Corrosion resistance of austenitic stainless steels in mixed sulfuric acid and copper sulfate solution

Viera Zatkalíková, Lenka Markovičová, Milan Uhríčik, and Silvia Hudecová

University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovakia

Austenitic stainless steels are widely used not only for common domestic, industrial, transport and architectural applications, but they are also acceptable as a construction material across the chemical-processing and petrochemical industries. It is due their ability to withstand attack from highly corrosive substances when they are in the passive state, as well as their effective mechanical characteristics. However, it is necessary to take into account, that stainless steels have some important limits in their corrosion resistance. In addition to the susceptibility to the local pitting corrosion in chloride containing media they may also suffer from the intergranular corrosion. This corrosion form usually takes place in aggressive environments after sensitization by thermal exposure in critical temperatures with consequent slow cooling in the air. Under these conditions, $M_{23}C_6$ chromium-rich carbides precipitate on the grain boundaries. It causes a drop of the chromium content near the grain boundaries under the passivity limit and chromium depleted zones become the preferential paths for pitting corrosion attack.

Stainless steels generally offer good resistance to the corrosion in sulfuric acid, but the level of their resistance varies depending on the grade of the used steel and the concentration and temperature of the sulfuric acid. The presence of oxidizing or reducing contaminants, velocity effects and solids in suspension also affect the aggressiveness of this acid toward the stainless steels. At ambient temperature, austenitic stainless steels exhibit stabile passivity state in highly concentrated sulfuric acid (above 93 %) and they are frequently used for piping and tankage where product purity is desirable. In dilute sulfuric acid solutions, molybdenum containing grades exhibit higher corrosion resistance than Cr-Ni steels. However, diluted sulfuric acid solutions are considered the environments that can induce intergranular corrosion of austenitic stainless steel. The aggressiveness of these solutions in relation to the intergranular corrosion can be increased if mixed with copper sulfate due to the catalytic effect of copper ions and promoting the precipitation of copper-rich phases at the grain boundaries

This study is focused on the evaluation of AISI 304 and AISI 316L stainless steels corrosion resistance in mixed 10 wt. % sulfuric acid and 10 wt. % copper sulfate solution. Sensitized (650 °C /40 hours) and solution annealed (1050 °C /15 min) specimens together with the untreated (as received) ones are examined by long-term (22-month) exposure immersion test at the temperature of 22 ± 3 °C on the bases of optical microscopy and SEM. Both tested stainless steels in as received and solution annealed state proved high corrosion resistance in the given corrosive environment. The cross-sections edges of sensitized specimens revealed a close relationship between local corrosion sites and weakened grain boundaries. The observed damage indicates incipient intergranular corrosion.

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