HÖGSKOLAN VÄST

Super Duplex Stainless Steels – Microstructure and Properties of Physically Simulated Base and Weld Metal

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AKADEMISK AVHANDLING

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Abstract

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High-temperature processing and application of super duplex stainless steel (SDSS) are associated with the risk of changes in the ferrite/austenite balance and precipitation of secondary phases. This study was therefore aimed at improving knowledge about effects of thermal cycles on the microstructure and properties of SDSS base and weld metal. Controlled and repeatable thermal cycles were physically simulated using the innovative multiple TIG reheating/remelting and the arc heat treatment techniques. In the first technique, one to four autogenous TIG-remelting passes were applied. During arc heat treatment, a stationary arc was applied on a disc mounted on a water-cooled chamber thereby subjecting the material to a steady state temperature gradient from 0.5 minute to 600 minutes. Microstructures and properties were assessed and linked to thermal history through thermal cycle analysis, thermodynamic calculations and temperature field modelling.

Remelting studies showed that nitrogen loss from the melt pool was a function of arc energy and initial nitrogen content and could cause highly ferritic microstructures. Heat affected zones were sensitized by nitride formation next to the fusion boundary and sigma phase precipitation in regions subjected to peak temperatures of 828-1028°C. Accumulated time in the critical temperature range, peak temperature and the number of thermal cycles are the most relevant criteria when evaluating the risk of sigma phase precipitation.

Arc heat treatment produced graded microstructures in SDSS base and weld metal with the formation of a ferritic region at high temperature due to solid-state nitrogen loss, precipitation of sigma, chi, nitrides, and R-phase with different morphologies at 550-1010°C and spinodal decomposition below 500°C. This caused sensitization and/or increased hardness and embrittlement. Results were summarized as time-temperature-precipitation and properties diagrams for base and weld metal together with guidelines for processing and welding of SDSS.