iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: III Month of publication: March 2018

DOI: http://doi.org/10.22214/ijraset.2018.3395

Effect of Tool Pin Geometries on the Tensile Strength of Friction Stir Welded Structural Aluminium Alloy Similar Joints

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Abstract: In this investigation, an attempt has been made to analyze the Tensile strength of similar joints Friction Stir Welded Structural Aluminium alloy plates under different tool pin geometries. The tool pin geometries used in this investigation were triangular, circular and hexagonal. It was observed that for triangular, hexagonal and circular tool pin profile, maximum tensile strength was 83 MPa, 82.1 MPa and 78.2 MPa at tool rotational speed of 1200 rpm.
Keywords: Friction Stir Welding; Aluminium alloys; Tensile Testing; Tool geometries

I. INTRODUCTION

Friction Stir Welding is an environment friendly solid state joining process mainly preferred for joining dissimilar alloys of Aluminium and Magnesium [1]. Tool pin profile, welding speed, rotational speed, tool tilt angle etc. are various parameters which are taken into account during Friction Stir Welding process [2–8]. In Friction Stir Welding process there are two types of material flow i.e. “pin driven flow” and “shoulder driven flow”. Tool pin profile plays an important role during Friction Stir Welding process. Tool pin is inserted into the work piece and it is a given a rotation which plasticizes the material at the given joint. The function of the tool shoulder is to provide heat by application of a large compressive force and tool rotation over the surface of the material being welded and to contain the softened, plasticized metal beneath it. The compressive stress also minimizes the formation of voids or pores in the consolidated metal. In the case of welding thin sheets, almost all of the frictional heat is provided by the friction between the tool shoulder and the work piece. The depth of tool pin is slightly shorter than the thickness of the alloy plate. The heat is generated during Friction Stir Welding due to mechanical working of the welding tool [9]. Tools used for friction stir spot welding (FSSW) experience only torsion due to rotational motion as opposed to tools used for FSW that experience both bending moment and torsion due to linear and rotational motion respectively. Despite the differences between FSSW and FSW, the tools used for the two processes are similar. The tool pin geometries used in this research were of hexagonal, triangular and circular profiles as shown in the Figure 1. Weld quality and tool wear are two important considerations in the selection of tool material, the proper- ties of which may affect the weld quality by influencing heat generation and dissipation. The weld microstructure may also be affected as a result of interaction with eroded tool material. Apart from the potentially undesirable effects on the weld microstructure, significant tool wear increases the processing cost of FSW. Owing to the severe heating of the tool during FSW, significant wear may result if the tool material has low yield strength at high temperatures. Stresses experienced by the tool are dependent on the strength of the work- piece at high temperatures common under the FSW conditions. Temperatures in the work piece depend on the material properties of tool, such as thermal conductivity, for a given work piece and processing parameters. The coefficient of thermal expansion may affect the thermal stresses in the tool. Other factors that may influence tool material selection are hardness, ductility and reactivity with the work piece material. The tool hardness is important in mitigating surface erosion due to interaction with particulate matter in the workpiece. The brittle nature of ceramics such as pcBN may be undesirable if there is a significant probability of breakage due to vibrations or accidental spikes in loads. Tool degradation may be exaggerated if the tool material and work piece react to form undesirable phases.

In this research AA6082 plates were used which belongs to 6XXX grade of Aluminium alloys. AA6082 is also known as a structural alloy, it has replaced AA6061 in many applications field due to its higher strength. AA 6082 is widely used in Trusses, transport applications and high stress applications. The chemical composition of AA6082 is shown in Table 1.

Figure 1: Triangular, Hexagonal and Triangular tool pin profiles

Table 1: Chemical composition (wt %) of AA6082

Composition	Al	Si	Fe	Cu	Mn	Cr	Mg	Zn	Ti	Others
Weight %	Bal	0.7	0.5	0.1	0.4	0.25	0.06	0.2	0.1	0.05

This research paper addresses the effect on tensile strength for different tool pin profiles. The rotational speed used in this case study were 1200 rpm, 1400 rpm and 1600 rpm. The feed rates used were 10 mm/min, 12 mm/min and 14 mm/min.

II. EXPERIMENTAL PROCEDURE

In this case study, AA 6082-T6 plates of dimensions 200 mm X 80 mm X 8 mm were used. Firstly, the surfaces of the plates were machined to remove the irregularities and roughness. Any presence of irregularities and non - smooth surfaces results poor qualities of joints. The material used for fabrication of weld tool was SS 304. The selection of tool material is done in such a way that it possesses more hardness value than the material to be welded [10]. The chemical composition of SS 304 is shown in the Table 2.

Table 2: Chemical Composition (wt %) of SS 304.

Composition	C	Mn	Si	P	S	Cr	Mo	Ni	N
Weight %	0.08	2.0	0.75	0.04	0.03	20.0	-	10.5	0.1

Secondly, the plates were mounted on the fixture in a proper orientation as show in the Figure 2. The design of fixture plays an important role while carrying out Friction Stir Welding process [11]. Thirdly, the welding tool pin was plunged deep into the faying surface of the two respective plates until there is contact between tool shoulder and the upper surface of work piece. The angle between the tool to work piece was 2.5 degree from the vertical axis in all welds. The number of joints Friction Stir welded was nine, i.e. three joints for each Hexagonal, Triangular and Circular tool pin profiles at different rotational speed and traverse speed parameters.

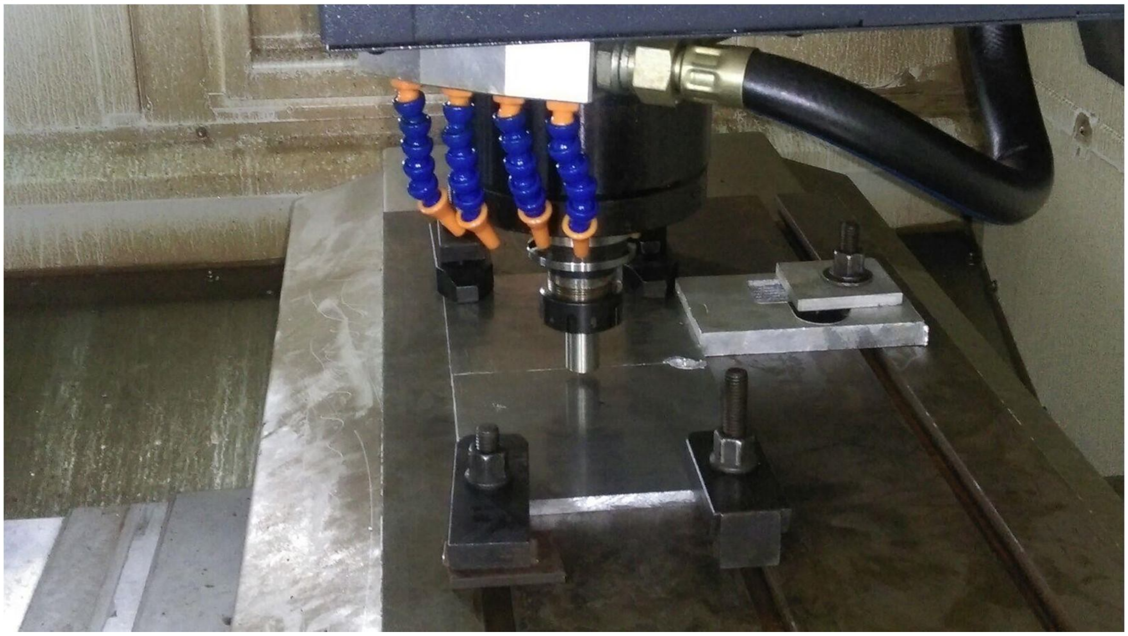

Figure 2: Plates butt welded on the fixture

In order to obtain the sound weld joint, the tool profile should be designed in such a manner that it results less formation of flashes and less chips formation as shown in the Figure 3.

Figure 3: Less formation of flash and chips in the weld

III. RESULTS AND DISCUSSIONS

The tensile test was carried out on Universal Testing Machine based on ASTM-B557 to determine the tensile strength of 9 specimens which were welded using different pin profiles. The tensile test specimen of width 19.05 mm and cross sectional area of 158.57 mm^2 was prepared as shown in the Figure 4. The results obtained for different tool pin profiles are tabulated in Table 3, Table 4 and Table 5.

For Hexagonal tool pin profile it was observed that it has maximum tensile strength of 82.1 MPa at tool rotational speed of 1200 rpm and traverse speed of 10 mm/min. For Triangular tool pin profile, maximum tensile strength of 83 MPa at tool rotational speed of 1200 rpm and tool traverse speed of 10 mm/min. Similarly, for circular tool pin profile 78.2 MPa maximum tensile strength was observed for same rotational speed and traverse speed.

It was also observed the failure occurred were ductile in nature and fracture was initiated from the weld zone as shown in the Figure 5.

Table 4: Tensile test of the specimen obtained by Hexagonal tool pin profile at different parameters

Tool pin profile	Hexagonal		
Tool Rotational speed (rpm)	1200	1400	1600
Traverse speed (mm/min)	10	12	14
Ultimate Tensile Strength (MPa)	82.1	81.9	78.0

Table 5: Tensile test of the specimen obtained by Triangular tool pin profile at different parameters

Tool pin profile	Triangular		
Tool Rotational speed (rpm)	1200	1400	1600
Traverse speed (mm/min)	10	12	14
Ultimate Tensile Strength (MPa)	83.0	82.40	80.06

Table 6: Tensile test of the specimen obtained by Circular tool pin profile at different parameters

Tool pin profile	Circular		
Tool Rotational speed (rpm)	1200	1400	1600
Traverse speed (mm/min)	10	12	14
Ultimate Tensile Strength (MPa)	78.2	77.5	75.7

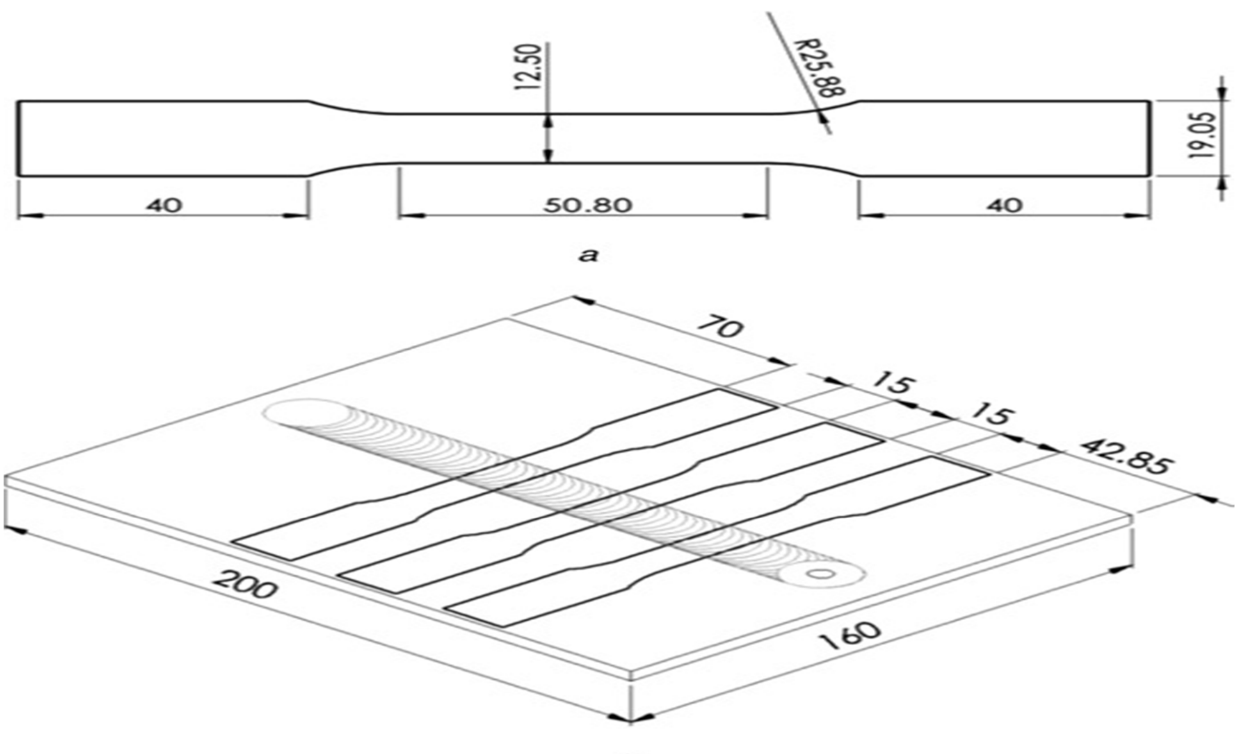

Figure 4: Tensile test specimens

Figure 5: Failure occurrence at the weld zone of the tensile test specimens

IV. CONCLUSIONS

It can be concluded that geometrical parameters like the design of tool pin profiles and process parameters like tool rotational speed, traverse speed etc. affects the tensile strength of the Friction Stir Welded joints. If we compare all results, Triangular tool pin profile at tool rotational speed of 1200 rpm and traverse speed of 10 mm/min results higher Ultimate Tensile Strength in comparison to other tool pin profiles.

REFERENCES

[1] Mishra, A., 2018. Friction Stir Welding Of Dissimilar Metal: A Review
[2] Leonardo N. Tufaro, Ivan Manzoni, Hernan G. Svoboda, Effect of Heat Input on AA5052 Friction Stir Welds Characteristics, Procedia Materials Science. 8 (2015) 914 – 923.
[3] K. K. Ramachandran, N. Murugan, S. Shashi kumar, Tool Design Friction Stir Welding of Aluminum Alloy AA5052and HSLA Steel, Welding Journal. 94 (2015) 291 – 300.
[4] K. Elangovan, V. Balasubramanian, Influence of tool pin profile and welding speed on the formation of friction stir processing zone in AA2219 aluminium alloy, Journal of Materials Processing Technology. 200 (2008) 163-175.
[5] P. Prasanna, C. H. Penchalayya, D. Anandamohana Rao, Effect of tool pin profiles and heat treatment process in the friction stir welding of AA 6061 aluminium alloy, American Journal of Engineering Research. 2 (2013) 7-15.
[6] S. M. Bayazid, H. Farhangi, A. Ghahramani, Effect of Pin Profile on Defects of Friction Stir Welded 7075 Aluminum Alloy, Procedia Materials Science. 11 (2015) 12 – 16.
[7] D. Venkateswarlu, N. R. Mandal, M. M. Mahapatra, S. P. Harsh, Tool Design Effects for FSW of AA7039, Welding Journal. 92 (2013) 41 – 47.
[8] S. Ugender, A. Kumar, A. Somi Reddy, Experimental investigation of tool geometry on mechanical properties of friction stir welding of AA 2014 aluminium alloy, Procedia Materials Science. 5 (2014) 824-831.
[9] Mishra, A. and Sharma, K., Abhishek, Analysis of Heat Generation During Friction Stir Processing of Aluminium Similar Joints (December 27, 2017).
[10] Friction Stir Welding for Beginners, Akshansh Mishra, 2018
[11] Mishra, A. and Rose, R., A & Singh, Anand & M, Saravanan.(2017). DESIGNING AND FABRICATION OF FIXTURE FOR FRICTION STIR WELDING OF ALUMINIUM AA6061 ALLOYS.. 10.13140/RG. 2.2, 33858.