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Susceptibility of 12% CR steels to sensitisation during welding of thick gauge plate

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SUSCEPTIBILITY OF 12% CR STEELS TO SENSITISATION DURING WELDING OF THICK GAUGE PLATE

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Declaration

I, Martin Nicholas van Warmelo, declare that this thesis, submitted in fulfilment of the requirements for the award of Master of Engineering, in the Faculty of Engineering, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

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Abstract

In recent years, the subject of sensitisation in unstabilised ferritic/martensitic dual phase 11-14%Cr steels has been investigated in some detail after a number of failures in service due to accelerated corrosion. It was found that sensitisation could occur due to a number of different mechanisms which were dependant on the heat treatment, the number of thermal cycles and the phases present in the material. All the detected modes of sensitisation could be prevented by stabilisation with titanium or niobium and suitable design of the material composition to produce a suitably high ferrite factor. However, these options could not readily be applied to thick gauge plate and therefore 12%Cr material available in the market above 10mm thickness still tends to be unstabilised.

This project was initiated with the intention of determining how sensitisation would manifest itself during welding of thicker plates and whether the degree of sensitisation could be controlled to acceptable levels by appropriate control of the welding parameters. This was done in two phases, namely evaluation of actual welds produced using varying heat input parameters and by simulation of the thermal treatment using a Gleeble 3500 thermomechanical simulator. The samples were evaluated using standard immersion tests (Strauss test) and electrochemical techniques.

Mode 2 sensitisation was found to occur on all samples and on all materials, irrespective of the welding parameters. This occurred at all points where the heat affected zone (HAZ) from one weld bead intersected with the HAZ from a previous bead. However, the sensitised regions were generally well below the surface of the material and would

therefore not be exposed to the atmosphere and any corrosive environment. The exception to this rule occurred when very high heat input resulted in an excessively large HAZ or when poor weld bead positioning and inappropriate bead overlap resulted in sensitisation of the HAZ on the surface.

Mode 3 sensitisation did not occur within the range of welding parameters investigated.

Mode 4 sensitisation was found to occur on all materials but could not reliably be detected by the Strauss test. Electrochemical evaluation clearly showed that sensitisation was present in the subcritical HAZ on all materials, irrespective of welding conditions. However, the degree of sensitisation was very low.

From a practical perspective, problems in service due to sensitisation are most likely to arise from very high heat input levels and welding defects such as excessive overlap of weld beads and incomplete fusion.

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