International Journal of Research in Engineering, Science and Management
Volume-2, Issue-1, January-2019
www.ijresm.com | ISSN (Online): 2581-5792

A Review on Friction Stir Welding of Aluminum Alloys

Sharda Sharma[1], P. Sudhakar Rao[2]
[1]*ME Scholar, Department of Mechanical Engineering, NITTTR, Chandigarh, India*
[2]*Assistant Professor, Department of Mechanical Engineering, NITTTR, Chandigarh, India*

***Abstract*: Friction stir welding is a solid -state welding process in which metals are heated up to a suitable temperature with high pressure without melting the parent parts to be Joint. So that a homogeneous mixture of welding can be achieved. Consequently, FSW welding has superior properties compared to arc welding. In this welding uses a cylindrical rotating tool (non-consumable) with a profiled pin that penetrates into the parts to be joined. FSW mostly used for soft materials and alloys ex-AL alloys, Due to high tool wear out the cost. FSW tool design, which plays an important role included the geometry of tools, material selection, that affect heat generation, joint strength, plastic flow, thus resulting in microstructure and mechanical properties.**

***Keywords*: Friction stir welding process, Mechanical properties, Tool material Al alloy, Effect of tool material on metal Joint.**

1. Introduction

The friction stir welding (FSW) process was invented in 1991 by The Welding Institute (TWI) at Cambridge, in the UK. After that, it is developed and was getting a legal form by The Welding Institute. The first built and commercially friction stir welding machines were produced by ESAB. Friction-stir welding (FSW) is a solid-state joining process in which a rotating tool rotates at a certain speed with a shoulder and terminating in a threaded pin, moves along the surfaces of two rigidly clamped plates that placed on a surface plate. Other types of metal join process as lap joint can be produced. In all cases, FSW process causes a large reduction of hardness within the stir zone below the tool. A slow tool rotation speed has lesser reduction and a narrower weld. After that, the final grain-size in the stir weld zone is always coarser than that in the starting microstructure.

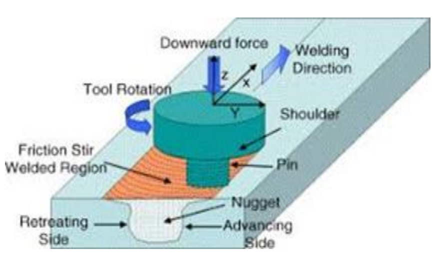

Fig. 1. Schematic diagram of FSW

Due to friction in between tool and material, heat transfer allows material flow outward direction and the properties of the materials to be welded. For example, the hardness of a particular age-hardened Al alloy decreases in the heat-affected zone on the retreating side, which then leads to a tensile fracture in cross-weld tests.

FSW is a technique of routine need joining of aluminum components; its applications for joining difficult metals but greater application in Al alloys. Application of FSW in aerospace, shipbuilding, automotive and railway industries. FSW is considered to be the most significant invention in welding and is an ‘‘environment-friendly’’ technique because it is used less Energy, environment-friendly, and easy to use. As compared to the conventional joining methods, FSW consumes less energy. There is no cover gas or flux is used, thereby process environmentally friendly. The joining no use of filler metal and therefore any aluminum alloy can be joined without concern of suitable composition, which is an issue in fusion welding. Dissimilar aluminum alloys and composites also joined easily. In contrast to the traditional friction welding, which is usually performed on small parts that can be joined by rotating and applying suitable pressure on parts, friction stir welding can be applied to different types of Joints like the butt joints, lap joints, T butt Joints, and fillet Joints. In aerospace industries, the demand for aluminum alloys is rapidly growing due to their characteristics like high strength, good formability, and corrosion resistance. But due to fusion process, these Materials difficult due to the low melting point. Defect induces due to Fusion distortion, porosity, oxidation, shrinkage etc. To reduce these difficulties FSW process is used. According to the knowledge of authors, FWS technique was developed by TWI Institution 1991.After that, so many researchers have been doing an experimental investigation to study different mechanical and metallurgical behavior of friction stir weld joints.

A. Commonly used tool materials

1) Tool steel

Aluminum and its alloy are commonly used steel tools. These tools also used in dissimilar materials in the butt and lap joints.

2) Polycrystalline cubic boron nitride tools

Polycrystalline cubic boron nitride tools: For high hardness and strength at elevated temperature with high-temperature stability PcBN preferred .some properties of the PcBN tool like low coefficient of friction results in smooth weld metal surface. However, tool cost is very high. Tool geometry is developing an effect on work properties. The tool geometry influences an important role in friction stir welding. A tool has a shoulder and a pin as discussed above. The tool has two important functions: (a) Proper heating and (b) material flow. In the initial stage of tool plunge, the heating takes place from the friction between pin and work piece. Additional heating results due to deformation of the material. The friction between the work piece and shoulder results in the component heating up to the desired temperature. Due to this heating aspect, the relative size of the shoulder and pin is important, and the other design features are not much important. The shoulder also provides for the heated volume of material. The secondary function of the tool is to 'stir' and 'move' the material in a particular direction. The homogeneity of microstructure and properties, as well as process force, is considered by the tool design. Generally, a cylindrical threaded pin and concave shoulder are used.

2. Tool design

By study of different research papers, we consider 3 types of tool they are

- Flat shoulder with using a tapered threaded pin. (Fig. A)
- Concave shoulder with using a tapered threaded Pin. (Fig. B)Concentric shoulder with using a tapered threaded pin. (Fig. C)

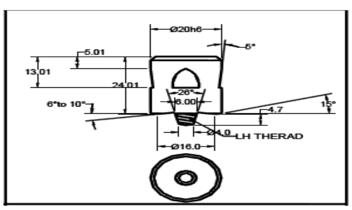

Fig. 1. (a)

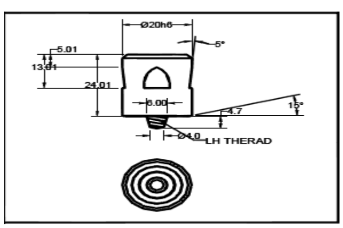

Fig. 1. (b)

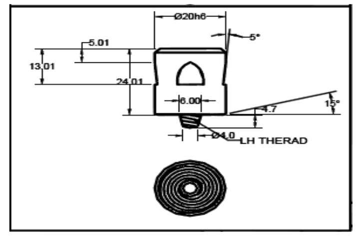

Fig. 1. (c)

Fig. 1. Types of tools

A. Tool wear, deformation, and failure

The rotation and translation speed of tool through the work piece it increases wear. The FSW tool may also deform plastically due to a reduction in yield strength at elevated temperatures in an environment of high loads. Therefore, FSW tools for welding of high strength materials such as steels. When the stresses in the tool greater than the material ability, then tool wear occurs.

B. Welding parameters:

For FSW, there are two Parameters: Rotation rate of (v, rpm) in Counterclockwise or Clockwise direction and Traverse speed (n, mm/min) over the line of joint. The tool rotation results in stirring and proper mixing of material between the joint over which pin is rotated and movement of tool moves the stirred material outward of the pin and complete welding process. Higher rates of tool rotation generate large temperature because of friction heating with high rate and result in Intense stirring and proper mixing of material. However, it is noted that a frictional couple of tool surface with the work piece is governed the heating.

C. Cooling and preheating

Cooling or Preheating can also important for some FSW processes. For materials with a higher melting point such as titanium and steel or high conductive material such as copper, the heat produced by friction may be not sufficient to plasticize and soften the material around the rotation of the tool. Thus, it is very difficult to produce the continuous and defect-free weld. In these cases, Additional external heating source or preheating can help in material flow and increase the process. On the other hand, materials that have a lower melting point of as aluminum and magnesium, cooling can be reduced.

Table 1
Key benefits of FWS

S. No.	Metallurgical benefits	Environmental benefits	Energy benefits
1	Solid phase process	No shielding gas required	Improved materials use
2	Work piece distortion Low	Surface cleaning is not required	Allows reduction in Weight
3	Dimensional stability Good and repeatability	Eliminate grinding wastage Required for dressing	Only 2.5% of the energy needed
4	No any loss of alloying elements		Decreases fuel consumption in lightweight metal joining
5	Excellent metallurgical properties in the joint area Fine microstructure no cracking	Consumable materials saving, such as rugs, wire or any other gases	Automotive, Aircraft and Ship applications
6	Multiple parts joined with FSW. No need of fasteners		

Table 1
Literature review

S. No	Title	Author	Parameter	Result
1	Material flow and Microstructure in FSW of AL alloy	J. H. Ouyang and R. Kovacevic	Alloy, Rotation speed of tool 151-914 rpm, Removal rate 57-330 mm/min	Plastic deformation and mechanical mixing of material Same as rotation speed faster .then material mixing more uniform.
2	Friction stir welding of aluminum alloy plates	Yong-Jai KWON, Seong Beom SHIM, Dong Hwan PARK	5052 Aluminum plats.(30mm width,160mm length and 2mm thickness) Tool dia10mm and prob dia 4mm Rotation speed 500-3000rpm and MRR100mm/min	Very smooth surface finish Onion ring structure formed Grain size decreased with increase speed Strength of weld plat similar to base metal
3	Friction stir welding tool	R.Rai, A. De, H. K. D. H. Bhadeshia and T. Debroy	Tools 1. tool steel 2. polycrystalline cubic boron nitride tools 3. tungsten tools Tool material selection, geometry, shoulder surface, check load bearing ability	Tool material property, strength hardness fracture roughness affect the weld Reactivity of tool metal with atm oxygen,
4	Friction stir processing of SSM356 Aluminum alloy	S.Chainarong, P.Muangjunbee, S.Suthummann	SSM356 aluminum alloys , Mechanical properties Rotation speeds 1320,1480,1750 MRR80,120,160 mm/min	Surface of specimen improved Homogeneous microstructure Not find any defect Increased hardness of the metal after FSW.(64.55HV)
5	Friction stir processing of 7075 Al alloy and subsequent aging treatment	Siavash Gholami, Esmaeilemadoddin, Mohd Tajlly, Ehasan Borhani	A7075Al alloy sheet of 250mm, Post age hardening, Microstructure observation	Homogeneous microstructure and fine re-crystallized grains which affects precipitation. Wear rate reduced with artificial aging. Single aging hardness larger than double aging process.
6	Study on temperature distribution during friction stir welding of 6082 aluminum alloy	S. Verma,Meenu, J. P Mishra	DIE Steel tool with threaded pin, AA6082 plate 75mm×100mm×6.35mm, UNILOG used for temperature measurement Study of thermal history.	During temperature distribution of AA6082 during FSW process varying tilt angle and dwell time; Conclusion that temperature increases with dwell time
7	Friction stir welding tool and Their effect on welding of AA6082 T6	Kalmeshwar Ullegaddia, VeereshMurthyb, Harsha R Nc, Manjunathad	Types of tools Geometry of tools Material used	Concave shoulder with tapered pin tool well below the melting point temperature of the work

3. Conclusion

FSW is the most useful joining method used in AMCs. Tool speed, welding speed, tool shoulder diameter and probe diameter are parameters that affecting FSW process forces and heat input. FSW of AMCs is difficult by rapid and severe wear of the tool which is due to the contact in between the tool and hard particles.).Heat input in FSW is affected by tool speed, tool diameter, and welding speed. Friction stir welding process improves the surface of the specimen.

4. Future scope

This process has demonstrated its capability and been approved as a noble method for joining aluminum and other metals. If proper care is taken weld properties become equal to those of base material. REFE.

References

[1] Mishra S R, Mahoney W M. Friction Stir Welding and Processing [M]. Material Park, Ohio: The Materials Information Society, 2007: 6−19.
[2] Su J Q, Nelson T W, Mishra R S, Mahoney M W. Microstructural Investigation Of Friction Stir Welded 7050-T651aluminium [J]. Acta Materialia, 2003, 51: 713−729.
[3] Rhodes C G, Mahoney M. W, Bingel W H, Calabrese M. Fine-Grain Evolution in Friction-Stir Processed 7050 Aluminium [J]. Scripta materialia, 2003, 48: 1451−1455.
[4] .Lee W B, Yeon Y M, Jung S B. Evaluation Of The Microstructure And Mechanical Properties Of Friction Stir Welded 6005 Aluminium Alloy [J]. Mater Sci Technol, 2003, 19: 1513−1518.
[5] Liu H J, Fujii H, Maeda M, Nogi K. Tensile Properties And Fracture Locations Of Friction Stir Welded Joints Of 6061-T6 Aluminium Alloy [J]. J Mater Sci Lett, 2003, 22: 1061−1063.
[6] Chen Y C, Feng J C, Liu H J. Stability Of The Grain Structure In 2219-O Aluminium Alloy Friction Stir Welds During Solution Treatment [J]. Mater Charact, 2007, 58: 174−178.
[7] Nishihara T, Nagasaka Y. Measurement of Tool Temperature during Friction Stir Welding [C], Proceedings Of 4th International symposium On Friction Stir Welding. Park City, 2003.