INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

An Investigation of Mechanical Properties of Friction Stir Butt Welding Processes on AA6082 and AA5083 Alloy

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Abstract:
Friction Stir Welding (FSW) is a solid state welding process. In particular, it can be used to join high-strength aerospace aluminum and other metallic alloys that are hard to weld by conventional fusion welding. It was performed on 6 mm thickness AA6082 and AA5083 Aluminum alloys. Aluminum alloy light weight, softer, tendency to bend easily, cost effective in terms of energy requirements so aluminum alloy has selected in this FSW technique. In this welding when two metals are joined with the help of heat generated by rubbing metals against each other. The friction stir welding is mostly used for joining aluminum alloys. The main defects occurring in this welding are holes, material flow rate. These defects are mainly caused due to improper selection of welding parameters.
In this project the mechanical properties of aluminum alloy AA6082 and AA5083 has tested with the help of tensile testing machine, hardness testing machine and non destructive type radiographic testing. In this experimental the testing of mechanical properties based on the input parameters such as rotational speed, tool speed and axial force with proper welding parameters. Finally, the experimental results will be compared and analyzed.

Key words*: FSW*

1. Introduction
Friction stir welding (FSW) is a new, solid-state welding technique, which was invented by The Welding Institute (TWI) in 1991. It has enabled us to long butt-weld Al alloys, which are often difficult to be fusion welded without void, cracking, or distortion. Basically, the detail of FSW process is that a non-consumable tool with a specially designed rotating pin is entered into abutting edges of a sheet or plate to be welded. Once entered, the rotating tool produces frictional heat and plastic deformation in the specimen. The tool is then translated along the joint to complete the joining process.
Aluminum is one of the most abundant elements in the earth’s surface, with virtually inexhaustible supplies in the oceans. Over recent years the industrial output of Aluminum alloys has been rising by almost 20% per annum, which is faster than that of any other metal. The increased use of Aluminum and magnesium alloys are of great interest to the automotive industry, with the goal of reducing the weight of road vehicles to make them more fuel efficient or to increase the vehicle specification without adversely affecting its fuel efficiency. In recent years there has been a renewed interest in the use of Aluminum parts for body components, many of which have made by pressure die casting. These have limited ductility, contain gas occlusions, and are frequently difficult to weld satisfactorily by fusion welding techniques. With the major proportion of magnesium alloys being made by casting there has not previously been an extensive need for improved weldability to be developed. The main objective of my work is to find the mechanical properties of AA6082 and AA5083 after the friction stir welding and to find the difference between tensile strength, hardness and defects of AA6082 and AA 5083.

2. Experimental Work
The plates of AA6082 alloy are machined to the required dimensions (90 mm x 30 mm x 4 mm). Square butt joint configuration was prepared to fabricate the joints. The plates to be jointed were mechanically and chemically cleaned by acetone before welding to eliminate surface contamination. The direction of welding was normal to the rolling direction to the base metal. High-speed steel tool was used for welding AL alloy having the shoulder diameter of 20mm. The tool had a pin height of 3 mm and a 4 mm pin diameter.

The vertical milling machine has been used to perform the welding process the automatic operated conditioned type of vertical milling machine selected for doing the welding process. The ordinary fixture of milling machine cannot be used for this process.
So, the fixture designing is very important role in the welding process. The fixture has been designed for the dimensions of the work pieces. The work pieces clamped to the fixture. The fixture placed in the work table. The fixture is used for arrest the movement of the work piece. The tool is placed in the tool holder by using collect of 25mm diameter. The vertical milling machine is checked for the conditions and also the parameters for the welding process. The welding process is having three phases like Plunging, Stirring, and Retracting. The welding process can be done by the vertical milling machine. The tool slowly plunged to the work pieces, the required feed rate is given to the machine then the weld can be performed.
The welding process is performed at various parameters. The rolled plates of aluminum alloy were machined to the required dimensions (90 mm x 30 mm x 4 mm).
Square butt joint configuration was prepared to fabricate the joints. The plates to be joined were mechanically and chemically cleaned by acetone before welding to eliminate surface contamination. The direction of welding was normal to the rolling direction. Necessary care was taken to avoid joint distortion and the joints were made by securing the base metal. A nonconsumable, rotating tool made of high carbon steel was used to fabricate FSW joints.
The plates are prepared to measure the temperature at 8 points using thermocouples. On each plate, four 6mm diameter holes were drilled on one side of the plate.
Type K thermocouples of 5 mm diameter are subsequently inserted into the holes and glued so that the thermocouple ends are in intimate contact with the workpiece. The welding was carried out at room temperature. In some cases intensive cooling of the surface of the sheets, which were earlier cooled down to 0about 259 K (-14^{o}C), was implemented. The cooling was performed by pouring granulated dry ice (CO_2) on the surface of the sheets being joined. The samples were investigated in the after-welding state (the samples stored at the temperature of 243 K (-30^{o}C). The joint performance was determined by conducting tensile test hardness test and radiography testing.



Figure 1: Friction stir welding process in stirring stage.
Figure 2: Fixture set-up
Figure 3: Temperature controller

3. Tool Design

The design of the tool is a critical factor as a good tool can improve both the quality of the weld and the maximum possible welding speed. It is desirable that the tool material is sufficiently strong, tough and hard wearing, at the welding temperature. Further it should have a good oxidation resistance and a low thermal conductivity to minimize heat loss and thermal damage to the machinery further up the drive train. Hot-worked tool steel such as AISI H13 has proven perfectly acceptable for welding aluminum alloys within thickness ranges of 0.5 – 50 mm but more advanced tool materials are necessary for more demanding applications such as highly abrasive or higher melting point materials such as steel or titanium.
The high speed steel raw material has been taken the tool materials. The tool was designed based on the chuck of the radial drilling machine. Then the tool was heat treatment applied to increase the hardness. Improvements in tool design have been shown to cause substantial improvements in productivity and quality.

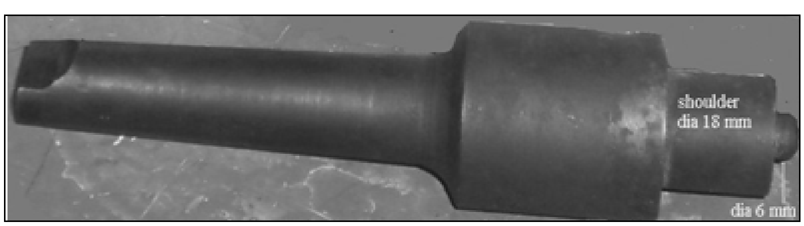

Figure 4: Tool

4. Selection of Welding Parameters and Composition of the Workpiece

4.1. Welding Parameters

No	w (rpm)	v (mm/min)	F(KN)
1	1120	50	7
2	1120	50	7

Table 1: shows welding parameters

4.2. Composition of Workpiece

S. No	Property	Value
1	Density	2700 kg/m3
2	Melting Point	555°C
3	Modulus of Elasticity	70 GPa
4	Electrical Resistivity	0.038x10-6 ohm.m
5	Thermal Conductivity	180 W/m.K
6	Thermal Expansion	24x10-6 /K

Table 2: shows composition of AA6082

5. Results and Discussion

5.1. Tensile Test

A tensile test, also known as tension test, is probably the most fundamental type of mechanical test you can perform on materials. Tensile test are simple, relatively inexpensive, and fully standardized. By pulling on something you will very quickly determine how the material will react to forces being applied in tension. As the material is being pulled, you will find its strength along with how much it will elongate.

Tensile tests were performed to determine the mechanical properties of the welded material. In FSW process with same rotational speed different aluminum materials were and there values were taken to investigate the welding parameters for the suitable aluminum alloys.

AA	W (rpm)	V (mm/min)	TS (Mpa)
5083	1120	50	NA
	1120	50	NA
6082	1120	50	230
	1120	50	229

Table 3: Friction weld of AA5083, 6082

In FSW process at the selected welding and rotational speed AA6082 has shown better performance when compared with AA5083and it is suitable for welding in the given parameters.

5.2. Hardness Test

The Vickers hardness test method consist of indenting the test material with a diamond indenter, in the form of a rigid pyramid with a square base between opposite faces subjected to a load of 1 to 100 kgf. The full load is normally applied for 10 to 15 seconds. The two diagonals of the indentation left in the surface of the material after removal of the load are measured using a microscope and their average calculated.

AA	W (rpm)	V (mm/min)	Hardness Value (VHN)
5083	1120	50	109
	1120	50	110
6082	1120	50	71
	1120	50	70

Table 4: Friction weld of AA, 5083, 6082

Table 4 shows the hardness value of the aluminum alloys AA5083 and AA6082 by friction stir welding. Here AA6082 has low hardness value when compared to AA5083.

5.3. Radiography Test

It employs X rays or gamma rays to penetrate an object, detect discontinuities by recording the difference on a recording device. It is used to detect internal flaws. Radiation safety is the major concern. X ray machines or IR 192 is the main source of radiation, uses penetrameters for ensuring the quality of the radiography procedure. Penetrameters are hole type and wire type. Sufficient radiography density is required for the radiograph for proper evaluation.

AA	W (rpm)	V (mm/min)	Radiographic results
5083	1120	50	Tunnel defect
	1120	50	Tunnel defect
6082	1120	50	Acceptable weld
	1120	50	Acceptable weld

Table 5: Friction weld of AA, 5083, 6082

Table 5 shows results of radiographic test for alloy AA5083. Tunnel defects were found while testing AA5083.AA6082 is welded and the radiographic test was taken, the report is good without any internal flaws and with proper surface finishing.

6. Conclusion

An investigation of AA6082 alloy can be successfully applied to the different testing conditions.

The results obtained from this investigation are as follows

- In tensile test AA6082 has shown better performance when compared with AA5083 for the given parameters.
- In hardness testing AA6082 has low hardness value when compared to the AA5083.
- In radiographic testing AA5083 has shown poor performance when compared to AA6082.

The overall performance of AA6082 was found to be good when compared to AA5083.

The usage of AA6082 is economical and will be very useful for industrial applications.

7. References

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