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TOP: Friction Stir Welding of Al-Alloy Pipes

Keywords: FSW; pipe welding; AA6082-T6, Aluminum Alloy; ANOVA

Findings

Circular sections are widely used in oil, gas, and chemical industries for fluid transport. However, fusion welding of these structures, particularly aluminium alloys like AA6082, poses challenges due to the need for pre/post-weld treatment, filler wire, welding skill, solidification defects, and a wide heat-affected zone (HAZ), all of which reduce joint strength. AA6082, commonly welded using AA4043 filler wire, often shows diminished mechanical properties due to these issues.

Friction stir welding (FSW), a solid-state process, has emerged as an effective alternative for welding aluminium alloys, offering benefits like improved microstructure, minimal HAZ, and the absence of solidification defects. Despite these advantages, applying FSW to pipes is difficult due to the complex tooling, pipe curvature, and limited tool-pipe contact area, which affect heat generation and material flow. Since research on FSW of pipes is relatively recent, optimization studies remain limited.

This study explores the effect of FSW parameters on AA6082 pipes (5 mm thickness) with outer diameters of 45, 60, and 80 mm. An H13 steel tool with a flat shoulder and square pin (4.24×4.24 mm, 4.4 mm length) was used. Key parameters varied include tool offset (2.5–3.5 mm), rotational speed (560–900 rpm), shoulder diameter (14–18 mm), and pipe diameter (45–80 mm). Experiments followed Taguchi's L18 orthogonal array, applying both single and double FSW passes.

Microstructural analysis using optical microscopy and SEM-EDS revealed distinct weld zones: stir zone (SZ), thermo-mechanically affected zone (TMAZ), and HAZ. The SZ showed fine grains, while tunnel defects and kissing bonds were observed in some samples. Vickers microhardness tests (0.3 kgf) exhibited a W-shaped hardness profile across the welds, with the lowest hardness in the HAZ.

Tensile tests (ASTM E8m standard) indicated the highest strength (315.7 MPa) in a single-pass weld on an 80 mm diameter pipe with 3.5 mm tool offset, 710 rpm, and 16 mm shoulder diameter. The same parameters in double-pass welding yielded slightly lower strength (274.5 MPa). Statistical analysis (ANOVA) confirmed parameter significance, and fractography revealed mixed ductile-brittle failure with dimpled features.

Brief Profile of Research Scholar

Name Jitendra Yadav
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Academic Career			
Course	Year of passing	Institute (Board/University)	Percentage
Ph. D	2021 (Year of registration)	Jamia Millia Islamia, A Central University, New Delhi	-
M. Tech. (Machine Design)	2008-2010	IIT Roorkee	7.2 CGPA
B. Tech. (Mechanical Engineering)	2001-2005	Govt. Engg. College, Rewa, M.P. (RGPV University)	70 %
12 th (PCM)	2000	SDM School, Gotegaon (M. P. Board)	75 %
10 th	1998	SDM School, Gotegaon (M. P. Board)	58%

Working Experience:

- Worked as an **Assistant Professor** (Mechanical Engineering Department) at SGIT Engineering College, Ghaziabad from August 2010 to July 2021.
- Worked as a **Lecturer** (Mechanical Engineering Department) COER from July 2005 to August 2008.