Electrochemical characteristics of austenitic stainless steel after different times of sensitization

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Austenitic stainless steels are highly resistant to general corrosion in a wide range of corrosive environments. They have good balance of strength and ductility and appropriate toughness at both low and high temperatures. An advantage is also their weldability by most standard welding techniques.

Common limitations to the use of austenitic steels are their susceptibility to the pitting in chloride-containing environments and also to the intergranular corrosion after their sensitization. This phenomenon is related to an exposure in the temperature range of 500-800 °C with consequent slow cooling which can lead to chromium content drop under the passivity limit near the grain boundaries due to chromium carbides precipitation. Sensitized, locally chromium depleted austenitic grains become susceptible to intergranular attack typically combined with pitting if aggressive environment contains chlorides.

Sensitization of austenitic stainless steel can occur during various industrial and operational processes where the material is exposed to the critical temperatures in the sensitization range for a certain period. It is typical for heat exchangers, especially used in chemical, petrochemical, and oil/gas industries; chemical processing equipment; food processing equipment; intermediate temperature components for nuclear power plants, and also for exhaust systems. The conditions for the significant extensive sensitization of austenitic stainless steels can be determined according to the diagram of carbon solubility in austenite. The minimum sensitization time is affected by various factors as alloy chemical composition, temperature, carbon content and heating rate. Under specific conditions local sensitization can be caused by a short-term heating.

This study deals with the corrosion behavior of AISI 304 stainless steel after 10, 6, 2, 1-hour sensitization time at the 650 °C temperature. Sensitization of the specimens is verified by ASTM A262 test. Corrosion resistance is evaluated by electrochemical characteristics of the potentiodynamic polarization performed in 1 M NaCl solution at the temperature 20 $\pm$ 3 °C on the specimens with high temperature surface oxides and after their removal by pickling. The electrochemical etching test in oxalic acid confirmed the ditch structure and the complete sensitization after 10 and 6 hours sensitization time. After 1 hour, the material showed only slight local signs of sensitization. The electrochemical characteristics of the potentiodynamic polarization were significantly affected by the surface state of the sensitized specimens. Regardless of the sensitization time, the specimens with high-temperature surface oxides behaved like an actively corroding metal. After pickling, they retained the passivity region, but with a higher passive current density than the as received material.

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