Experimental and computational analysis of thermal and mechanical characteristics in friction stir welding of dissimilar aluminum alloys with varying tool pin geometries

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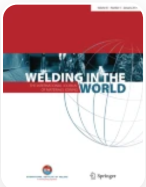

Welding in the World

Aims and scope

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Abstract

This study investigates friction stir welding (FSW) of dissimilar aluminum alloys AA6061-T6 and AA7075-T6, focusing on tool pin profile geometries and their mechanical performance. ABAQUS finite element analysis revealed complex energy dissipation characteristics, with the hexagonal pin profile demonstrating superior thermal and mechanical behavior. Frictional energy analysis showed the hexagonal profile generated 15% lower frictional heat compared to cylindrical profiles, while plastic dissipation energy measurements indicated 22% more uniform energy distribution. Peak plastic strain reached 0.68 at the weld interface, with the hexagonal pin profile exhibiting more consistent strain localization. At an optimal rotational speed of 1200 rpm, the hexagonal pin profile achieved the highest tensile strength of 608.12 MPa, representing a 33.5% improvement over cylindrical profiles. Microstructural analysis exposed refined grain structures and reduced intermetallic formation, while macrostructural examination highlighted improved joint integrity. These results provide critical insights for high-reliability dissimilar metal joining in aerospace and automotive industries, demonstrating the hexagonal pin's potential for enhanced welding performance.

Data availability

Not applicable.

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Contributions

R. Manikandan: Led the research project, developed the study concept, and supervised the experimental and simulation work. He also played a key role in drafting and finalizing the manuscript.

G. Elatharasan: Contributed to the experimental setup, conducted material flow analysis, and participated in data collection. He also assisted in the interpretation of the simulation results.

A. Parthiban: Provided expertise in stress analysis and was responsible for conducting the thermal characteristics experiments. He contributed to the analysis and discussion sections of the manuscript.

T.G. Sakthivel: Coordinated the research activities, performed the simulation studies, and took the lead in writing the manuscript.

T. Gopalakrishnan: Supported the research by conducting a thorough literature review and assisted in the statistical analysis. He also reviewed and contributed to the final manuscript revisions.

Ramesh Raju: Coordinated the research activities and handled the submission process and correspondence with the journal.

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Ethics declarations

Ethical approval

Not applicable.

Consent to participate

Not applicable.

Consent to publish

The authors agree consent to publish regarding the publication of this article.

Competing interests

The authors declare that there is no competing interest regarding the publication of this article.

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- Tool pin profiles
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