

# INFLUENCE OF TOOL PROFILES ON MECHANICAL PROPERTIES IN AI-5083 ALLOY USING FRICTION STIR WELDING

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## ABSTRACT

In the present paper, we evaluated the effect of welding process parameters like tool rotational speed, feed rate and tool geometry on butt joints of Al 5083 alloy fabricated using friction stir welding technique. The tool for this investigation is made up of High speed steel material. We considered tool profile as tapered and pin is with threaded and without threaded and also discusses the process parameters and their effects on mechanical properties of similar welded aluminum alloys. The joint is fabricated at a tool rotational speed of 825 rpm, feed rate of 32mm/min and angle of 3degree for joining process. We find that there is a no surface level cracks in a welded region by using liquid penetrant testing (NDT) method. The mechanical testing results of tapered with threaded tool profile gives 15.65% increases in tensile strength and in the hardness test decreases and increases of machinability and in impact test is increases using threaded tool.

**Key words:** Tool speed (rpm), welding speed (mm/min), Tool profiles.

## Introduction

AA 5083 (Magnesium (0.5% -5.5%) alloy has the highest strength during non-heat treatment process and exceptional performance in extreme environments. 5083 is highly resistant to attack by both seawater and industrial chemical environments. Alloy 5083 also retains exceptional strength after welding. It has the highest strength of the non-heat treatable alloys but is not recommended for use in temperatures in excess of 65°C. When welding 5083 to itself or another alloy from the same subgroup, the recommended filler metal is 5183. Other suitable fillers are 5356 and 5556. Weldability of Resistance welding is Excellent. Among the welding techniques, friction stir welding is suited for the joining of aluminum alloys. Applications of Al 5083 is Ship manufacturing, Vehicle chassis, phones, heavy truck bodies Rail coaches, high Pressure vessels and drilling rigs etc.

**Friction stir welding (FSW)** is a process of joining of metals in solid state . This process is efficient in energy, eco-friendly and comfortable to do. It is considered that the most significant development in metal joining process in 21<sup>st</sup> decade. Non-consumable tool is used to join two faces of workpieces without melting the workpiece material. Heat is generated by friction between the rotating tool and the workpiece and plastic deformation of work piece, which leads to a softened region near the FSW tool. While the tool is traversed along the joint line, it mechanically intermixes the two pieces of metal, and forges the hot and softened metal by the mechanical pressure, which is applied by the tool, much like joining clay. Thus a joint is produced in solid state. It is primarily used on wrought or extrude and particularly for structures which need very high weld strength.

By aiming of study to the evaluation of post welding heat treatment in semi solid region by the effects on the mechanical properties of welded plates of AA 5083.

## Materials and Experimental work

### Tool material

The basic characteristic for any material to qualify as a FSW tool material is that it should not lose its geometry and features during the process. Many of the advancements made in friction stir welding have been enabled by the development of new welding tools. The welding tool design, including both its geometry and the material from which it is made, is critical to the successful advancement of the process. This study has led to higher weld production speeds, high workpiece thickness, and improvement of joining property of the materials. Welding tool material development has enabled welding of high melting point materials, such as titanium, steel, and copper, and has improved productivity in aluminum welding. Welding tool mainly consists of two parts such as the shoulder and the pin. The shoulder mainly does the function of frictionally heating the work piece material by rubbing against the work material. It also confines the heated volume of material within the weld zone. The tool pin functions to plastically deform the material being joined. The pin “stirs” and “moves” the material. The quality of the mechanical properties of the joint are effected by the tool design. The important features of the tool are 1.pin length (PL), 2.pin diameter (PD), 3.tool shoulder diameter (SD), 4.SD/PD ratio of the tool. New welding tool features developed with a aim of reducing process parameters increasing in weldability in the process.

### Experimental work

Aluminum plates of 6 mm thick, Al 5083 alloy base metal of rolled configuration, were cut to the required size (150 mm x50 mm) by power hacksaw cutting and milling. Square butt joint configuration (300 mm x50 mm) was prepared and the direction of welding was normal to the rolling direction of the base plates. Single pass welding procedure was followed to fabricate the joints. The chemical composition and mechanical properties of base metals Al5083 are presented in Table 1 & 2

Composition	Mg	Mn	Si	Fe	Cr	Zn	Ti	Cu
Amount (%)	4.0-4.9	0.40-1.0	0.0-0.40	0.0-0.40	0.05-0.25	0.0-0.25	0.0-0.15	0.0-0.10

Table no : 1 chemical composition of Al 5083

Property	Yield strength	Tensile strength	Elasticity modulus	Brinell hardness
Value	228 Mpa	317 Mpa	71 pa	85HB

Table no : 2 mechanical properties of Al 5083

There are many varieties of tool materials are using for the friction stir welding. The non-consumable tool is made of HSS (High Speed Steel) material. The shoulder and pin of the tool is designed and machined by using the CNC machine. The shoulder profile of the tool is flat and pin is tapered with thread and other one is tapered without thread. Then both tools are made by using heat treatment process. The profiles of the tools are in fig 1, 2 shown below



Fig 1 : Tapered without threaded pin



Fig 2 :Tapered with threaded pin

Profile type	Shoulder dia	Pin length	Pin dia
Taper with Threaded	20 mm	5.7 mm	7 mm
Taper without thread	20 mm	5.7 mm	7 mm

Table: 3 tool profile and their specifications

Base metals	Rpm	Feed	Angle of tilt	Axial force
Al5083 & Al 5083	825	32 mm/min	3 degree	5 KN
Al 5083 & Al 5083	825	32 mm/min	3 degree	5 KN

Table no 4: process parameters

We have considered the friction stir welded parameters like angle of tilt, tool rotational speed, welding speed, axial force, for welding process are given in table 4. From referring to various journals we are taking following process parameters for conducting experiment.

After considering of all these process parameters we are selecting the FN2V milling machine the specifications are shown below in table no 5. Faces of the two plates are placed like butt joint and single pass welding procedure is followed to fabricate the joints. To study the effect of the feed rate and tool rotational speed, we have choose the two different speeds, feeds, tool angle of tilt in the table 4. There are 4 plates are taken and clean with the acetone and place in the Vertical Milling Machine (VMM) is used for friction stir welding. The base metal (BM) sheet of Aluminum alloy of considered dimension to be welded is fixed tightly on the table. A tool of HSS material and profile of tapered with thread and without thread is used for machining process is fixed tightly in its position. A constant axial force was applied on tool with some tilt angle on axis direction. Set the gear box in proper gear ratio such that the tool travel with constant rpm and feed along horizontal direction. This processed is continue by changing speeds and feeds. The welded plates are shown in fig 3 & 4.



Company	HMT
Model no	FN2V
Spindle speed	1.8-1800 rpm
Voltage	420 V
Phase	3 phase
Total power	5.5 Kw
Net weight	2500 Kg

Table no 5 figure and specifications of the FN2V milling machine



Fig no 3 before the FSW process

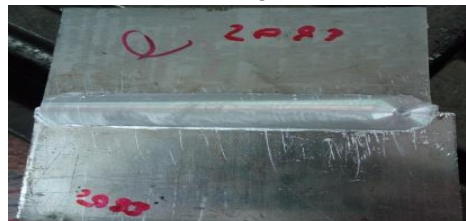


Fig no 4 after the FSW process

## Testing and Results

### Liquid penetrant testing (PT) (NDT method)

Non-destructive testing is the type of unconventional testing methods used to test the materials, components etc. LPT method is used to find the surface level defects in any industrial product such as non-porous materials. This method is also used for testing non-magnetic materials. The process uses either visible penetrant or fluorescent penetrant. By this testing there are no defects occur at welded zone. Testing plates are in fig 5 & 6. Further the weldments are taken for the mechanical testing like tensile strength test, impact test, hardness test.



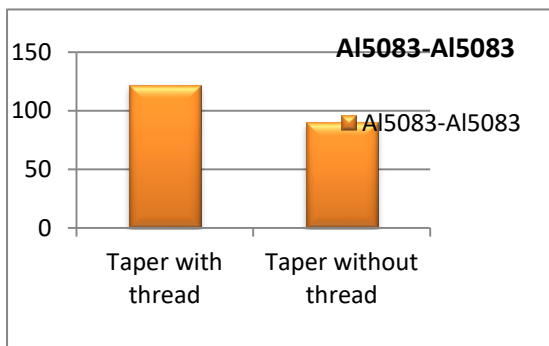
Fig 4: Before LPT method



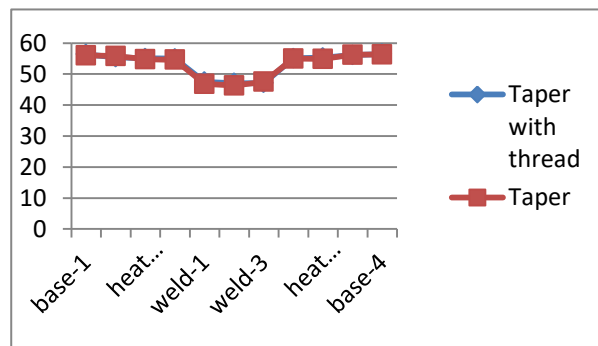
Fig 5: After LPT method

### Mechanical testing

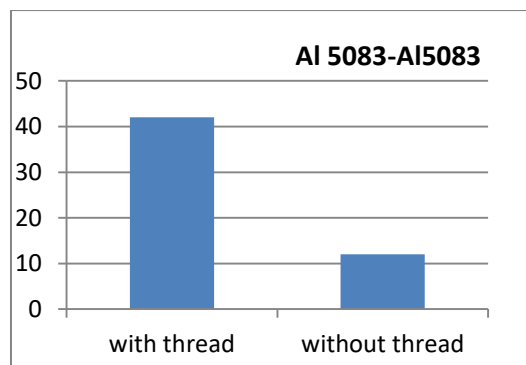
The tensile strength of Al5083 weld joints is investigated. The Al5083 plates were welded by Friction Stir welding technique with each input condition the three different joints are prepared. The finished joints are shown in fig 4. The weldments before taking to destructive testing are subjected to dye penetrant test to find the surface and subsurface defects. Then they are subjected to tensile and hardness tests. The results are tabulated, presented in table 6.



Graph no 1: shows the tensile test



Graph no 2: shows the hardness test



Graph no 3: shows impact test

	<b>Tensile strength</b>	<b>Hardness</b>	<b>Impact</b>
<b>Tapered with threaded pin</b>	122.024 MPa	55.57 BHN	42 J
<b>Tapered without thread pin</b>	90.473 MPa	46.87 BHN	12 J

Table no 6: mechanical testing values

## Conclusion

In this experiment the two process parameters of FSW i.e., feed rate and tool rotational speed are varied to find the effect on mechanical properties of friction stir welded Al 5083 alloy plates of 6.0mm thickness of those parameters. A combination of two tool rotational speeds and two welding speeds were employed in this experiment. As a result two joints were fabricated. Each joint is subjected to tensile test to know their mechanical properties. The following are the results that are derived from these experimentations.

From the experiment it is found that the aluminum 5083 alloy plates can be successfully welded by using a tool made of High speed steel rod having a flat shoulder and cylindrical tapered with and without threaded pin profile. No macroscopic defects were observed in the weld joints welded at tool rotational speeds of 700 to 1120 rpm, feed rate of 32 mm/min.

Tool profile influence the tensile strength of weldments taper with thread tool gives better results as higher Rpm then tapered without threaded is 15.65% increases in Al5083-Al5083.

There is very small change in hardness between two tool profiles and hardness value decreases with increasing tool rotational speed hence machinability increases.

There is influence of tool profile on the impact test .Taper with threaded tool gives better result at 825 Rpm value thus gives more impact strength compared to without thread.

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