Austenite Stabilization in 316L Welds by Nitrogen-bearing Arc Shield Gas Mixtures

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We report on efforts to maintain a completely austenitic material in the weld zone of 316L CRES tubing joined by orbital tube welding (OTW). The OTW method most often yields a dual-phase weld microstructure consisting of austenitic (γ) and ferritic (α) phases. The relative fraction of these phases in OTW welds is dictated almost entirely by the starting material composition and the shield gas employed. Maintenance of a fully austenitic weld zone reduces the susceptibility to brittle failure resulting from the presence of ferritic and other secondary phases, which are subject to embrittlement at cryogenic temperatures. The stabilization of γ-austenite in weld zones by the introduction of nitrogen into the weld shield gas is well known. In the present study, the α–ferrite content of OTW formed welds joining 6.35 mm diameter tubes with wall thickness 0.89 mm has been measured, using arc shield gas mixtures with nitrogen contents ranging from 0% to 100%. The ferrite contents in the weld zones were measured by both magnetic and metallographic techniques. The magnetic state of the weld zone material was measured via inductive and vibrating sample magnetometer measurements. Typically, α–ferrite exhibits a ferromagnetic response under an applied magnetic field. The microstructural properties of select weld specimens were examined via optical- and electron-microscopy, x-ray diffraction, and microhardness measurements. Some results found in this study differ significantly from commonly accepted behavior of welds formed by OTW in the presence of nitrogen. Welds formed with shield gas containing 20% or greater nitrogen showed large or complete suppression of magnetic phase formation, but the results at higher nitrogen contents were very equipment specific.

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