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Establishing correlations between the ruthenium concentration of cladded 304L stainless steel and its corrosion resistance in acidic media

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Abstract

The corrosion behaviour of laser alloyed surface cladded 304L stainless steel with ruthenium was evaluated by conducting a series of electrochemical tests including open circuit potential and potentiodynamic polarisation. This research utilised a laser cladding method to obtain an alloyed layer of uniform thickness of various ruthenium concentrations on the 304L stainless steel samples. The resultant compositions of the ruthenium enriched samples were 0.44 wt%, 0.82 wt%, 2.92 wt%, 2.44 wt% and 4.67 wt% ruthenium.

The laser cladded samples were exposed to various corrosive agents including sulphuric acid solutions (with and without sodium chloride) as well as hydrochloric acid. The test series was conducted at ambient conditions (25˚C) and at elevated temperature (45˚C). The corrosion protection offered by the alloyed ruthenium doped samples was compared to that of uncladded 304L stainless steel, 316, SAF2205 duplex stainless steel and Hastelloy C276. In this way the most viable application for this form of corrosion protection could be established.

It was observed that the addition of ruthenium showed better results in terms of measured corrosion rates and passivation characteristics compared to the 304L samples without ruthenium. It was also observed that the ruthenium cladded samples behaved differently in the different environments and that an optimum ruthenium range exists which was not always at the highest concentrations of the precious metal. A direct correlation of improved corrosion protection with increased ruthenium concentration was more prominently observed in the environments containing chloride; indicating the real benefit of the ruthenium addition.

The introduction of chloride ions to the solution, both via the salt or hydrochloric acid, caused severe attack on the protective layer of the stainless steel and created harsh corrosive conditions that increased the tendency of the sample to corrode and, in the case of hydrochloric acid, introduced pitting corrosion. Higher temperatures had a detrimental effect on all the 304L samples and their alloys.

Passivation was only observed for the 1 M sulphuric acid and 1 M sulphuric acid with 1% sodium chloride solutions at 25^{o}C. It was observed that active corrosion was taking place in all other environments tested. When passivation is achieved, the ruthenium containing samples can compete with commercially available steels providing that the cladding is less than 200 µm thin. Where passivation is not achieved, the SAF2205 and Hastelloy C276 showed equivalent or better corrosion protection.