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# Corrosion and other properties comparison of AISI 316L stainless steel surface alloyed with Ru/Ni mixtures with the parent metal and with Hastelloy© C-276

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# ABSTRACT

The surfaces of AISI 316L stainless steel plate were laser alloyed with ruthenium powder as well as a mixture of ruthenium and nickel powders using a Nd:YAG laser set at fixed operating parameters. The microstructure, elemental composition, and corrosion characteristics of the alloyed zone were analysed using optical and scanning electron microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS), and corrosion potential measurements. EDS analysis of the alloyed specimen showed that through the laser surface alloying, 2 mm surface layers with 12.5wt % Ru and 5.2wt% Ru were produced on an AISI 316L stainless steel.

Similar microstructures which were dendritic and columnar grains, typical of weld beads under non-equilibrium cooling conditions were observed for all samples. Hardness profile measurements showed a significant increase from 160 HV for the substrate to a maximum of 247 HV for the alloyed layer. Using an Autolab potentiostat, the corrosion behaviour and resistance of the laser alloyed layers, substrate AISI 316L, and Hastelloy© C-276 were evaluated and compared in sulphuric acid solution of different concentration and temperatures. The Hastelloy© C-276, followed by the 12.5wt% Ru presented the most noble corrosion potential ($E_{corr}$) and the lowest corrosion current density ($i_{corr}$). However, in 60wt% $H_2SO_4$ and 40$^{o}$C, the 5.22 wt% Ru alloys exhibited slightly better anticorrosive properties than 12.5wt% Ru. The observed corrosion potential, $E_{corr,}$ for untreated AISI 316L stainless steel sample in 40wt% sulphuric acid solution at 40$^{o}$C was -277 mV. The 5.22 wt% Ru and 12.5wt% Ru alloyed stainless steel samples presented -240 mV, and 61 mV respectively in the same solution. Besides showing comparable

performance to 5.2wt%Ru sample within specific short potential ranges, Hastelloy© C-276 was generally superior in all solutions. In addition it was found that the stability of the passive layer was improved with additions of Ru.

Based on the developed costing equation the cost of 5 mm AISI 316L stainless steel plate with surface area (A = 1 $m^2$) surface alloyed with 5.2wt% Ru to a depth of 2 mm using Nd: YAG laser is estimated at R15 989, and it is less than the cost of a Hastelloy© C-276 plate of similar size which is estimated at R19 900. As the material thickness increases, the cost benefit of laser surface treatment increases and vice versa. Reduction of the Ru additions to levels below 5.2wt% would improve cost competition without detracting from performance.