Numerical Study of Friction Stir Welding on Different Aluminum with Different Profile Pin

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Abstract - *In this research paper, a numerical study of friction stir welding on the aluminum sheet, there are three Almunium sheets for friction stir welding such as Al 5086, Al 6070, and Al 7075 with different profile pins, and there are selected six types of the pin profile which are Straight Cylindrical, Threaded Cylindrical, Tapered Cylindrical, Threaded tapered cylindrical, Triangular, and pentagonal pin. Here checking that which profile pin provides maximum strength by changing the rotation speed of the profile pin and also changing pressure on the aluminum sheet to see the effect of strength on the materials, also checking which profile pin is more stable as compared other five profile pin. The detailed property of all these three aluminum material sheets is given in the designing section.*

Key Words: Al 5086, Al 6070, Al 7075, friction stir welding, numerical, pin profile, pressure, the rotation speed of pin.

1. INTRODUCTION

Friction stir welding (FSW) has approach a long way since its improvement by Wayne Thomas, as a component of the Welding Institute (TWI). in 1991. The first technique of FSW took into account adjoining aluminum plates to be welded commonly and, surprisingly, non-wieldable compounds were effectively welded [11]. The system extra created make it workable for the friction stir welding of different materials like titanium, zinc, magnesium, and even steel [1]. Advancement was fundamental during FSW extension, like the utilization of an unmoving convey for titanium FSW, expected since of its high conductivity [9]. Up to this point FSW welding has just been feasible on smooth surface, yet new advancement have reasonable for the FSW of corners of shifting points. FSW and corner FSW (CFSW) are exceptionally equal interaction in various ways [3]. In FSW a non-consumable device, commonly comprising of shoulder and apparatus pin (or test), is dove into two adjoining plates in a decent position [10]. By the course of frictional warming from the turning device, the planned substance relax and is then consequently twisted as the instrument traversed the weld locale [13]. What makes FSW extraordinary is that as opposed to liquefying the material, it goes through contained unforgiving plastic stream roughly the borer [4]. Rather than the welding method being a projecting strategy like other welding strategy, it is a hot fashioning process or thermo-mechanical system. The divergence of being a thermo-mechanical technique rather than a projecting interaction is the reason FSW accomplishes such great weld coherency, skill, and might in fact be estimated to be a green cycle [2]. The disparity among FSW and CFSW is that the convey - rather than being fixed - is separating and created to hold the point of the bend that it is welding. Figure-01 shows the course of friction stir welding, and table-01 addresses the upside of friction stir welding [5].

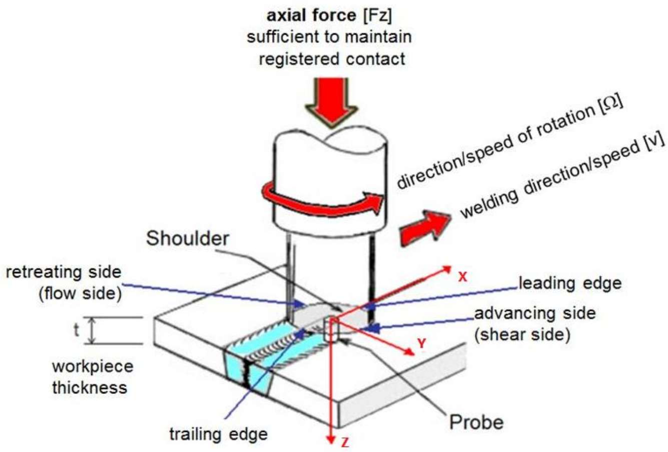


Figure-01: Process of Friction Stir Welding.

Table-01: Advantage of Friction Stir Welding [3].

Metallurgical advantages	Environmental Advantages	Energy Advantages
Solid-state joining process.	No Shielding gas required.	Improved materials use (i.e. joining different thicknesses) allows a reduction in weight.
Low distortion of the workpiece.	No surface cleaning required.	Only 2.5% of the energy needed for a laser weld.

Good dimensional stability and repeatability.	Eliminate grinding waste.	Decreased fuel consumption in lightweight aircraft, automotive, and ship applications.
No loss of alloying elements.	Eliminate solvents required for degreasing [12].	
Great metallurgical properties in the joint area.	Consumable materials saving, such as rugs, wire, or any other gases.	
Fine microstructure.	Can be performed underwater.	
Replace multiple parts joined by a fastener.		
Absence of cracking.		

1.1. Applications of FSW

While FSW is predominantly used on aluminum it has also been used on multiple materials which include steel, titanium, nickel-base superalloys, copper, and magnesium [5]. Besides, it has seen use in the airplane business, railroads, atomic and other electrical power plants, autos, machine instruments, metal handling, the petrochemical business [14], and electrical and mechanical areas [6]. Because of a fast take-up of the innovation [4], the FS Welding system has been applied to ordinary welding [8], yet additionally further fields that include the welding of barrel shaped and three-layered joints [12]. With the expansion of now corner FSWelding [15], there are not many applications that FSW doesn't have [7].

2. PROPERY OF ALUMUNIUM SHEET

The property of these three aluminum sheets is given in detail.

2.1. Property of Al-5086

The mechanical property and component of the Al-5085 are given in table-01 and table-02.

Table-02: Component of Al-5086

S.No	Component	Percentage (%)
1	Al	93 - 96.3
2	Cr	0.05 - 0.25
3	Cu	Max 0.1
4	Fe	Max 0.5
5	Mg	3.5 - 4.5
6	Mn	0.2 - 0.7
7	Si	Max 0.4
8	Ti	Max 0.15
9	Zn	Max 0.25

Table-03: Mechanical Property of Al-5086

S.No	Property	Metric
1	Hardness, Brinell	78
2	Hardness, Knoop	101
3	Hardness, Vickers	88
4	Ultimate Tensile Strength	290 MPa
5	Tensile Yield Strength	207 MPa
6	Elongation at Break	12%
7	Modulus of Elasticity	71 GPa
8	Compressive Modulus	72.4 Gpa
9	Ultimate Bearing Strength	552 MPa
10	Bearing Yield Strength	331 MPa
11	Poisson's Ratio	0.33
12	Fatigue Strength	150 MPa
13	Fracture Toughness	49 Mpa-m^0.5
14	Machinability	30 %
15	Shear Modulus	26.4 GPa
16	Shear Strength	175 MPa

2.2. Property of Al-6070

The mechanical property and components of the Al-6070 are given in table-04 and table-05.

Table-04: Component of Al-6070

S.No	Component	Percentage (%)
1	Aluminium / aluminum, (Al)	97
2	Silicon (Si)	1.40
3	Magnesium (Mg)	0.80
4	Manganese (Mn)	0.70
5	Copper (Cu)	0.28

Table-05: Mechanical Property of Al-6070

S.No	Property	Metric
1	Tensile strength	145 MPa
2	Yield strength	69 MPa
3	Shear strength	97 MPa
4	Fatigue strength	62 MPa
5	Elastic modulus	70-80 GPa
6	Poisson's ratio	0.33
7	Elongation	20%
8	Hardness	35

2.3. Property of Al-7075

The mechanical property and components of the Al-7075 are given in table-06 and table-07.

Table-06: Component of Al-7075

S.No	Component	Percentage (%)
1	Aluminium / aluminum, (Al)	94 to 95.1
2	Silicon (Si)	0.4
3	Magnesium (Mg)	2.1 to 2.9
4	Manganese (Mn)	0.30
5	Copper (Cu)	1.2 to 2
6	Fe	0.5
7	Zn	2.1 to 3.3

Table-07: Mechanical Property of Al-7075

S.No	Property	Metric
1	Tensile Yield strength	503 MPa
2	Ultimate Tensile strength	572 MPa
3	Shear strength	331 MPa
4	Fatigue strength	159 MPa
5	Elastic modulus	71.85 GPa
6	Poisson's ratio	0.33
7	Elongation	11%
8	Hardness	53.5

3. DETAILS OF PIN PROFILE

There are six types of pin profile used, that are Straight Cylindrical, Threaded Cylindrical, Tappered Cylindrical, Threaded tapered cylindrical, Triangular, and pentagonal pin. The details of every pin profile are given in table-08

Table-08: Mechanical Property of Al-7075

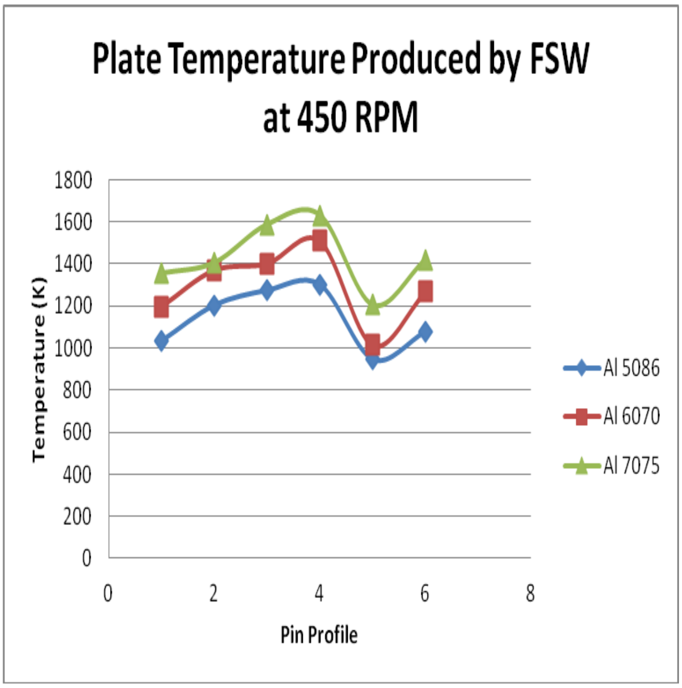
S.No	Type of Pin Profile	Bottom Parameter of Pin	Top Parameter of Pin	Height of Pin
1	Straight Cylindrical	5mm Diameter	5mm Diameter	8mm
2	Threaded Cylindrical	5mm Diameter with 0.5mm cutting gap	5mm Diameter 0.5mm cutting gap	8mm
3	Tappered Cylindrical	5mm Diameter	6.5mm Diameter	8mm
4	Threaded tapered cylindrical	5mm Diameter with 0.5mm cutting gap	6.5mm Diameter with 0.5mm cutting gap	8mm
5	Triangular	5.5 mm width	5.5.mm width	8mm
6	pentagonal pin	3.5 mm width with 108 degree	3.5 mm width with 108 degree	8mm

4. CALCULATION AND RESULT

In the Calculation and result, there is result come out after the numerical analysis of the different pin profiles such as Straight Cylindrical, Threaded Cylindrical, Tappered Cylindrical, Threaded tapered cylindrical, Triangular, and pentagonal pin at the different aluminum sheets such as Al 5086, Al 6070, and Al 7075. The dimension of every aluminum sheet is 45cm*25cm*5cm.

4.1. Plate Temperature at 450RPM

Temperature produced at the surface of the aluminum sheet due to joining the two aluminum plates with help of the friction stir welding is known as plate temperature. When the rotational speed of of the pin profile is kept at 450 RPM, the temperature generated at the surface of the aluminum plate is given in the graph-01:

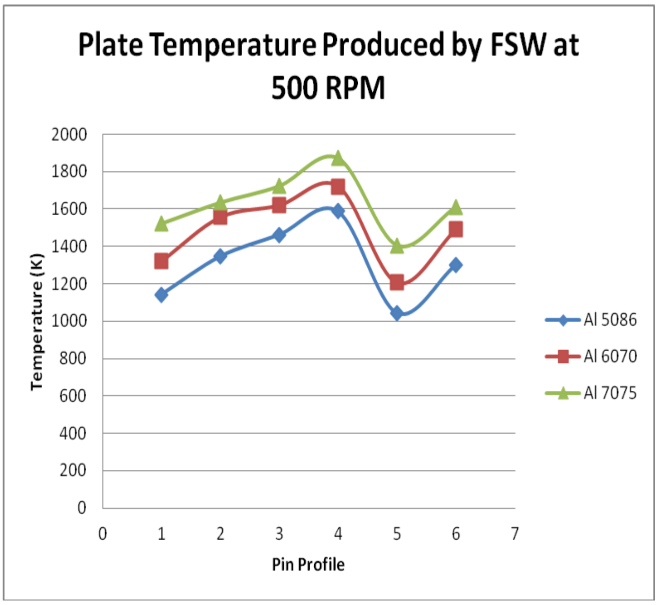


Graph-01: Plate temperature produced by FSW at 450 RPM.

From the above graph, the minimum temperature produced in the Al-5086. Where pin profile on the X-axis 1 to 6 represent Straight Cylindrical (1), Threaded Cylindrical (2), Tappered Cylindrical (3), Threaded tapered cylindrical (4), Triangular (5), and pentagonal pin (6) respectively.

4.2. Plate Temperature at 500 RPM

When the rotational speed of the pin profile increases up to 500 RPM, the temperature generated at the surface of the aluminum plate is given in graph-02:

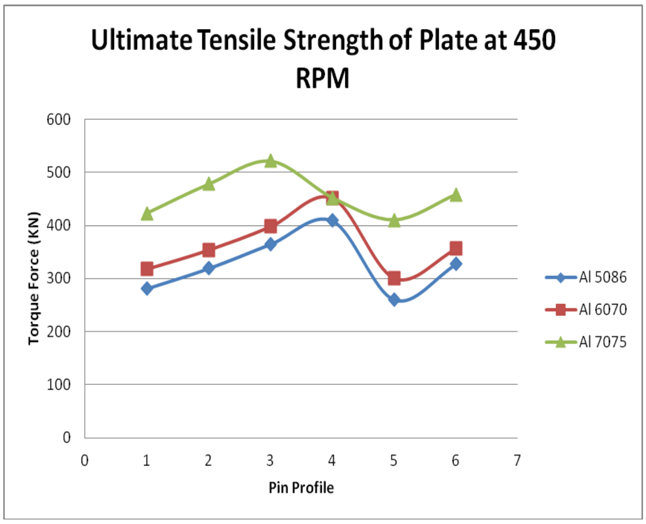


Graph-02: Plate temperature produced by FSW at 500 RPM.

From the above graph of the plate temperature, the maximum temperature generated in the Al 7075.

4.3. Ultimate Tensile Strength of the Plate at 450 RPM

Ultimate tensile strength (UTS), often shortened to tensile strength (TS), is the maximum stress that a material can withstand while being stretched or pulled before breaking. The joining of two aluminum plates with help of the friction stir welding at the rotational speed of the pin profile is 450RPM, the ultimate tensile strength of these three aluminum sheets with different pin profiles is given in graph-03:

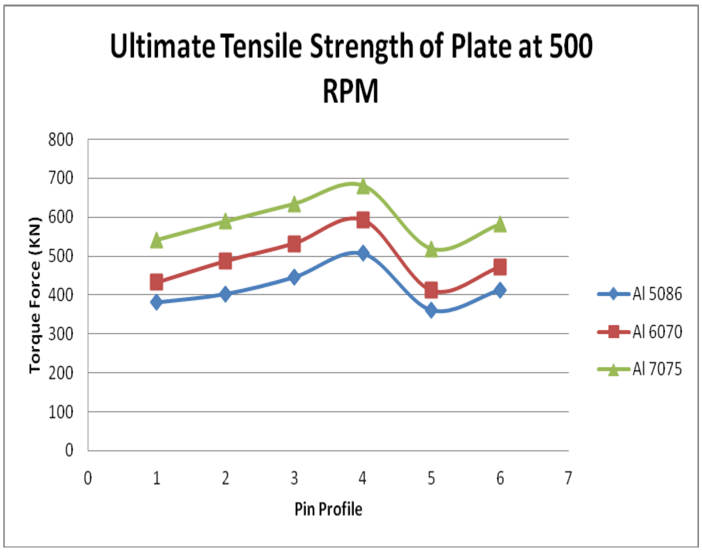


Graph-03: Ultimate tensile Strength of Plate at 450 RPM.

From the above graph of the ultimate tensile strength of the aluminum plate at the 450RPM, the ultimate tensile strength is almost the same for every aluminum sheet at the pin profile Threaded tapered cylindrical.

4.4.Ultimate Tensile Strength of the Plate at 500 RPM

The joining of two aluminum plates with help of the friction stir welding at the rotational speed of the pin profile is 500RPM, the ultimate tensile strength of these three aluminum sheets with different pin profiles is given in graph-04:



Graph-04: Ultimate tensile Strength of Plate at 500 RPM.

From the above graph of the ultimate tensile strength, the value of the tensile strength is decreased by using the Triangular pin profile in any type of aluminum sheet.

5. CONCLUSION

After numerically analysis of the friction stir welding on the three different aluminum sheets with six different pin profiles such as Straight Cylindrical, Threaded Cylindrical, Tapered Cylindrical, Threaded tapered cylindrical, Triangular, and pentagonal pin by increasing the rotational speed of the pin profile on the alumunim sheet. When the rotational speed of the pin profile kept 450RPM at every aluminum sheet, then it found that temperature getting decrease at the triangular pin profile and maximum temperature at the threaded tapered cylindrical in every profile. The ultimate tensile strength of every aluminum sheet is increasing by increasing the rotational speed of the pin profile, and it also found that maximum tensile strength can be achieved by using the threaded tapered cylindrical.

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