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

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ABSTRACT

In the present paper, Evaluate the effect of welding process parameters like tool rotational speed and welding speed 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. Discussion of process parameters and their effects on mechanical properties of similar welded aluminum alloys. It is found that the joint fabricated at a tool rotational speed of 825rpm, welding speed 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%) has the highest strength of the non-heat treatable alloys 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 sub-group, 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 Shipbuilding, Rail cars, Vehicle bodies, Tip truck bodies, Mine skips and cages, Pressure vessels, drilling rigs etc.

Friction stir welding (**FSW**) is a relatively new solid-state joining process. The joining technique is energy efficient, environment friendly and versatile. It is considered that the most significant development in metal joining process in 21^{st} decade. It uses a non-consumable tool to join two facing 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. As a result of this process 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 investigate the effects of FSW on the mechanical properties of welded plates of AA 5083 along with the evaluation of post welding heat treatment in semi solid region.

Materials and Experimental work

Tool material

Many of the advances 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 use of the process. This field of study has led to higher weld production speeds, higher workpiece thickness, improved joint property, new materials and new welding equipment. 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 primarily consists of two parts namely 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 microstructure and the mechanical properties of the joint are governed 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 have been developed with, for the goal of reducing process forces, increasing the robustness of the process, or simplifying welding control. Different features are used by different practitioners of FSW, depending on the materials being welded and the process performance goals required. FSW practitioners needing to weld at higher travel speeds or with deeper weld penetration may adopt variations to the original tool design.

Experimental work

Rolled plates of 6 mm thick, Al5083 aluminum alloy base metal, were cut to the required size (150 m 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 and Table 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	7mm
Taper without thread	20 mm	5.7 mm	7 mm

Table: 3 tool profile and their specifications

Table no 4: process parameters

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

We are considered the process parameters such as tool rotational speed, feed, axial force, angle of tilt 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 tool rotational speed and welding speed and 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)

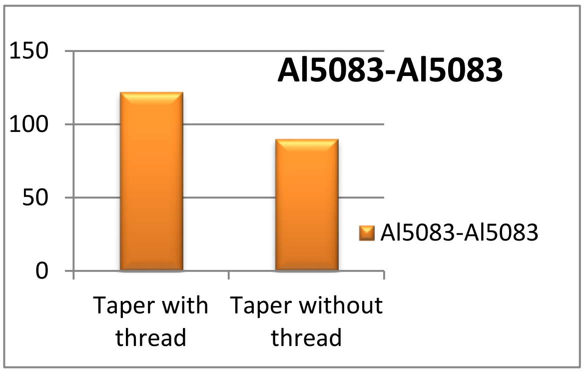
Non-destructive testing is the use of physical methods which will test materials, components and assemblies for flaws in their structure without damaging their future usefulness. LPT method which can be employed for the detection of open-to-surface discontinuities in any industrial product which is made from a non-porous material. This method is widely used for testing of non-magnetic materials. The process is illustrated Penetrants used are either visible dye penetrant or fluorescent dye penetrant. By this testing there is no defects are 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

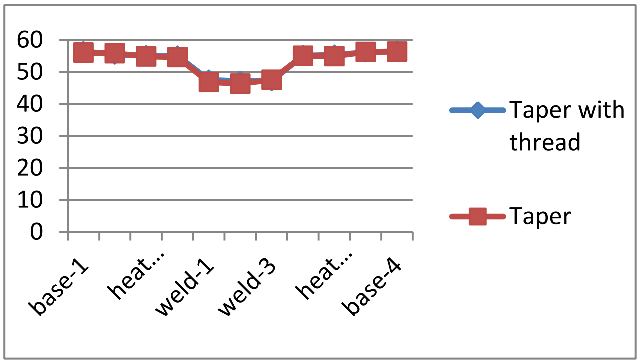
Fig 5:After LPT method

Mechanical testing

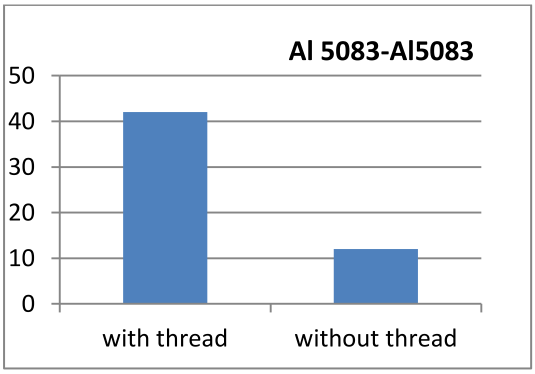
The tensile strength of Al5083 weld joints is investigated. The Al5083 plates were welded by Friction Stir welding technique with each input condition the three different joints are prepared. The finished joints are shown in fig 4. The weldments before taking to destructive testing are subjected to dye 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

	Tensile strength	Hardness	Impact
Tapered with threaded pin	122.024 MPa	55.57 BHN	42 J
Tapered without thread pin	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., tool rotational speed and welding speed are varied to find the effect of those parameters on mechanical properties of friction stir welded Al 5083 alloy plates of 6.0mm thickness. 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. From the results derived from these experimentations following conclusions have been drawn.

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, welding speeds 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 then gives impact strength is more.

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