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SELF-SHIELDED FLUX-CORED ARC WELDING - PRACTICAL APPROACHES FOR IMPROVED PERFORMANCE OF GIRTH WELDS IN HIGH-STRENGTH STEEL PIPELINES

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ABSTRACT

Self-shielded flux-cored arc welding (FCAW-S) has been widely used in some parts of the world for mainline and tie-in welding of large diameter pipelines for many years. FCAW-S offers high deposition rates and requires less equipment than gas-shielded wire processes. Consequently, FCAW-S is an attractive option for girth welding under difficult field conditions (e.g., windy, remote and/or challenging terrain) and is under consideration as an alternative to shielded metal arc welding (SMAW) with cellulosic electrodes due to several well-documented girth weld failures of predominantly newly constructed X70 pipelines in North America. While FCAW-S is not likely to produce weld properties as robust as is possible with mechanized gas metal arc welding (GMAW, GMAW-P) or gas-shielded flux-cored arc welding (FCAW-G), it is evident that FCAW-S offers higher performance and productivity than SMAW with cellulosic electrodes.

This paper provides a comprehensive update of key considerations and drivers that influence FCAW-S weld toughness, specifically the causes of seemingly large variation in CVN energy through the transition region. CVN transition curves were developed for seven E81T8 FCAW-S welds fabricated under a range of welding conditions represented by heat inputs ranging from 0.6 to 1.7 kJ/mm. Toughness performance, measured as mid-transition temperature was considered in the context of fracture morphology below the CVN notches and metallographic examination of notch locations in transverse and longitudinal weld sections. Analysis indicates that toughness improves when welding practices are employed that maximize the amount of reheated weld metal at the Charpy notch location. Comparison of CVN performance with E8010 cellulosic SMAW under welding conditions typical for pipeline girth welds, the FCAW-S exhibits higher upper shelf energies and lower mid-transition temperatures.

The FCAW-S and cellulosic SMAW were also compared relative to HAZ softening and weld strength overmatching using the data from microhardness maps. HAZ results indicate the FCAW-S will produce a narrower softened zone than the SMAW for a given steel at a comparable heat input. Weld metal results indicate greater potential for overmatching an X70 specified strength range with FCAW-S.

The outcome indicates that FCAW-S can be a viable option for girth welding of high strength pipelines provided certain process controls and welding practices are implemented. Recommendations for improving performance are provided for consideration.

Keywords: FCAW-S, SMAW, pipeline girth welds, weld toughness, welding practices, HAZ softening, strength mismatch

NOMENCLATURE

API ®	American Petroleum Institute®[2]
ASME®	American Society of Mechanical Engineers®[3]
AD	As-Deposited Weld Metal

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