International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Effect of Friction Stir Welding Tensile Properties on the 2024-T3 Aluminum Alloy

[1]Sudhakar Uppada, [2]Lalith Kumar Gedi, [3]Someswara Rao Bhyri, [4]Jaya Krishna Muddada, [5]Harika Majji

[1,2,3,4,5] Mechanical Department, GMR Institute of Technology, Rajam, Andhra Pradesh, India
sudhakar.u@gmrit.edu.in

ABSTRACT:

Welding is a crucial part of a few enterprises, for example, automobile, aviation, mechanical technology and development. Many of these industries make systems and components out of aluminum alloys without welding. The presence of non-heat treatable alloys, porosity, solidification, and liquidation of cracks make friction stir welding of aluminum alloys difficult. Four distinct microstructure zones are formed in the weld during friction stir welding of metallic alloys, resulting in diverse mechanical properties. In the review, changes in the strength and elastic way of behaving of grating mix welds in Al 2024-T3 composite over the long haul are examined. The welded and heat-treated MFSC joints' microstructure, failure load, hardness, and fracture behaviour.

Keywords: Porosity, Solidification, Aluminum alloy, Liquidation of cracks

1. Introduction

Friction Stir Welding (FSW) is a strong state joining process created at TWI Ltd in 1991. A non-consumable tool is used in friction stir welding to rotate and plunge into the interface of two work pieces. The device is then traveled through the connection point and the frictional intensity makes the material intensity and mellow. FSW is prepared to create excellent welds without porosity, hardening deformities and breaking. It additionally delivers welds with phenomenal mechanical properties, like high strength and weakness obstruction. Aluminum has a smaller window of work ability than other metals and can easily result in burning due to its higher thermal conductivity and low melting point. All things considered FSW is utilized to weld aluminum parts rather than typical welding processes.

The greatest weld piece temperature (up to around 400-550 °C) causes warm mellowing, reinforcing encourage coarsening and disintegration into the Al grid during the erosion mix handling of precipitation solidifying Al amalgams. Solute misfortune initiated coarsening of hastens is accounted for to happen during the cooling pattern of the welding system. The outcomes of frictionally incited heat input on welds incorporate over-maturing (at the intensity impacted zone), and coarsening and solutionizing of reinforcing components (at the mix zone and thermoprecisely impacted zone). Inevitable characteristics of friction stir welded precipitation hardening Al alloys include decreased nugget hardness, nonhomogeneous particle distribution, and the Portevin-Le Chatelier effect (during the axial loading process). Therefore, friction stir welded precipitation hardening alloys must achieve maximum kinetics of hardness and strength recovery. Post-weld laser shock peening, in-process rapid cooling/underwater welding, and post-weld heat treatment cycle processes can further enhance the properties of as-welded precipitation hardening Al alloys.

The Friction Stir Welding process parameters includes the main role on the tensile properties on the 2024-T3 AA.

2. Literature

2.1 FSW Process Parameters:

Friction Stir Welding (FSW) is a solid-state joining process crucial for producing defect-free joints, with process parameters at its core, particularly heat input. Optimal control over FSW parameters significantly impacts joint quality, ensuring the absence of defects such as cracks. The interplay between tool variables, machine variables, and material properties is instrumental in achieving high-quality FSW joints.

2.2 Tool Variables:

The design and specifications of the FSW tool, including shoulder diameter, pin diameter, pin length, and material composition, directly influence the welding process. The tool's geometry dictates heat generation, material flow, and the mechanical interaction with the workpiece. Proper tool selection ensures efficient heat generation and plasticized material flow, mitigating the risk of defects.

2.3 Machine Variables:

Parameters like rotational speed, welding speed, tilt angle, and applied force are critical machine variables. Rotational speed regulates the frictional heat generated, while welding speed affects material flow and joint formation. The tilt angle influences material displacement and the welding tool's penetration into the workpiece. Applied force affects material consolidation and joint quality.

2.4 Material Properties:

The properties of the base materials being welded profoundly impact the welding process. Material composition, thickness, and mechanical properties influence how the material responds to the heat and mechanical forces during FSW. Variations in material properties can affect heat generation, material flow behaviour, and the susceptibility to defects.

2.5 Impact on Joint Quality:

The careful selection and control of these variables are pivotal in achieving defectfree FSW joints. Improper parameter selection or deviations can lead to defects, primarily cracks, within the welded joint. Inadequate heat input or excessive material displacement due to incorrect parameter settings can result in poor fusion, incomplete bonding, or excessive stresses, leading to crack formation.

2.6 Optimization Strategies:

To obtain high-quality joints, a systematic approach involving parameter optimization, process monitoring, and material characterization is essential. Advanced techniques such as numerical modelling, experimental design methodologies, and in-situ process monitoring aid in determining the optimal parameter ranges for specific materials and joint configurations. Iterative adjustments based on empirical data and process analysis help fine-tune parameters for defect-free welding.

In summary, achieving defect-free FSW joints necessitates a holistic understanding and precise control of tool variables, machine variables, and material properties. Their synergistic optimization ensures proper heat input, material flow, and consolidation, mitigating the occurrence of defects like cracks and ultimately enhancing the overall quality and reliability of FSW joints in various applications.

Due to this, the impact on the tensile properties of the friction stir welds of the aluminum alloy will become solute and the making this alloy property will increase and the strength of the joint is gradually increase or decrease as the joint is made by pure heat.

3. Experimental Procedure:

Aluminum alloy plates measuring 150 × 70 mm and 4 mm in thickness underwent buttseam welding using a conventional tool, depicted in Fig. 1. The welding tool specifications included a shoulder diameter of 18 mm, pin diameter of 5 mm, and pin length of 3.8 mm. Welding parameters such as a tilt angle of 1.5°, rotational velocity of 1200 rpm, and welding speed of 100 mm/min were employed to create the weld joints. Post-welding assessments comprised X-ray examinations, with select samples additionally photographed after aging for 24 months. Mechanical tests were conducted on the welds at two distinct time points: immediately after welding (0 days) and after a duration of 2 years. Notably, all specimens were stored in the laboratory under natural environmental conditions throughout this aging period. Vickers hardness tests were executed on prepared surfaces using a 0.5 kg load applied for 15 seconds, with a step increment of 1 mm. These tests covered half of the weld thickness, as visually depicted in Fig. 2.

(a) (b)

Fig. 1. (a) Clamping system, (b) Welding tool (unit: mm).

Additionally, tensile test specimens were meticulously prepared perpendicular to the weld direction, adhering to the standards outlined in ASTM standard E-8, as illustrated in Fig. 3. Tensile tests were performed at room temperature (~20°C) under controlled displacement loading at a cross-head speed of 0.1 mm/s.

This crucial parameter is expressed per unit volume and calculated from the area beneath the stress-strain (tensile) curve. The comparison of mechanical properties, hardness, and tensile strength between the freshly welded and aged specimens provides valuable insights into the longterm structural integrity and performance of the welded joints in the aluminum alloy plates. The experimental methodology and comprehensive examination of the welds at varying time intervals aim to elucidate the influence of aging on the mechanical characteristics of the welded joints. The outcomes of these tests hold substantial implications for understanding the durability, reliability, and aging effects on the welded aluminum alloy structures, contributing significantly to material science and engineering practices.

Aluminum alloys are particularly wellsuited for FSW due to their favorable properties, including high thermal conductivity, low melting point, and susceptibility to hot cracking during fusion welding. FSW minimizes these concerns by using a non-consumable rotating tool to mechanically mix and without reaching the melting point, resulting in joints with excellent mechanical properties

Fig. 2. The microhardness specimen (unit: mm).

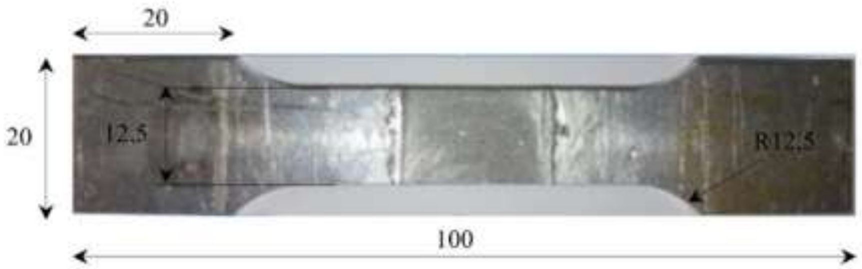

Fig. 3. The tensile test specimen (unit: mm).

(b)

(a)

Fig. 4. (a) Friction-stir weld in 2024-T3 aluminum alloy, (b) X-ray image of the weld.

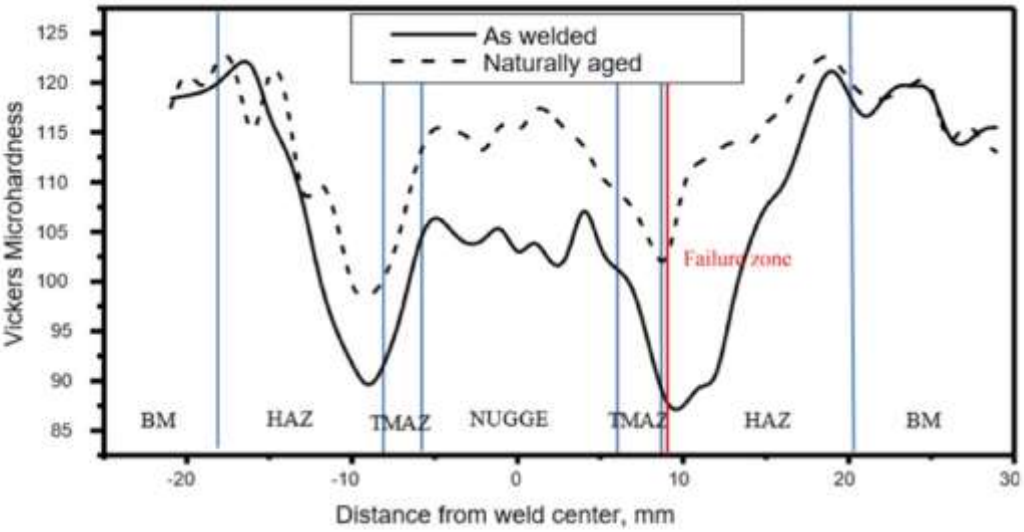

Fig. 5. Micro hardness map of a friction stir weld in 2024-T3 aluminum alloy

The above diagram indicates the microhardness map of a friction stir weld in2024t3 aluminum alloy and the tensile properties of the AA 2024-T3.

This experiment delves into the intricacies of utilizing Friction Stir Welding (FSW) to join Aluminum-Based Composites

(ABCs), shedding light on microstructural changes, hardness variations, and ductile properties observed in the resulting weldments. FSW shows promise in joining ABCs, known for their unique properties derived from aluminum matrices reinforced with various materials. The survey meticulously analyzes microstructural evolution, highlighting changes in grain morphology and intermetallic phases within weld and affected zones. It also covers hardness variations across different weld regions, crucial for assessing mechanical strength, and extensively discusses tensile properties such as strength, ductility, and fracture behavior. This review serves as a vital resource for researchers, engineers, and scientists seeking deeper insights into optimizing FSW for ABCs, paving the way for advancements in material development and high-performance structure design.

4. Conclusion:

The deformation behavior of a freshly welded, friction-stir butt-seam-welded 2024-T4 aluminum alloy plate (4 mm thick), which was allowed to age for 24 months without loading, is the subject of this study. The picked apparatus and welding boundaries empower us to acquire sound welds with acceptable mechanical qualities in the embraced setup. In light of maturing, the weld strength (mechanical obstruction) expanded by 9% which didn't forestall the weld durability of dropping by 19% in view of a lower deformability (−27% of lengthening). It ought to be noticed that all breaks in elastic tests happened in the intensity impacted zone of the new welds and the normally matured welds. The production and utilization of mechanical structures made from this material may benefit from these outcomes.

References

[1] S. Hassanifard, A.Ghiasvand, S. M. Hashemi, A. Varvani. Effect of natural aging on the tensile properties and toughness of friction stir welds of 2024-T3 aluminum alloy. Journal of Advanced Joining Processes

[2] M. Paidar, K. Tahani, R. Vaira Vignes, O. O. Ojo, H. R. Ezatpour, A. Moharrami Modified friction stir clinching of 2024-T3 aluminium alloy. Material Science and Engineering

[3] Rui-dong Fu, Jian-feng Zhang, Yi-jun Li, Ju Kang Effect of heat input and post-welding natural aging on hardness of stir zone for friction stir welded 2024-T3 aluminium alloy. Material science and Engineering

[4] S. Hassanifard, A.Ghiasvand, S. M. Hashemi, A. Varvani The effect of the friction stir welding tool shape on tensile properties of welded Aluminium joints. Materials Today Communications

[5] R. S. Mishra, Z. Y. Ma Friction stir welding and Processing Material science and Engineerig

[6] K. J. Colligan, The friction stir welding: an overview, Woodhead Publishing series in welding and other joining technologies

[7] V. K. Yadav, V. Gaur, I.V. Singh, Corrosion-Fatigue behavior of welded aluminum alloy 2024-T3, International Journal of Fatigue

[8] Caizhi Zhou, Xinqi Yang, Gouhong Luan, Effect of root flaws on the fatigue property of friction stir welds in 2024-T3 aluminum alloys, Material Sciences and Engineering

[9] H.J.K. Lemmen, R.C. Alderstien, R. Benedictus, Fatigue initiation behaviour throughout friction stir welded joints in AA 2024-T3, International Journal of Fatigue

[10] Hakan Aydin, Ali Bayram, Ismail Durgun, The effect of Post weld heat treatment on the mechanical properties of 2024 T3 friction stir welded joints. Material and Design

[11] D. Ambrosio, Y. Morisada, K. Ushioda, H. Fujii, Material flow in friction stir welding: A review, Journal of Material Processing Technology

[12] Connor Strawn, Alvin M. Strauss, Investigation of friction stir welding for lunar applications, Acta Astronautica

[13] M. Dilip Kumar, K. Ankaiah, P. Sujatha, P. Bharath Kumar Experimental investigation of friction stir welding of aluminum alloy, Material Today: Proceedings

[14] Sachinkumar Patil, M. Nagamadhu, S. H. Prasanth, N. Santhosh A survey on friction stir welded aluminum composites and their microstructure, hardness, and tensile properties, Material Today: Proceedings

[15] Patrick L. Inacio, Francisco B. Ferreira, Pedro Vilaca, J. P. Oliveira, Telmo G. Santos, Assessment of the energetic efficiency of friction stir welding and processing, Journal of Manufacturing Processes