AN OVERVIEW ON FRICTION STIR WELDING

Joshva J[1], Dr.K.Venkatesan[2], Prof.D.Noorullah[3]
[1]*PG Student, Department of Metallurgical Engineering*
[2]*Associate Professor, Department of Metallurgical Engineering*
[3]*Head of the Department, Department of Metallurgical Engineering*
[1, 2 3,] *Government College of Engineering,Salem-11*

Abstract-Friction Stir Welding (FSW) is a solid-state welding process. Low distortion, absence of melting related flaws, and good joint strength are the main benefits of this process. Friction Stir Welding has now grown to be a significant joining method in the shipbuilding, railway, and aerospace industries, particularly when fabricating aluminium alloys. The procedure involve in it produces frictional heat in the work piece by spinning a non-consumable tool. This study examines a review of the friction stir welding method and numerous welding factors for joining aluminium alloys or various dissimilar alloys, such as tool rotation, transverse speed, tilt angle, plunge depth, and tool design. This joining technique is energy efficient, environment friendly and versatile.

Keywords: Friction stir welding, microstructure, welding speed, tensile strength, axial force, tool rotation speed, corrosion.

INTRODUCTION

For designers and technicians, welding aluminium and its alloys has long been a significant issue. Particularly with heat-treatable aluminium alloys, fusion welding methods have troublesome. Due to their poor solidification microstructure and fusion zone porosity, aluminium alloys are often unweldable using traditional welding techniques like arc welding and gas welding. Moreover, there are significant losses in mechanical qualities relative to the underlying material. Traditional fusion welding of aluminium alloys frequently results in a weld with flaws, like porosity that develops as a result of trapped gas being unable to escape from the weld pool during solidification. The sWelding Institute (TWI) invented and patented the friction stir welding (FSW) solid-state joining process to be used on high strength alloys (2xxx, 6xxx, 7xxx, and 8xxx series) for aerospace, automotive, and marine applications that were challenging to connect with traditional methods.

WORKING PRINCIPLE OF FSW

Friction stir welding (FSW) is a solid-state joining technique in which coalescence occurs owing to thermomechanical deformation of workpieces as the resulting temperature exceeds the solidus temperature of workpieces. A cylindrical tool with a profiled shoulder is used in the friction stir welding process. It is gently moved into the joint between two pieces that are linked together using butt joints, creating wear-resistant frictional heat between the work piece material and the welding tool.

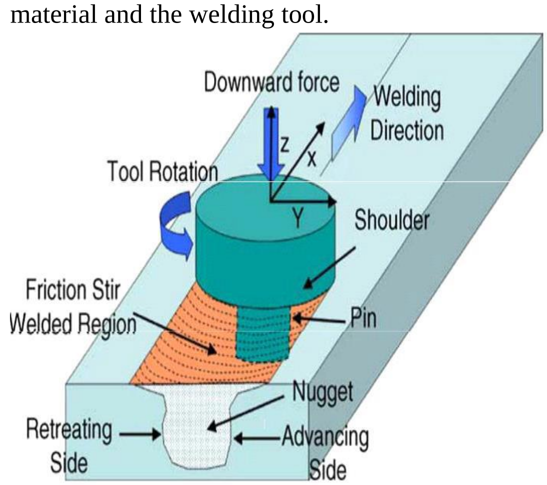

Figure.1 Schematic diagram of FSW

Without melting the tool, this heat enables tool movement along the weld line. The working principle of FSW is explained in the schematic diagram above. The plasticized material is forged by the contact of the shouldered tool and pin profile and is transferred from the front edge of the tool to the back edge of the tool probe. The following materials are joined via friction stir welding:

- Copper and its alloys
- Zinc
- Magnisium and its alloys

- Titanium and its alloys
- Nickel alloys
- Plastics
- Mild steel
- Stainless Steel
- Lead

PROCESS PARAMETERS

1. TOOL GEOMETRY: This is a crucial component since it has the potential to increase both the maximum welding speed and the weld quality. A tool material that is robust, tough, and long-lasting at the welding temperature is a requirement.

2. TOOL ROTATING SPEED: A solid state joining technique called friction stir welding involves creating friction between a tool pin profile and a plate in order to weld. Rotational speed influences the formation of friction. Weld quality is likely to improve or deteriorate in direct proportion to the tool's spinning speed.

3. WELDING TRAVEL SPEED: When welding speed is increased, the temperature at the local position falls. While the temperature will rise when the feed pace is slow.
4. AXIAL FORCE: One of the key process variables that will cause friction between the tool and the work piece is axial force. If the material's thickness is increased, the axial force also increases.

5. TOOL TILT ANGLE: The interaction section employs the Coulomb friction model. The findings indicated that tilt angle raises the temperature and frictional force of welding. These factors are said to have an impact on the tool's backside material flow velocity.

WELD ZONES
- Unaffected Material
- Heat Affected Zone (HAZ)
- Thermo-Mechanically Affected Zone (TMAZ)
- Weld Nugget (Part of Thermo mechanially affected zone

APPLICATIONS OF FSW

The FSW technique has a wide range of applications. of which several are listed below.
1. In the construction of railroad tankers and container bodies, FSW is employed.
2. Also utilised in the construction of hulls, aluminium extrusions, and offshore accommodations in the maritime, marine, and automotive sectors.
3. FSW may also be used for the housing of electric motors, kitchen appliances, gas tanks, gas cylinders, and the connecting of copper or aluminium coils in rolling mills.
4. This technology is utilised by every sector of the transportation sector, including pipelines, storage tanks, shipbuilding, offshore transportation, rail (high-speed trains, carriages), automobile (chassis, wheel rims, space frames, truck bodies), and aerospace (civil and military aircraft).
5. widely employed in manufacturing light constructions, doors, furniture, motorcycles, land transportation, and refrigeration

LITERATURE SURVEY

[1] Sunggon et al. (2008) Variations in the welding parameters, such as rotation and welding speeds, were made in order to investigate the tensile behaviour of friction stir welding for AA6061-T651. The tensile test demonstrates that reducing welding speed or increasing rotation speed lowers the percentage elongation of friction in AA6061-T651. The impact of process factors also affects yield and ultimate tensile strength.

[2] Kumaran et al. (2011) Many improvements in the area of materials processing have been made as a result of this research. An essential method for attaching solid-state components is friction welding. In this study, friction welding of tube-to-tube plate with an external tool (FWTPET) was carried out, and Taguchi's L27 orthogonal array was used to prioritise the process parameters. The parameters of the welding process are optimised using a genetic algorithm (GA). By calculating the difference between the welding process parameters that were predicted and those that were actually produced experimentally, the practical importance of applying GA to the FWTPET process has been confirmed.

[3] Singh et al. (2011) researched about the effect of post weld thermal treatment (T6) on the microstructure and mechanical properties of friction stir welded 7039 aluminium alloy joints. By welding at 8 and 12 mm/min while maintaining a constant rotating speed of 635 rpm, FSW characteristics were improved. It was found that the stir zone has finer granules than the thermomechanically affected zone (TMAZ). The findings showed that PHWT increases the percentage elongation of the joints while decreasing the yield strength and ultimate tensile strength.

[4] Sato et. al. (2001) examined the precipitation pattern in an AA6063 aluminium friction stir weld after post-weld ageing. It was observed that FSW causes a softened area in the weld. The dissolved zone contains a minimum hardness region. It was discovered that there is a rise in hardness after post-weld ageing. He performed post-weld ageing at 443 K for a period of 12 hours, increasing the hardness in the welded area.

[5] Zhang (2012) studied that, the thermal modelling of underwater friction stir welding (FSW) was undertaken employing a three-dimensional heat transfer model. To clarify the boundary conditions of underwater FSW, the vaporising properties of water were examined. The modelling took into account the material's temperature-dependent characteristics. The computed results showed good agreement with the experimental data when FSW experiments were conducted to validate them. Although the surface heat flow of the shoulder during the underwater FSW is larger than that during the normal FSW, the results show that the highest peak temperature of an underwater joint is much lower than that of a normal joint. For underwater junction, the high-temperature distribution region is dramatically narrowed and the welding thermal cycles in different zones are efficiently managed in contrast to the regular joint.

[6] Sigematsu et al. (2003) joined cold rolled 5083 with AA6061 by FSW under varied rotational speed and traversing speed of the tool. He noticed that whereas the soft, heat-affected zone was unaffected, age increased the hardness at the interface.

[7] Peel et al. (2003) By adjusting the welding parameters, such as tool design, rotation speed, and translation speed, AA5083 aluminium alloy was employed for FSW. Investigations into the microstructure, mechanical characteristics, and residual stress of four aluminium AA5083 samples showed that thermal input has a greater impact on welding parameters than tool-induced mechanical deformation.

[8] Panaivel et al. (2012) based on the influence of tool rotational speed, pin profile, and tensile strength aluminium alloys, demonstrated that different FSW of AA5083-H111 and AA6351-T6. The square tool pin, hexagonal pin, octagonal pin, tapered pin, and cylindrical pin are crucial factors to improve tensile strength and defect-free weld. The three material flow regions—mechanically mixed region, unmixed region, and mixed region—were discovered and noted.

[9] Park et al. (2010) examined the results of putting 5052 and 6061 aluminium alloys on the advancing and retreating sides. It was claimed that improper mixing caused A5052 placed in the retreating side to create thinner weld nuggets.

[10] Sakthivel et al. (2009) By adjusting the traverse speed from 50 mm/min to 175 mm/min, researchers examined the impact of various welding speeds on the alloy's metallurgical and mechanical qualities. It was discovered during the tensile test that the development of insufficient heat input results in a drop in ultimate tensile strength with a rise in traversal speed. On the other side, slower welding speeds result in more heat generation.

[11] Dhilip et al. (2010) It is justified that material placement, tool positioning, and process parameters depending on the characteristics of the materials to be joined affects the welding of the dissimilar metals in FSW.

[12] Hassan et al. (2010) examined the microstructure and mechanical properties of plates made of different cast aluminium alloys A319 and A356 that were bonded using FSW. He looked at the impact of post-weld heat treatment and tool rotational welding speeds. A solutionizing temperature of 540°C is used for the post-weld heat treatment for 12 hours, followed by 6 hours of ageing at 155°C. Increases in tool rotating speed or decreases in welding speed are observed to increase the hardness at the weld zone. According to their research, increasing the tool's

rotational speed increases the joint's ductility but decreases its tensile and yield strength.

[13] Taylor et al. (1999) analysed alloys of the type AI-Si-Cu that contain Fe. They discovered that the iron creates the AI5FeSi intermetallic phase according to the data. Because to the difficulty in feeding the liquid metal into the crevices, these platelets look under an optical microscope as needles with shrinkage pores.

[14] Da Silva et al. (2011) The impact of joining settings on the mechanical characteristics, microstructural characteristics, and material flow of different FSW of 3 mm-thick AA2024-T3 and AA7075-T6 joints was examined. Using the stop action technique, he looked at how the mixing performed in terms of hardness and tensile testing. The findings of the SEM observations showed that no onion rings were forming. There is no material mixing occurring in the stir zone. A cavity develops on the pin's back as a result of an unstable rotating flow.

[15] Li et al. (1998) AA2024 aluminium to AA6061 alloy flow visualisation and residual microstructures were analyzed. It was noted that the residual, equiaxed grain at the FSW joint, which ranges in size from 1 to 15 mm, creates a superplastic flow. The residual micro hardness was found to be reduced by 40% in the AA6061 and by 50% in the AA2024 at higher speeds (> 800 rpm).

CONCLUSION

The researchers concluded from the provided literature evaluation that each procedure of parameter has a unique effect on the characteristics of the joints. Axial force, tool pin profile, tilt angle, and tool rotating speed are a few of them. This study contributes to our understanding of the several industries in which aluminium and its alloys are used. Industries cannot imagine alloys without the use of aluminium. Its significance may be seen in the welding of the aluminium alloy. The goals are derived from the literature review investigates the impact of FSW process parameters on weld tensile strength, weld quality, and the investigation of the impact of FSW process parameters on heat affected zone.

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