

Solid- vs. Tubular-Wire Electrode Welding of HPS Steels

By S. Nelson*, A. Seals* and Y. Adonyi**, LeTourneau University

This project is part of several hydrogen-induced cracking studies on the High Performance Weathering Steels (HPS) with 70 ksi yield strength. The study was initiated for Metal-Core wire/flux combination for Submerged Arc Welding (SAW) and Tubular electrodes for Gas Metal Arc (GMAW) and Flux Cored-Arc (FCAW) welding of these steels. Tubular electrodes are known to produce higher deposition rates than solid wires and allow for more flexibility in electrode formulation. The purpose of this research was to compare hydrogen-induced cracking of solid- vs. tubular-wire electrode deposits for the SAW, GMAW and FCAW welding processes.

The Gapped Bead-on-Plate (G-BOP) test was used for evaluation, after accelerated environmental exposure of the cored-wires was performed to high humidity and temperature. Deposit mechanical properties at high heat inputs were also measured, with emphasis on the effect of oxygen on the weld deposit toughness. At the same time, the effects of electrode stickout, arc length and welding current on the diffusible hydrogen of the deposit were quantified. The effect of using Pulsed- vs. Continuous Wave arc modes on G-BOP test results was also studied for the GMAW welding process.

It was found that modern metal and flux- core-wires were not as susceptible to moisture pick-up as in the past. However, the variation in diffusible hydrogen and total oxygen content in the weld deposit was greater than when solid wire electrodes were used. Thus, different preheat temperatures and heat inputs were required to eliminate cracking and produce acceptable mechanical properties than for solid wires. Pulsed-wave type current also resulted in higher cracking of G-BOP tests than regular Continuous-wave. It was found that this behavior was caused by changes in weld bead depth-to-width ratio and lower net heat inputs for equal arc energies.

It was concluded that, using proper shipping and storage conditions, modern cored-wire based consumables can produce similar properties as solid-wire based consumables and they should be used for welding of HPS steels. However, following specific guidelines to avoid variability in properties and adequate process qualification were recommended for the tubular wires.

* Research Associates, LeTourneau University, Longview, TX

** Professor, Omer Blodgett Chair of Welding and Materials Joining Engineering