

EXPERIMENTAL INVESTIGATION OF TAPERED AND TAPERED THREADED TOOL FOR FRICTION STIR WELDING FOR DIFFERENT GRADES OF ALUMINIUM ALLOY.

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Abstract: This research deals with the determination of the weld strength of the aluminum alloy of different grades in friction stir welding (FSW). The different grades of the plates are welded by the different tool geometry namely as tapered tool and the tapered threaded tool. During the welding the rotational speed of tool and feed rate of the tool are kept constant. Testing of the specimens is carried out by ASME –SEC-IX and the weld strengths are compared. As a result it is found that the threaded tool geometry gives the better weld strength and also the surface finish compare to the tapered tool geometry.

Keywords:FSW (FRICTION STIR WELDING).

I. INTRODUCTION

FSW was invented at The Welding Institute (TWI) of the United Kingdom in 1991 as a solid-state joining technique. It was initially applied to aluminium alloys.it is a Solid state joining process. It is used for application where the original metal characteristics must remain unchanged as far as possible. Figure 1 shows the working principle of the friction stir welding process.

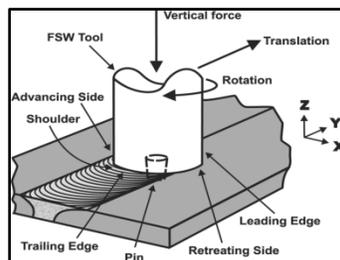


Figure 1 working principle of the friction stir welding

Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) that uses a third body tool to join two facing surfaces. Heat is generated between the tool and material which leads to a very soft region near the FSW tool. It then mechanically intermixes the two pieces of metal at the place of the joint, then the softened metal (due to the elevated temperature) can be joined using mechanical pressure (which is applied by the tool), much like joining clay, or dough. It is primarily used on aluminium, and most often on extruded aluminium (non-heat treatable alloys), and on structures which need superior weld strength without a post weld heat treatment.

II. LITERATURE SURVEY

BiswajitParida^[1] *et al.* have done development of friction stir welding (FSW) of commercial grade Al-alloy to study the mechanical and microstructural properties.

P. Cavaliere^[2] *et al.* studied the effect of welding parameters on mechanical and microstructural properties of AA6056 joints produced by Friction Stir Welding.

Ahmed khalidhussain^[3] *et al.* have done evaluation of parameters of Friction stir welding for Aluminum AA6351 alloy.

H.J. Liu^[4] *et al.* studied tensile properties and fracture locations of friction-stir-welded joints of 2017-T351 aluminum alloy.

K. Elangovan^[5] *et al* referred the three tool rotational speeds and five tool profiles in investigation to fabricate the joints, The joint fabricated using square pin profiled tool at a rotational speed of 1600 rpm showed superior tensile properties.

III. WORK PIECE

Initially FSW was confined to relatively soft work piece materials such as lead, zinc, magnesium and a range of aluminum alloys. More recently, copper, titanium, low carbon ferritic steel, alloy steels, stainless steels and nickel alloys have been welded. In principle, any material which can be hot worked can be welded by this process. About 85% of aluminum is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminum alloys yield cost-effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. In this research following grades of aluminum alloys are selected:

- Aluminium alloy 6061
- Aluminium alloy 7005
- Aluminium alloy 8011

IV. TOOL MATERIAL

There are many types of tool materials available for FSW. The following tool materials are mainly used for FSW:

Tungsten	Molybdenum
Tungsten-Rhenium	H13 (Hot Work Tool Steel) steel
Polycrystalline Diamond (PCD)	Polycrystalline Cubic Boron Nitride (PCBN)

Hot Work Tool Steel (H13) steel tool material has been selected for experiment because it has high hardenability, excellent wear resistance and hot toughness. It has good thermal shock resistance and will tolerate some water cooling in service. H13 has greater homogeneity and exceptionally fine structure, resulting in improved machinability, polish ability and high temperature tensile strength. Two types of tool geometries are selected:

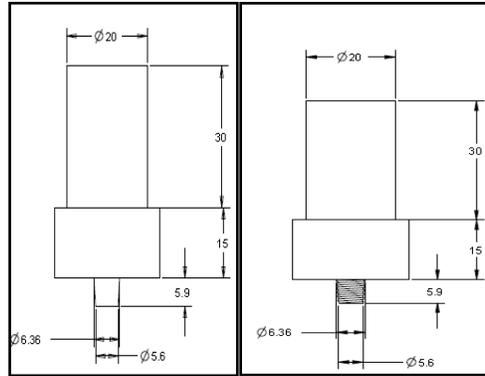
1. Tapered tool
2. Tapered Threaded tool

Table 1 Chemical composition of HWTS (H13)

C%	Cr%	V%	Mo%
0.32	5.411	1.053	1.269

Table 2 Properties of HWTS (H13)

Density	Thermal Expansion	Hardness
Kg/m ³	10 ⁻⁶ /°C	HRC
7750	10.4	49



Tapered tool

Tapered Threaded tool

Figure 2 Tool geometry

V. EXPERIMENTAL WORK

A conventional milling machine can be successfully modified in to a Friction Stir Welding machine which is capable of producing defect free aluminum welds.



Figure 3 Vertical Milling head machine



Figure 4 Work piece & tool set up

During the welding of all the grades of Al alloy, the rotational speed of the tool is kept constant and it is 2000 rpm. The Transverse feed rate for all the weld is also kept constant and it was 10 mm per minute. Figure 3 shows the vertical milling head machine on which all the welds are carried out. Figure 4 shows the work piece and tool set up on the vertical milling machine. Two plates are held against each other and it is fixed rigidly with the help of fixtures. Figure 5 shows the welded plats of Al alloy namely 6061, 7005, 8011 which are weld by tapered tool and the tapered threaded tool.

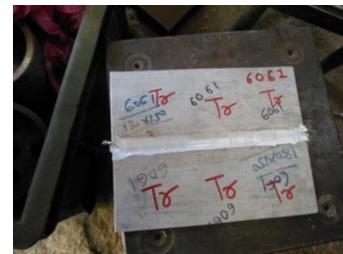
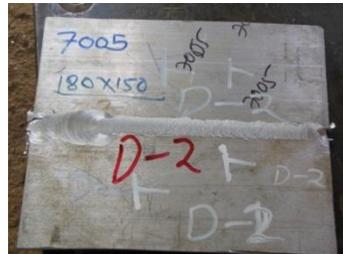
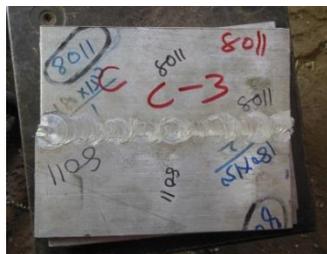


Figure 5 Welded plate of 8011 Al alloy

Figure 6 Welded plate of 7005 Al alloy

Figure 7 Welded plate of 6061 Al alloy

VI. TESTING, RESULT & DISCUSSION.

After the welding tensile test specimens are made by performing the machining on the welded plates. The tensile specimens are made and testing is carried out according to the ASME SECTION-9. Figure 8 shows the dimensions of the tensile test specimen.

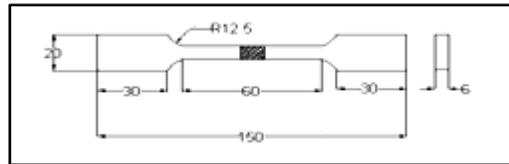


Figure 8 Tensile test specimen dimensions

Tensile strength of the all FSW joints was evaluated by conducting test on universal testing machine at Met-Heat Engineers Pvt Ltd, Vadodara. Figure 9 shows the specimens after the tensile test.



Figure 9 Tensile test specimens after test.

Table 3 Comparison of weld strength

SR NO	GEOMETRY OF TOOL	ALLOY	AVERAGE WELD TENSILE STRENGTH(average of 10 plates) MPa
1	Tapered tool	6061	105.7
		7005	49
		8081	47
2	Tapered Threaded tool	6061	128.7
		7005	108.0
		8081	135.1

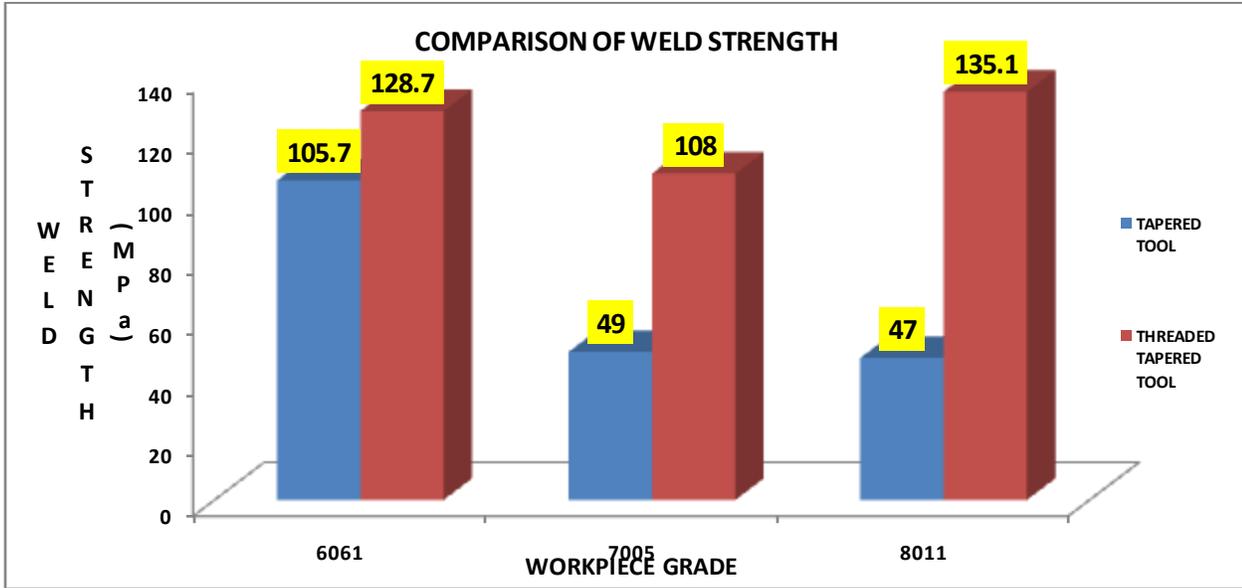


Figure 10 comparison of weld strength

Table 3 shows the weld strength of welded joints of three different grades of the Al alloy by tapered and tapered threaded tool geometry. From the comparison it is clear that the threaded tapered tool will give the more strength for all three grades. The reason for such result that due to threaded tool more friction is generated and also due to the threads the metal is evenly distributed in the zone of joint and due to that better joining of the two plates can be achieved. Figure 10 shows the same thing which also concludes the same results.

Figure 11 shows the comparison of the surface roughness of the welded plates by tapered and the tapered threaded tool. By visual observation it is clear that the threaded tool will give the better surface finish compare to the tapered tool.



7005 alloy welded by tapered tool



7005 alloy welded by tapered threaded tool



8011 alloy welded by tapered tool



8011 alloy welded by tapered threaded tool



6061 alloy welded by tapered tool



6061 alloy welded by tapered threaded tool



Figure 11 Visual comparison of surface roughness of the welded joint.

VII. CONCLUSION

From this experimental work it can be concluded that threaded tool geometry gives the better surface finish and also better weld strength compare to the tapered tool geometry and that is because more heat generation and good string effect of threaded tool. Furthermore study can be carried out on the parameters like rpm of tool, tool feed rate, tool tilt angle and tool life.

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