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Effect of Welding Speed on Tool Pin Profile using Friction Stir Welding

[1] Dr.G.Thirupati Reddy, [2]Syed Rabbani Bash
Principal & Professor,
Sree Visvesvaraya Institute of Tech. & Science,
Mahabubnagar, Telengana State, India
E-Mail: gtr_osho@yahoo.co.in
PG Scholar
Sree Visvesvaraya Institute of Tech. & Science,
Mahabubnagar, Telengana State, India
E-Mail **syed.rabbanibasha@gmail.com**

1. Abstract
Friction stir welding (FSW) process is an emerging solid state joining. The FSW process parameters such as rotational speed, welding speed, axial force and attack angle play vital roles in the analysis of weld quality. In this investigation an attempt has been made to understand the influences of welding speed and pin profile of the tool on friction stir processed (FSP) zone formation in AA2014 aluminum alloy. The most suitable method for welding AA 2014T6 is solid state joining process. Friction stir welding (FSW) is an emerging solid state joining process which avoids bulk melting of the basic material, hot cracking and porosity.

Tri-flutes and taper screw thread pin curvature have been used to fabricate the joints. Mechanical properties of AA 2014-T6 weldments will be evaluated at the weld center of all the joints. From the results it is observed that joints at 40mm/min fabricated by taper cylindrical threaded Triflute pin and taper cylindrical pin profile give better mechanical properties than joints fabricated at 50mm/min.

In fact the addition of a transition geometry structure, proper flow, mixing and forging of the plasticized work piece material that flows from the front of the probe as the probe moves in welding direction, due to these mechanical properties of the weld specimen increased.

Keywords: Friction stir welding, tool pin profile, welding speed, strength

2. **Introduction**

Aluminum and its alloys are widely used in engineering applications because of their low density, good

Mechanical properties, good surface finish and relative good corrosion resistance. Most preferred welding process for AA2014 is Fusion welding technique, which is better

for easier applicability and better economy but we aren't Getting good mechanical properties, strength and good surface finish from fusion welding technique, for reducing these problems FRICTION STIR WELDING (FSW) was invented at the TWI(UK) in 1991 by Thomas.FSW is an emerging solid state joining process.

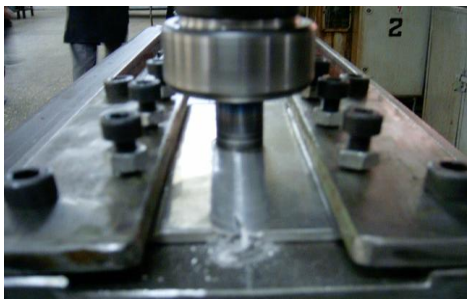


Figure1: Schematic illustration of welding of the different aluminum alloys

The process is fully mechanized, needs no traditional welder skills, no consumables, and produces solid state welds with minimal distortion, and excellent mechanical properties. It is also very useful for joining dissimilar materials.

3. Experimental Setup

The tool pin profiles selected are taper cylindrical threaded, taper cylindrical threaded with triflutes as shown in the fig below. The dimensions of pin are 8mm diameter and 3.8mm length and 0.5mm pitch for threading.

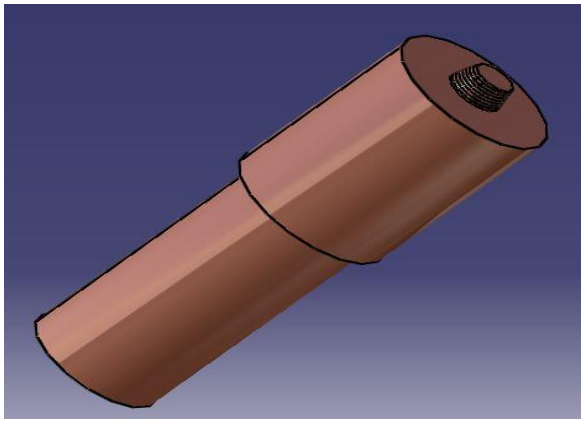


Fig 2 : Taper cylindrical threaded pin 3D Model

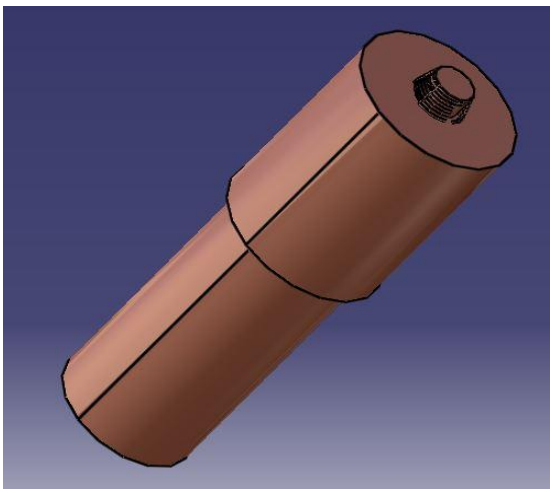


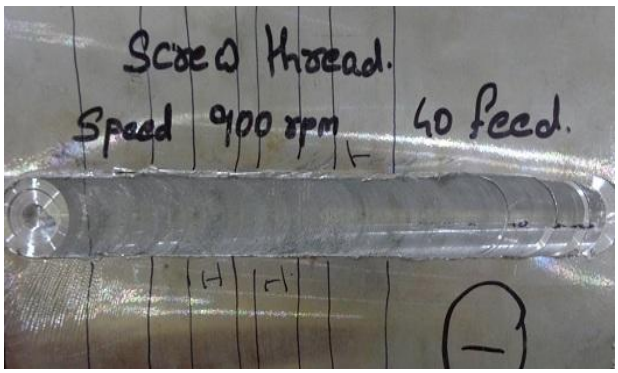
Fig 3 : Taper Cylindrical threaded pin with triflutes 3D Model

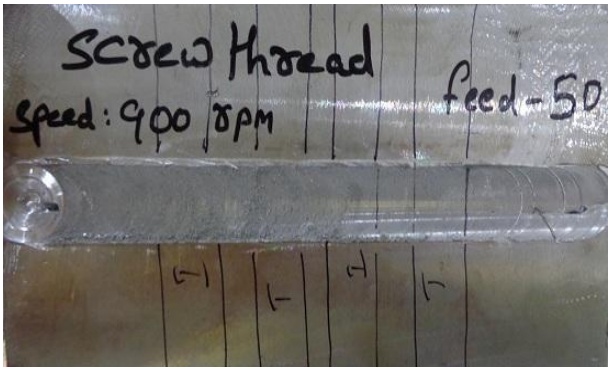
The tools (Fig 4) are specially designed with tapered cylindrical threaded profile & triflute pin and are accommodated in a predrilled hole along the weld interface. A constant axial force is used for the entire friction stir welding (FSW) experiments.

Fig4: FSW tools before welding

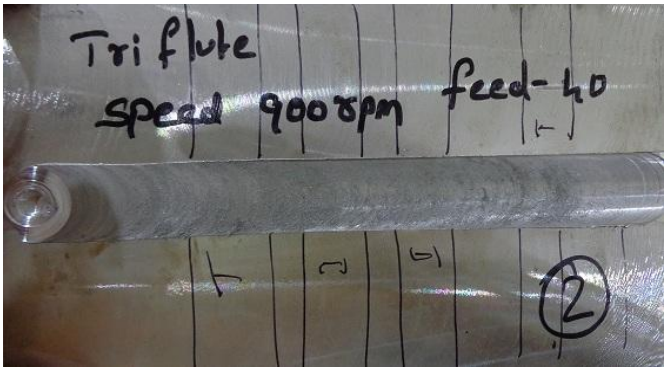
Fig5: FSW tools after welding

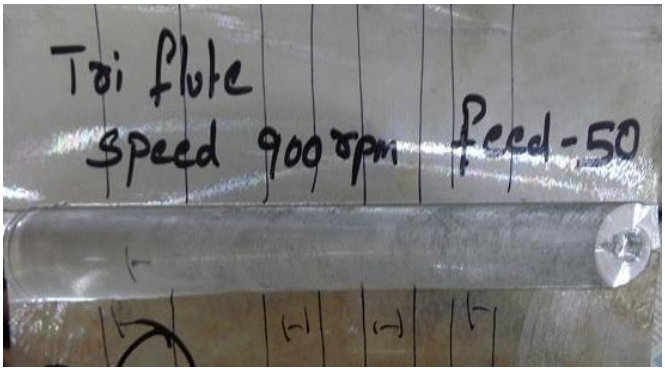
The direction of welding is normal to the rolling direction. Single pass welding procedure is used to fabricate the joints. Joints were fabricated using constant rotational speed and welding speed. Fabrication of friction stir welded joints are shown in fig 6.





Tool profile	Condition	Rotational/ Traverse Speed (mm/min)	Yield stress (N/mm2)	UTS (N/mm2)	% of Elongation	Impact strength (joule)	Hardness BHN
1A	Taper cylindrical threded pin	900/40	256.35	303.43	4.3	6	126
1B	Taper cylindrical threded pin with triflutes	900/40	265.20	305.90	3.4	4	132
2A	Taper cylindrical threded pin	900/50	184.97	210.26	3.72	4	123
2B	Taper cylindrical threded pin with triflutes	900/50	101.91	132.02	2.66	2	130

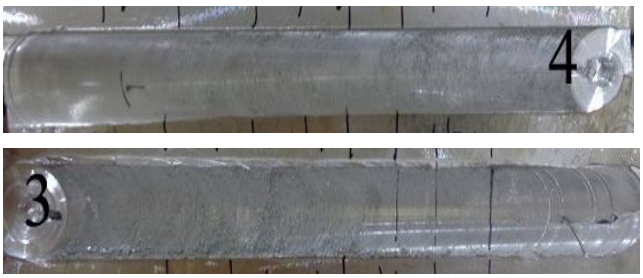




Experiment 1 **Experiment 2** **Experiment 3** **Experiment 4**

Fig6: Friction stir welded joints

4. Results and Discussions



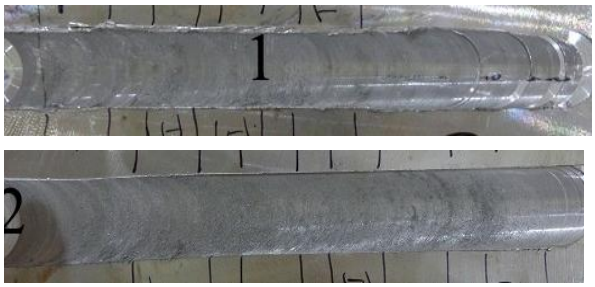


Fig7: Appearance of the weld **(1)** welded by tool A(taper screw thread WS=40mm/min) **(2)** welded by tool A(triflute pin WS=40mm/min) **(3)** welded by tool B(taper screw thread WS=50mm/min) **(4)** welded by tool B(triflute pin WS=40mm/min)

5.1. Effect of the pin geometry on mechanical properties

Tensile strength was observed at the fusion zone of AA2014-T6 weldments at 900 rpm with a welding speed of 40 and 50 mm/min with different tool pin profiles. The mechanical properties of welded joints with different pin profiles were shown in the Table

Table 1 : Mechanical properties of AA2014 Friction stir weldments

Table 10 : Mechanical properties of base metal

Material	Yield Strength(Mpa)	Ultimate Tensile strength(Mpa)	Impact strength (joule)	Elongation (%)	Brinell Hardness (BHN)
Base Metal **AA20**	**414**	**483**	**8.3**	**13**	**135**

14					

Fig8: Specimens before tensile testing

Fig9: Specimens after tensile testing

Impact toughness was observed at the TMAZ zone of AA2014-T6 weldments with different pin profiles at 900 rpm with a welding speed of 40 mm/min, from the fig 36, Toughness is higher by using pin profile 1A (6 joules at 40mm/min) than other pin profile(1B at 50mm/min) with welding speed of 50mm/min due to the presence of fine grain size. In triflute pin toughness is higher by using pin profile 2A (4 joules at 40mm/min) than other pin profile (1B at 50mm/min).

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5.2. Effect of tool pin profile and welding speed on the tensile properties

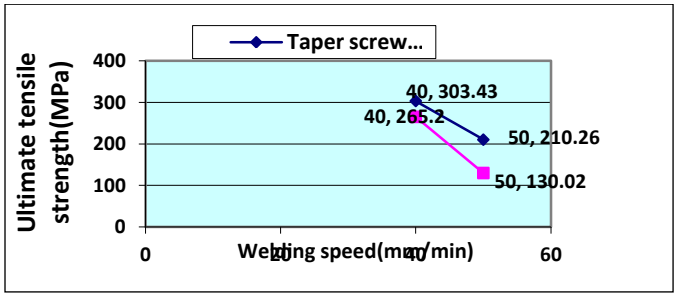
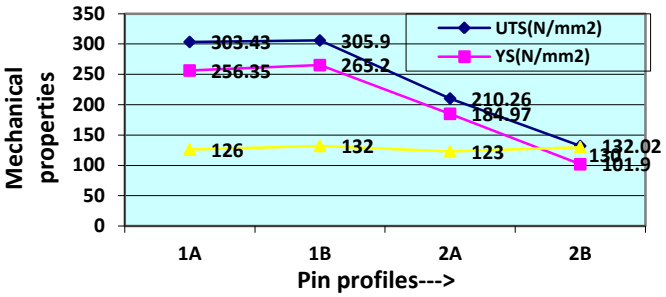


Fig10: Effect of tool pin profile and welding speed on UTS



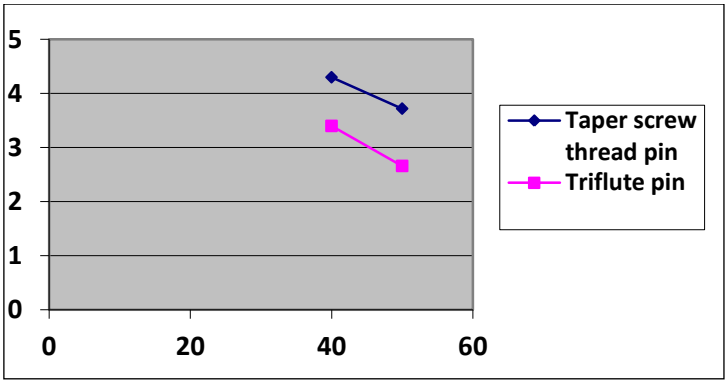


Fig11: Effect of tool pin profile and welding speed on the % of elongation

Figure 11: presents the variation of % elongation with welding speed for these two joints.

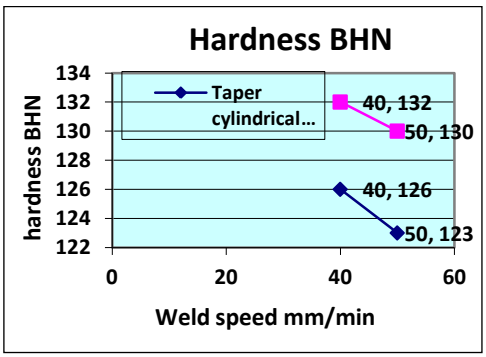


Fig12: Effect of tool pin profile and welding speed on the hardness

From the fig 13 shows the tool profile 1B (132BHN) gave best hardness at 40mm/min compare to other pin profile 2B (130BHN) at 50mm/min, tool 2A gave lowest hardness value (123 BHN) at 40mm/min compare to other pin profile 1A at 50mm/min.

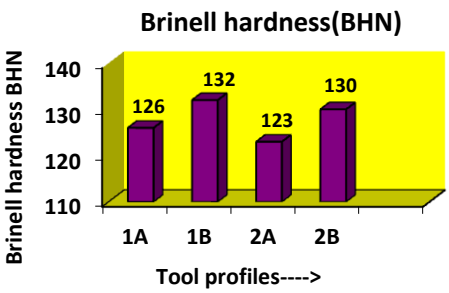


Fig13: Vickers Hardness chart for different pin profilesTool 2B also consists of taper cylindrical threaded triflute pin profile but we got less mechanical properties because of its welding speed 50mm/min. It plays a vital role to generate mechanical properties

6. Conclusions

The micro structure of AA2014-T6 weldments consists of four different zones such as (a) Weld nugget (b) Thermo mechanically affected zone (c) Heat affected zone (d) Parent metal, the micro structure of the weld nugget has been observed to be finer than the parent metal due to the dynamic recrystalization.

The samples were characterized by means of tensile strength, hardness, elongation. From the present experimental investigation the following conclusions are derived:

1. The addition of transition geometry region at the intersection of the shoulder face and base of probe has been found to significantly increase the operation life of tool.

2. When combined with other new features such as a tapered thread root that increases in depth from the base of the probe to its distal end and an increase in tool material strength. In fact the addition of a transition geometry structure, proper flow, mixing and forging of the plasticized workpiece material that flows from the front of the probe as the probe moves in welding direction, due to these geometry mechanical properties of the weld specimen increased.

3. For the given set of parameters, tool rotation speed as 900 rpm at welding speed 40mm/min, of the two tool profiles used taper cylindrical threaded tool and triflute pin profile gave good mechanical properties.

Triflute pin is a further refinement of the whorl pin. In addition to the helical ridge, the MX Triflute pin contains three cut into the helical ridge. The flutes reduced the displaced volume of a cylindrical pin by 70% and supply additional deformation at the weld line.

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