



Optimizing Joint Efficiency in Stainless Steel-Aluminum Alloy FSW Joints through Advanced Parameter Control

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Abstract

The present study investigates optimization of ultimate tensile strength (UTS) in FSW of AA2024-T3 and SS304 in a butt joint configuration. An L_{18} mixed-level orthogonal array was used to design 18 experiments, varying tool rotational speed (450, 560, and 710 rpm), traverse speed (20, 25, and 40 mm/min), and pin offset (1 and 1.5 mm toward the Al side). The tool rotational speed had the greatest influence on UTS, contributing nearly one-third of the total variance, followed by pin offset and traverse speed. The optimal combination, 450 rpm, 20 mm/min, 1.5 mm offset, yielded a UTS of

344.7 MPa and a joint efficiency of 78.3%. At this setting, peak temperatures reached ~ 356 °C, ensuring sufficient plasticization and uniform mixing of the Al-SS interface, producing a refined stir zone with an average grain size of 4.2 μm . Fracture analysis revealed ductile failure at the optimal parameters, whereas suboptimal conditions resulted in brittle or mixed fractures due to either insufficient or excessive heat input. These results demonstrate that Taguchi optimization effectively correlates process parameters, thermal profile, material mixing, and mechanical performance, enabling reliable, defect-free dissimilar FSW joints for structural and aerospace applications.

Keywords

FSW, SS304 / AA2024-T3, Optimization, Tensile strength, Fractography.

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