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Abstract

The main objectives of the current study were to further develop tensile and toughness testing protocols and to provide a better understanding of the factors that control both weld metal and HAZ microstructure and properties in pipeline girth welds. In this investigation, two series of rolled (1G) girth welds were made in X100 pipe of 36 in. diameter and 0.750 in. wall thickness using two pulsed-gas metal arc welding process variants: single and dual torch. The small-scale testing program included evaluations of all-weld-metal tensile strength, Charpy impact and standard fracture toughness measured by single-edge bend SE(B) tests, along with preliminary fracture toughness results using a single-edge tension SE(T) test developed at CANMET. Additional information was obtained from detailed microstructural characterizations of weld metal and HAZ regions along with microhardness testing. All-weld-metal tensile tests using round and strip tensile specimens showed variations with through-thickness location and in some case with clock position. Full stress-strain curves were generated, and 0.2% offset yield strength, flow stress, ultimate tensile strength, and uniform strain were measured and compared with pipe properties using calculated weld strength mismatch factors based on these properties. Charpy V-notch transition curves were generated for both weld metal and HAZ (notched within 0.5 mm of the fusion line). Fracture toughness of both weld metal and HAZ regions of single torch welds was assessed using standard SE(B) testing procedures with Bx2B preferred specimens notched through-thickness at the weld centerline and in the HAZ (within 0.5 mm of the fusion line). Full J-resistance curves were measured using SE(T) tests of surface-notched WM and HAZ specimens; the SE(T) test was designed to match the constraint of full-size pipeline girth welds.

Keywords

Pipeline, High-strength steel, Girth weld, Microstructure, Tensile property, Weld metal, HAZ