

**D. Comparison of Friction Stir Weldments and Submerged-Arc Weldments in HSLA-65 Steel**

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The objectives in this task were to evaluate friction stir welding (FSW) tools and equipment, develop procedures, and demonstrate the feasibility of FSW 0.25-in thick HSLA-65 steel weldments fabricated from 10-foot long plate sections, on a production-size, purpose-built FSW machine. In addition to the above objectives, measurements were taken to compare the amount of weld distortion with that of a conventional submerged-arc weldment (SAW), and characterize the mechanical properties and microstructures of the weld regions.

Two types of tool materials were evaluated: a polycrystalline cubic boron nitride (PCBN) tool and W-25 %Re. Due to difficulties in establishing suitable operating parameters for the PCBN tools on the production-size FSW machine at CTC, only a short weld length was available for evaluation. W-Re was evaluated as a pin material in a two-piece FSW tool using a Mo-TZM shoulder. The W-Re pin performed well with minimal wear, but the Mo-TZM shoulder wore excessively during fabrication of the 10-foot weldment. Transverse and longitudinal weld distortion measurements were obtained on a useable six-foot length of this weldment and compared to those of a similar length of the SAW weldment. Transverse weld tensile, Charpy V-notch impact, and guided bend tests were obtained from the W-Re FSW weldments and the SAW weldment.

Distortion measurements indicated that both the FSW and SAW weldments exhibited significant longitudinal weld distortion, with the FSW weldment having marginally less distortion. However, the SAW weldment was bowed in the transverse direction, while the FSW weldment exhibited no transverse distortion. The mechanical properties of the weldments will also be discussed.

The results show that FSW of HSLA-65 using a W-Re tool is technically feasible and can be used to mitigate transverse weld distortion.

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