Buried Gas Tungsten Arc Welding with Convective Cooling for Welding High Strength 10 Nickel Steel

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A study was conducted to evaluate the feasibility of using the Buried Gas Tungsten Arc Welding (BGTAW) process to join thick section 10 Ni steel with no added filler material. Full penetration weldments were made in one and a half inch thick 10 Ni steel plate in two passes using the BGTAW process. The calculated heat input for some of the BGTAW welds investigated in this study was as high as 15.8 MJ/m (400-kJ/in).

Mechanical property results were promising, given that no filler wire was used. The yield strength of fusion zone was 923 to 985 MPa (134 to 143 ksi), which was comparable to the base plate tensile properties. The results of mechanical property evaluation indicated there was a reduction in the fusion zone Charpy V-notch (CVN) toughness in the fusion zone of the first side welded compared to the fusion zone of the second side welded. The fusion zone of single pass weld typically exhibited an average CVN toughness of over 81 J at –51°C (60 ft-lbs at – 60 °F). In a two pass weld, the fusion zone of the first pass exhibited a lower CVN toughness after the second welding pass was performed (54 J at 51°C or 40 ft-lbs at – 60 °F). Although slightly lower than the second pass, the toughness of the first pass is higher than many of the current weld metal toughness requirements for high strength steel consumables.

The low toughness is believed to be due to overheating of the weld metal during this high heat input welding process. Metallographic characterization, microhardness mapping, and additional CVN testing was performed on the weldments to characterize the low toughness zone. The results of this metallurgical investigation indicated the fusion zone microstructure exhibited a dendritic structure with a fine lath structure within the dendritic packets. This was the predominant microstructure in the fusion zone of both the first and second side fusion zone. Microhardness mapping was used to identify differences in hardness of the fusion zone. The fusion zone was found to vary in hardness from 360 to over 440 Vickers hardness.

An in-situ convective cooling device and procedure was developed to modify the thermal history of the BGTAW welds. The application of convective cooling was found to increase the hardness and improve the CVN toughness of the first side welded fusion zone. The effects of convective cooling on the hardness and mechanical properties of BGTAW welds in 10 Ni steel are presented.

The results of this investigation indicated that good strength and toughness could be achieved in thick section 10 Ni steel weldments using a buried gas tungsten arc welding process in conjunction with a convective cooling procedure.