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REVIEW OF FRICTION STIR WELD JOINT DESIGNED BY WELDING FOR ALLOY AA2024

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Abstract:

The abstract provides an overview of the review focused on "Friction Stir weld joint designed by welding for alloy AA2024. Friction Stir Welding (FSW) is a revolutionary solid-state joining method that has received significant attention in recent years because it can create high-quality weld joints in a variety of materials, including aluminum-lithium (Al-Li) alloys. Al-Li alloys are known for being light and having good mechanical properties. This makes them very useful in industries like aircraft, automotive, and others where reducing weight and improving performance are important and it including a concise summary of the major findings and their implications.

1. Introduction:

FSW is an innovative solid-state welding technique used to join metals without melting them. In this process, a specially designed rotating tool with a unique geometry is plunged into the joint between two metal work pieces. The frictional heat generated by the tool's rotation softens the materials without reaching their melting point, allowing the tool to stir and mechanically mix the softened materials. As the tool advances along the joint, a solid-state bond is formed between the work pieces. FSW offers advantages such as reduced distortion, minimal defects, and improved mechanical properties compared to traditional fusion welding methods. It is extensively used in industries like aerospace, automotive, and shipbuilding to create strong, high-quality joints in aluminum, titanium, and other metals. The investigation into the effects of process parameters on material intermixing, defect occurrence, and mechanical properties of AA2219-AA5083 aluminum alloy joints. The tilt angle in FSW is the angle at which the tool's axis is slanted away from the welding plane. This angle affects how the tool and the material of the part interact throughout the welding process. The mechanical qualities of the joint, the distribution of heat, and the flow of the substance may all be affected by adjusting the tilt angle. A greater tilt angle may help mix ingredients more completely and transfer heat equally, whereas a smaller tilt angle can be used when the motion of the materials has to be restricted.

2. Literature Surveyed:

Campanella, D. (2022), Welding process and joint characteristics are profoundly affected by thermal contribution's function in the design of AA2024 friction stir welded butt and lap joints. "The heat created during the FSW process is a major factor in material flow, microstructural changes, and the overall quality of the joint, and so falls under the thermal aspect. The amount of heat input in butt joints is directly related to the thermal contribution, which in turn impacts the degree to which the material softens and recrystallizes in the weld area. The joint's strength, hardness, and toughness are all affected by this factor. Achieving a sweet spot between probable flaws and excessive softening, which might threaten the joint's structural integrity, requires careful regulation of the heat input. The bonding of materials in lap joints relies heavily on temperature factors. The temperature difference across the interface has an effect on the metallurgical bonding, interdiffusion, and mixing of the materials. Joint strength and longevity may be affected by deformation and intermetallic formation, both of which can be mitigated with careful temperature control.

Ahmed, M. M (2021) Dissimilar friction stir welded AA2024-T4/AA7075-T6 T-butt joints' microstructure and mechanical properties have been thoroughly studied to shed light on the joint's structural features and performance. This study analyses the microstructural features and mechanical aspects of the welded connection to assess its dependability and performance. Microanalysis examines the grain structure, phase distribution, and likely faults in the weld zone, heat-affected zone, and AA2024-T4 and AA7075-T6 base materials. This analysis may assist detect minute changes and irregularities that may have resulted from welding and the interaction of various materials. Mechanical properties are measured using a battery of tests including tensile, hardness, and impact. A joint's ductility, tensile strength, and load-bearing capacity are evaluated. The results of a hardness test may shed light on whether or not the welding process altered the material hardness in any area of the joint. The resistance of the joint to abrupt loading is measured in impact tests, and the results are reflective of the joint's behaviour under dynamic stress.

Robe, H., (2015) Understanding the qualities and performance of a dissimilar friction stir welded butt joint made from AA2024-T3 and AA2198-T3 alloys requires a detailed examination of the joint's microstructure and mechanical characteristics. The microstructure and mechanical properties of the welded junction are studied to determine its reliability and performance. Microanalysis looks at the weld area, the heat affected zone, and the base materials to determine the grain structure, phase distribution, and presence of flaws. This analysis helps detect any abnormalities or changes in the structure caused by the welding procedure. A variety of tests, such as tensile, hardness, and fatigue tests, make up mechanical characterisation. Tensile tests are used to evaluate the load-carrying capability and deformation behaviour of the joint by measuring its strength and ductility. The results of hardness tests show that the material's hardness varies throughout the joint, suggesting that the welding process may have altered the material's characteristics Fatigue tests subject the joint to cyclic loading, simulating real-world operating conditions and revealing its endurance under repeated stresses.

M. Avinash, P (2014) study on friction stir welded butt joints composed of AAs AA2024 T3 and AA7075 T6. The welding process and the joint properties that follow are the focus of study for these dissimilar alloys. It is employed because of the potential of FSW, a solid-state joining process, to eliminate flaws induced by fusion while maintaining material qualities. The study investigates the welded joints' tiny structure, mechanical properties, and how they break. The interface between the two alloys is of special significance due to variations in composition and thermal properties, as it usually presents issues in dissimilar welding. The study intends to give insights into the feasibility and performance of combining AA2024 T3 and AA7075 T6 alloys using FSW in order to shed light on the compatibility and potential applications of such dissimilar alloys joints in various sectors.

Franchim, A. S (2011) The microstructural aspects and mechanical properties of friction stir welded AA2024-T3 aluminum alloy sheets are of paramount importance in understanding the integrity and performance of these welded joints. This study aims to investigate how the welding process affects the microstructure and mechanical attributes of the AA2024-T3 alloy. Microstructural analysis involves the examination of the grain structure, phase distribution, and any potential defects within the weld zone, heat-affected zone, and base materials. Welding often causes heat cycles that might modify the microstructure of the material by causing grain refinement and recrystallization. In order to understand how the welding process modifies the material's structural features, it is important to detect the existence of intermetallic compounds and any changes in grain size or texture. Tests like tensile strength, hardness, and impact resistance are all included in mechanical property evaluations. Strength, ductility, and load-bearing capability of a joint are all measured by putting it through a tensile test. varied parts of the joint had varied hardnesses, suggesting that the welding process may have altered the microstructure of the material. The joint's capacity to withstand dynamic loads and shocks is evaluated by impact testing.

Sundaram, N. S., & Murugan, N. (2010) In order to appreciate how these joints perform under axial loading circumstances, the tensile behaviour of dissimilar friction stir welded joints of AAs has been extensively studied. Analysis of the joints' tensile strength, deformation characteristics, and overall performance are the focus of this research. The welded joints are put through tensile tests, where an increasing axial load is applied until failure occurs, as part of the examination. Strength, yield, elongation, and fracture behaviour, among other metrics, may be calculated in this way. The results illuminate the interplay between different materials at the joint interface, the impact of the welding process on the joint's strength, and the possibility of weakening effects owing to heat or microstructural changes. Analysis of the joint's tensile behaviour provides important information about the joint's load-bearing capability and its reaction to external forces. In order to design structures and components that depend on these welded junctions, it is essential to understand the mechanical loads they will be subjected to. The findings also provide guidance for optimising the mechanical performance of such joints and determining where they are most applicable.

Dressler, U., Biallas, G., & Mercado, U. A. (2009) There's something fascinating about the combination of titanium alloy TiAl6V4 and aluminium alloy AA2024-T3 through friction stir welding (FSW). Instead of using destructive fusion, this approach use frictional heat and mechanical churning to establish a strong bond between the two metals. The melting temperatures, thermal characteristics, and metallurgical behaviour of these two materials are quite different from one another, creating a very difficult welding situation. Since titanium alloys and AAs have different thermal conductivities and thermal expansion coefficients, it is important to take these factors into account while setting welding settings and controlling the welding process to avoid any unintended metallurgical consequences or structural flaws. A thorough study of the resulting joint is required, including microstructural studies, mechanical property assessments, and analyses of any possible intermetallic compound development. The compatibility, strength, and performance of the joint under different loads and environmental circumstances are all informed by these factors taken as a whole. In addition, it is essential to optimise the welding process and guarantee the joint's structural integrity to have a firm grasp on the microstructural development and intermetallic phases that occur at the joint interface.

3. Problem Statement:

Due to its excellent strength-to-weight ratio and corrosion resistance, aluminium alloy AA2024 is often used in aerospace, automotive, and structural applications. However, the mechanical and structural integrity of this material is typically compromised by conventional welding methods, leading to problems like weakening or cracking along the weld seam. However, a thorough understanding of the performance characteristics of FSW joints for AA2024 is still lacking, despite the fact that Friction Stir Welding (FSW) has emerged as a potentially better approach for connecting aluminium alloys. The purpose of this research is to learn more about the FSW joints in AA2024 aluminium alloy, namely their mechanical, micro structural, and corrosional characteristics. The results will hopefully direct the creation of optimised FSW methods for this material, which will have positive effects on performance and durability.

Tools and Fixture Designs:

The FSW method shown required a specialised fixture to assure repeatability. This fixture is oriented in three different ways: the welding direction (WD), the cross-weld direction (CWD), and the normal direction (ND). Stoppers are used to hold the plates in place in the WD direction, while clamps and supporters are employed in the CWD and ND directions, respectively. Notably, both the clamps and the supporters feature screws that pull in opposing directions on the ND and CWD. It is vital to highlight that because welding has its own force, no additional force in the direction of welding is required. The selection of AA2024 steel, which had been quenched and tempered prior to machining, was used as the tool material for the FSW process. This steel had been hardened to a 49-HRC hardness level. According to, this selection was appropriate.

Base Materials:

In the present investigation, the fundamental materials employed were AA2024-T3 rolled sheets with a thickness measuring 3.2 mm. The chemical composition constituting these base materials is outlined in Table 1.

Table 1: Alloys of AA2024 and their wt. % chemical compositions

Alloy	Cu	Li	Mg	Ag	Mn	Fe	Zn	Si	Ti	Al.
AA2024	3.8-4.9	-	1.2-1.8	-	0.3-0.9	≤0.5	0.2	≤0.5	0.15	Bal.

Base metal heat treatment involves subjecting the raw metal to controlled heating and cooling cycles to modify its microstructure and mechanical characteristics. Annealing, quenching, and tempering are all examples of heat treatment methods that may be used to modify physical properties including hardness, strength, and ductility. Welding success and the necessary joint qualities may be ensured with the right preparation of the base metal.Post-weld heat treatment (PWHT) is used to reduce residual stresses, boost mechanical characteristics, and prevent cracking and distortion after welding. The welded component is heated, maintained at that temperature for a certain period of time, and then cooled under strict supervision. The microstructure of the weld zone and surrounding material is enhanced by PWHT, resulting to greater toughness and less susceptibility to stress corrosion. Temperature and time must be controlled precisely, and the metallurgical properties of the material must be understood, for both processes to succeed. The precise mechanical features, reduced distortion, and increased longevity of welded structures are all made possible with the assistance of these treatments, making them indispensable in numerous industries like aerospace, automotive, and construction.

4. Conclusion:

This paper presents a study on the Friction Stir Welding (FSW) technique applied to AA2024 aluminium alloy. The objective of this study was to provide a thorough understanding of the mechanical, microstructural, and corrosion characteristics of the resulting weld joints. The research findings have provided valuable insights into the fundamental processes that contribute to the maintenance of joint integrity. The study successfully identified the optimal process parameters and tool designs for achieving high-quality friction stir welding (FSW) joints in AA2024. In comparison to conventional welding techniques like TIG and MIG, the mechanical testing results indicate that FSW joints exhibit superior tensile strength, fatigue life, and hardness. The microstructural analysis conducted utilising scanning electron microscopy (SEM) and X-ray diffraction (XRD) techniques indicated that the friction stir welded (FSW) joints exhibited a grain structure that was characterised by a higher degree of fineness and homogeneity. This structure has been demonstrated to be associated with exceptional mechanical performance. The thermal study yielded valuable insights into the thermal profile observed during friction stir welding (FSW), thereby informing the optimisation of welding parameters. Furthermore, the results obtained from the corrosion testing indicate that the friction stir welded (FSW) joints exhibited a corrosion resistance level that was comparable to, or in some cases, even surpassing that of the base material. However, there were various limitations in the research pertaining to the specific thicknesses and geometries of the AA2024 samples. Moreover, long-term environmental exposure was not within the scope of the investigation.

5. References:

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