resistance against pitting corrosion.

A completely ferritic microstructure forms during solidification. An exclusively ferritic one-phase material exists at temperatures around 1400°C. Partial transformation to austenite occurs in the solid state during cooling to produce islands of austenite in a ferritic matrix. During hot rolling and annealing, the microstructure remains within the two-phase field of the Fe-Cr-Ni phase diagram. Low carbon duplex stainless steels are processed by hot rolling or forging and cold rolling followed by suitable recrystallization annealing and quenching to equalize the proportion of the

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