Review Paper on Friction Stir Welding of various Material

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Abstract

***Objective**: The comprehensive body of knowledge that has built up with respect to the friction stir welding (FSW) of aluminum alloys since the technique was invented in 1991 is reviewed on this paper. **Methods/Analysis**: The Friction Stir Welding of aluminum alloys with various other alloys are reviewed on this paper. The basic principles of FSW are described, followed by process parameters study which affects the weld strength. **Findings:** The microstructure and the likelihood of defects also reviewed. Tensile strength properties attained with different process parameters are discussed. **Conclusion:** It is demonstrated that FSW of aluminum and other material is becoming an emerging technology with numerous commercial applications*

Keywords : Aluminum Alloys, Axial Force, Friction-Stir Welding, Microstructure, Tensile Strength

1. Introduction

Friction Stir Welding (FSW) was invented at The Welding Institute (TWI) of the United Kingdom (Cambridge) in 1991 as a solid state joining technique and was initially applied to Aluminum Alloys (Dawes C and Thomas W, TWI Bull, 1995; Thomas W M, *etal.*, 1991). Friction Stir Welding is a solid state joining process combining deformation heating and mechanical work to obtain high quality, defect free joints. Friction Stir Welding is especially well suited to joining Aluminum Alloys in a large range of plate thickness and has particular advantages over fusion welding when joining of highly alloyed Aluminum is considered.[1]. The heat input into the material and the resulting welding temperature can be controlled by adapting process parameters like the down-force, rotational speed or welding speed as shown in Fig. 1

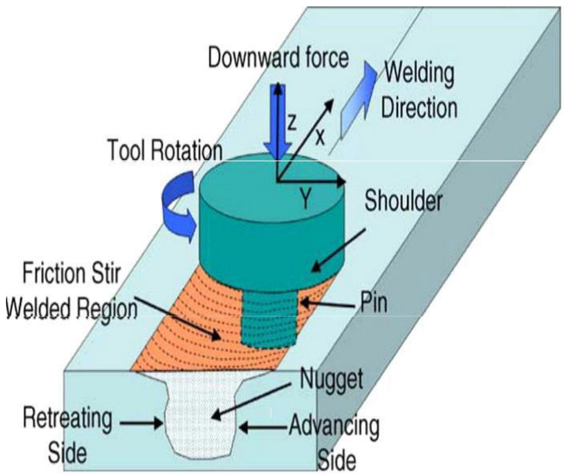

Fig. 1 Principle drawing of the FSW process for joints with indication of the main parameters

A method of solid state joining on a workpiece offers a tool pin of material harder than the base metal's continuous surface which causes relative cyclic movement between the pin and the base metal. The frictional heat is generated as the pin stirs the workpiece so as to create a plasticized region in the metal around the probe, stopping the relative cyclic movement, and allowing the plasticized material to solidify around the probe.[2]

2. Principle of Operation

A non-consumable rotating tool with a specially designed pin and shoulder is inserted into the abutting edges of sheets or plates to be joined and subsequently traversed along the joint line. the FSW tool rotates in the counterclockwise direction and travels into the plunge (or left to right).The advancing side is on the right, where the tool rotation direction is the same as the tool travel direction (opposite the direction of metal flow), and the retreating side is on the left, where the tool rotation is opposite to the tool travel direction (parallel to the direction of metal flow)

The tool serves three primary functions, that is, heating of the work piece, movement of material to produce the joint, and containment of the hot metal beneath the tool shoulder [1].

3. Process parameter and their effect

The factors which influence on the friction stir welding are as follows
1. Rotational Speed
2. Welding Speed
3. Pressure on Tool (Down Force)
4. Tilting Angle

Parameter	Effects
Rotation speed	Frictional heat, stirring||, oxide layer breaking and mixing of material
Tilting angle	The appearance of the weld, thinning
Welding speed	Appearance, heat control
Down force	Frictional heat, maintaining contact conditions.

4. Tool Material and Design

Afterwards the selection of base material also the vital restriction in FSW process is selection of tool materials and shape of tool pin, shoulder. The tool produces the thermo mechanical deformation and work piece frictional heating necessary for friction stirring. When the down force is applied on tool then tool is introducing in the base materials. The friction stirring tool contains of a pin or probe, and shoulder. Contact of the pin with the work piece produces frictional and deformational heating and moderates the work piece material contacting the shoulder to the work piece increases the work piece heating, expands the zone of softened material, and constrains the deformed material. [12]

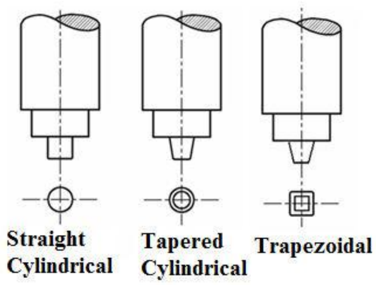

Fig. 2 Different varieties of tool used

5. Microstructure Studies

In the friction stir welding, mainly two-phase confluction is produced, Heat affected Zone (HAZ) and Thermo and Thermo mechanically affected zone (TMAZ). Affected thermally and mechanically at different degrees, microstructures in these two zones are composed of grains with different structures. The transition from the HAZ to the TMAZ is sharp. During the FSW process, the sub-size concave shoulder cause intense plastic material flow in the HAZ. The TMAZ is the result of the thermal effect and the plastic shear stress caused by the plastic material flow in the HAZ, thus grains in this zone are appreciably elongated along the direction of maximum shear stress. As HAZ is affected by both the sub-size concave shoulder and the rotating tool pin. Because of the experienced high temperature and intense plastic deformation, microstructures in the HAZ are characterized by fine and equaxied grains, which are formed according to the dynamic recrystallization mechanism. HAZ also experiences high temperature and intense plastic deformation caused by intense stirring effect of the rotating tool pin, and microstructures in this zone are also characterized by fine and equaxied grain structures owing to the dynamic recrystallization mechanism which is a usual phenomenon when affected by high temperature and intense plastic deformation[3].

6. Case Studies: Effect of Various Welding Parameters on FSW

Sr. No	Author Name	Substrate material	Parameter selected for study	Conclusion
1	Shashi prakash dwivedi [3]	A356/C355 Alumnium Alloy	Welding speed, tool speed, Axial force	It was found that the parameters which affect the tensile strength in descending order are as follows: tool rotational speed, axial force and welding speed.
2	Adil sheikh, K.D.Bhatt, AlokB. Choudhary[8]	HDPE with 4% filler material	Rotational speed and welding speed	Although the tensile strength of the welded specimens was about 45MPa which is almost 80 % that of the base plate, the FSW process can be employed to weld HDPE plates with 4% filler minerals. Increasing the work linear speed from 14 to 56 mm/min had a decreasing effect on tensile strength
3	L. Suvarna Raju, Dr Adep kumar, Dr P. Indrewaraiah[7]	Cu plates of 200*100mm	Axial force, tool speed, Welding speed	Weldment made by FSW at the tool rotation speed of 900rpm and weld speed 40mm/min exhibited better mech properties. This is due to sufficient heat generation and proper mixing of material in the weld zone
4	P. Chandra Prasad P. Hema K. Ravindranath[1]	6.35 thick plate of Al Alloy	Axial force, tool speed, Welding speed	As the Tool Rotational Speed increases, effectively Hardness also increases, and in the same manner Axial Force also effects, if Welding Speed increases, effectively Hardness will be increases up to 60mm/min and slightly decreases at

				72mm/min
5	M.P.Meshram, Basant kumar, [12]	Austinitic stainless steel 120*80*4mm	tool speed, Welding speed	A defect free weld with parameters of 1100rpm and traverse speed 8mm/min showed tensile strength of Base material with 37% elongation
6	H. Ahmadi, N.B.Mostafa arab F.Ashenai Ghasami[4]	Plates of PP composites With 20% CF 100*50*4 mm	Welding speed, Rotational speed, Tilt angle	The welding speed was the most significant welding process parameter whereas the tilt angle was the least significant one affecting the tensile-shear strength
7	G.Elatharasan V.S.Senthil kumar[5]	AA6061-T6 And AA7056-T6	Welding speed, Rotational speed, Axial force	Ultimate tensile strength of FSW joints increases with increase in tool rotational speed and welding speed upto a max value and then decreases.

7. Conclusion

FSW is the best process to welding of different alloys of aluminum for long lengths with an excellent quality. Considerable effort is being made to weld higher temperature materials such as alloys of magnesium, titanium and steels by using FSW. Extensive effort are also required for joining of dissimilar aluminum alloy with various variables under consideration.

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