Title

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Abstract

This paper showcases welding optimization results from a research program co-funded by US Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) and Pipeline Research Council International (PRCI) aimed at developing high-strength welding technologies and associated weld assessment and qualification procedures. The research program covered a wide range of topics, from linepipe specifications, weld testing, to essential variables and the correlations between the weld microstructure and mechanical properties. One of the primary outcomes of the program is an approach for improving the reliability and consistency of mechanical performance in narrow gap girth welds in high strength steel line pipe, specifically X100. Various weld metal chemical compositions were investigated with Pcm ranging from 0.2 to 0.3 under a range of welding conditions that include both single- and dual-torch variants of the gas metal arc welding (GMAW) process.

For weld metals at and above the X100 strength level, the results indicate that the optimum weld metal composition to achieve a desired balance of weld strength and impact toughness varies depending upon the specific welding process conditions in use. For example, a single chemical composition is unlikely to produce the same level of mechanical performance with both single- and dual-torch GMAW. Detailed analysis of the welding process variables indicates that the primary drivers influencing weld mechanical performance are weld chemical composition, True Heat Input, preheat/interpass temperature, and torch configuration. Over the typical range of variations observed in a typical narrow gap joint configuration, weld joint geometry does not appear to be a factor in controlling weld metal properties.

Results show that transfer functions developed from design of experiments (DOE) linking welding variables and the resulting weld mechanical properties provide a means for recommendations for control methodology of the welding process variables. Application of the control methodology to 5G pipe welding simulating field service conditions indicate that it can be implemented with proper monitoring of true heat input as well as the other aforementioned welding variables. This approach provides a means of reducing the variation in weld mechanical properties, and this is shown for the yield and tensile properties obtained in these welds.

Keywords
Pipeline, Girth welding, Strength, Toughness