Detection of the resistance of austenitic stainless steels to the intergranular corrosion

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Intergranular corrosion is the special form of a local corrosion, which can occur in many alloy systems when the corrosion rate of the grain-boundary areas is higher than that of the grains interiors. This localized attack is very dangerous because the surface damage of the material is usually easily overlooked but it often leads to the dislodgment of individual grains and to the intensive negative influence on the mechanical properties. Intergranular corrosion is very typical corrosion attack in austenitic stainless steels. In common oxidizing environments these steels have good corrosion resistance due to the formation of passive protective surface film. However, under the action of aggressive halide ions, local breakdown of passivity occurs, causing pitting corrosion. The susceptibility of the austenitic stainless steels to the intergranular corrosion is connected with their exposition in the temperature range of 500 - 800 °C ("critical temperatures") and with consequent slow cooling in the air which leads to the precipitation of $M_{23}C_6$ chromium-rich carbides on the grain boundaries. The precipitation of chromium carbides consumes the main alloying element - chromium from a narrow band along the grain boundary and this makes the zone anodic to the unaffected grains. If the chromium content near the grain boundaries drops under the passivity limit (11.5 wt. %), the steel becomes to be sensitized and susceptible to the intergranular corrosion in aggressive environments. The chromium depleted zone becomes the preferential path for corrosion attack or crack propagation if under tensile stress.

The sensitization temperature range is often encountered during isothermal heat treatment, slow cooling from the solution annealing temperature, improper heat treatment in the heat affected zone of the welds or weld joints or hot working of the material. Degree of the sensitization is influenced by the factors such as the steel chemical composition, grain size, degree of strain, or temperature and time of isothermal annealing.

This contribution deals with the susceptibility of three austenitic stainless steels (AISI 304, AISI 316L, AISI 316Ti) to the intergranular corrosion. Both "as received" and improperly heat-treated specimens (sensitization for 10 hours at 650 °C and consequent cooling in the air) were tested by ASTM A262 standard method, A and E practices. Optical microscopy and SEM analysis were used for assessment of the obtained results. According to performed experiments all three steels in "as received" state showed high resistance to intergranular corrosion. After improper heat treatment AISI 304 stainless steel reflected the lowest resistance and AISI 3016Ti stainless steel the highest resistance to the intergranular corrosion.

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