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Heat treatment and corrosion behaviour of 2101 duplex stainless steel cathodically modified with ruthenium

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ABSTRACT

The objective of this study was to improve the overall corrosion ressitance of 2101 by cathodic modification with ruthenium. Initially, the corrosion behaviour of 2101, 316, 2205 and 2507 was studied by potentiodynamic tests.

Samples of 2101 with different amounts of ruthenium up to 10wt% were manufactured using arc melting. All as-received samples were analysed by spark emission spectroscopy. Samples were characterised with optical and scanning electron microscopy with EDX analyses, and the phases were confirmed with XRD. The volume fractions of the phases were also measured. Hardness measurements were done to check that the ruthenium additions were not detrimental to the mechanical properties.

Thermo-Calc was used to deduce the expected phases, check for any low temperature phase and to deduce the temperatures at which the ferrite:austenite ratio was 50:50. The dual phase threshold (1080°C) was then used for the heat treatment. The actual heat treatment time was determined experimentally. Thermo-Calc showed that ruthenium additions of up to 0.2wt% Ru did not give a significant change to the phase proportion diagram, thereby retaining the duplex structure, whereas above 2.5wt% Ru, the phases were different. The calculation with up to ~10% Ru gave ferrite and hcp. The temperature at which the liquid disappeared in 2101-10 wt% Ru was 1280°C, which was lower than the other 2101 alloys with less ruthenium. The results of Thermo-Calc agreed with the experimental results.

The effects of ruthenium additions to 2101 lean duplex stainless steel on corrosion were studied in sulphuric acid, sulphuric acid with chloride, hydrochloric acid and sodium chloride solutions, and compared to 316, 2205 and 2507 stainless steels using potentiodynamic measurements. Ruthenium was beneficial at both the cathodic and anodic regions of the curves by modification of the cathodic and anodic behaviour. The increase in ruthenium addition increased the corrosion resistance in all the solutions. Increasing temperature and concentration of the corrosive media increased the corrosion rates, passive current densities and critical current densities of the alloys investigated. The optimum ruthenium addition was 1wt% Ru.