STUDIES ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF TUNGSTEN INERT GAS AND ELECTRON BEAM WELDED GRADE 91 STEEL

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ABSTRACT

The effects of post weld heat treatment (PWHT), its time and multiple PWHT on microstructure and mechanical properties of weld joints of Grade 91 steel produced by multi-pass Tungsten Inert Gas (TIG) welding have been studied and compared with similar weld joints made by Electron Beam Welding (EBW). Transverse-weld tensile strength of multi-pass TIG weld joints decreases by 25-30 MPa with increase in PWHT duration from 1 to 12 h. The impact toughness of multi-pass TIG weld metal and base metal shows no noticeable change with increase in PWHT time beyond 1h. It is also observed that multiple PWHT cycle does not have any adverse effect on mechanical properties and microstructure in comparison to single PWHT cycle. The different subzones of HAZ were simulated in a Gleeble simulator based on experimental measured thermal cycles. The hardness and microstructure of simulated specimens for different peak temperatures (860, 900, 975, 1200 °C) were found to be comparable with corresponding locations in the HAZ in the welded sample. Charpy V-notch impact toughness measured after PWHT (760°C for 4h) for different peak temperatures shows good toughness in comparison to base metal and multi-pass TIG weld metal. EBW joints needs longer PWHT time to reduce the hardness across the weld as compared to multi-pass TIG weld joint, which is attributed to auto tempering of previous weld bead including HAZ during subsequent weld passes in multi-pass welding. The room temperature cross-weld tensile properties, impact toughness (at 18°C) of weld metal after PWHT for both types of weld joints (EBW and TIG) are found to be comparable. However, EBW joints showed significantly higher elevated temperature mechanical properties. Cross-weld tensile properties (YS, UTS) at 550°C are found to be higher for EBW joint compared to multi-pass TIG joint. Creep rupture tests carried out at 650°C have demonstrated that the creep life of EBW joint is comparable to base metal; whereas multi-pass TIG joints have shown significant drop in creep life tested for the same stress level. Both types of weld joints show Type IV cracking for all stress levels. The steady state creep rate of multi-pass TIG is found to be fifteen times than that of EBW joint for stress level of 80 MPa, which may be attributed to over tempering, more re-austenization, and fine grain structure of FGHAZ/ICHAZ of the TIG joints. In contrast, single-pass and rapid weld thermal cycles associated with EBW process causes minimum phase transformation in the FGHAZ and ICHAZ. Microstructure studies on creep tested specimens shows creep cavities formed at the primary austenite grain boundaries nucleated on coarse carbide precipitates.

Key words: Grade 91 steel; welding; Gleeble simulation; post weld heat treatment, heat affected zone; microstructure; harness, toughness, tensile properties, creep life.