

# OPTIMIZATION AND CHARACTERIZATION OF DISSIMILAR WELDING OF AA5083 & AA6082 ALUMINIUM ALLOYS

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**Abstract** – The aluminum alloys of AA5083 and AA6082 were friction stir welded. The welded samples were prepared for tensile test. The optimization of welding parameter is found by taguchi method under design of experiments. The tensile strength of friction welded joint is analyzed. The present work was focused on optimization dissimilar of aluminum alloys of AA5083 and AA6082 welds. This may lead to have a difference in mechanical properties of weld joints with respect to the varying parameters.

**Key Words:** friction stir welding, aluminum alloys of AA5083 and AA6082 welds, tensile test, bending test, taguchi method, analysis of variance and optimization of parameters.

## 1. INTRODUCTION

### 1.1 FRICTION STIR WELDING

Friction stir welding (FSW) is a solid-state joining process that 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 material, 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, or dough.

It is primarily used on wrought or extruded aluminium and particularly for structures which need very high weld strength. FSW is also found in modern shipbuilding, trains, and aerospace applications. A rotating cylindrical tool with a profiled probe is fed into a butt joint between two clamped workpieces, until the shoulder, which has a larger diameter than the pin, touches the surface of the workpieces.

The probe is slightly shorter than the weld depth required, with the tool shoulder riding atop the work surface. After a short dwell time, the tool is moved forward along the joint line at the pre-set welding speed. Frictional heat is generated between the wear-resistant tool and the work pieces. This heat, along with that generated by the mechanical mixing process and the adiabatic heat within the material, cause the stirred materials to soften without melting. As the tool is moved forward, a special profile on the probe forces plasticized material from the leading face to the rear, where the high forces assist in a forged consolidation of the weld. This process of the tool traversing along the weld line in a plasticised tubular shaft of metal results in severe solid-state deformation involving dynamic recrystallization of the base material

### 1.2 OBJECTIVE OF THE WORK

To study the effect of optimization of process parameter of tilt angle is 0°, 1°, 2°, tool rotation speed 700, 900, 1100 rpm, transverse speed of 70, 90, 110 mm/min. Macrostructure and Microstructure study. hardness survey of dissimilar joint.

## 2. EXPERIMENTAL PROCEDURE

### 2.1 MATERIAL SELECTION

AA5083 is an magnesium base aluminium alloy. It is known for exceptional performance in extreme environments. It is highly resistance to attack by both sea water and industrial chemical environments. It is the highest strength of the non heat treatable alloy but is not recommended for use in temperatures in excess of 65 c. AA6082. The 6XXX series aluminium magnesium silicon alloys possess medium strength and corrosion resistance. It is highest strength of the 6XXX series alloy. 6XXX the last two digits represent the purity of the metal. The mechanical properties on two different friction stir welded aluminium alloys 5083 and 6082 which finds applications in ship building, construction and other fabrication industries.

**Chemical Composition**

Table 3.1 Chemical Composition of AA6082 and AA5083

Aluminim Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	AL
AA6082	1.30	0.50	0.10	1.00	1.2	0.25	0.20	0.10	Bal
AA5083	0.4	0.50	0.10	1.2	4.9	0.09	0.25	0.15	Bal

**2 .Experimental design of taguchi method**

Taguchi’s L9 orthogonal array with 3 LEVEL 3factors

Table. 2 level of the process input parameter

Factor	Level 1	Level 2	Level 3
Rotational speed(rpm)	700	900	1100
Travel speed (mm/min)	70	90	110
Tilt angle (°)	0	1	2

**Welding parameters**

Weld Travel speed = 70,90,110 mm/min

Tool rotational Speed = 700, 900,1100 rpm

Tilt angle = 0°,1°, 2°

Material thickness = 6mm

Tool material= HSS(High speed steel)

Threaded Tool = 5 threads

Pin length = 4.7mm

Type of joint = Butt joint

Table 2.1 L9 experimental design parameters

Sample no	Tool Rotational speed (rpm)	Travel Speed (mm/min)	Tilt Angle (°)
1	700	70	0°
2	700	90	1°
3	700	110	2°
4	900	70	1°
5	900	90	2°
6	900	110	0°
7	1100	70	2°
8	1100	90	0°
9	1100	110	1°

### 3. Welded specimen



Fig.2.1 welded specimen

#### 3.1 Ultimate Tensile Strength

Then tensile testing has been done on UTM until fracture of specimen as per the standard ASTM E8/E8M-09 and calculates the ultimate tensile strength and elongation for all specimens.

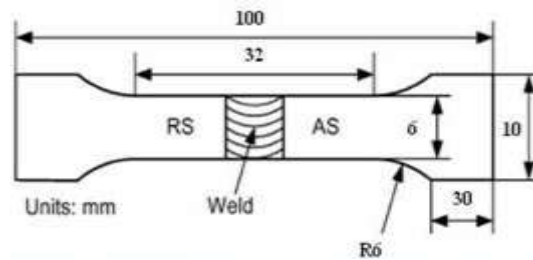


Fig 2.2 Tensile test specimen preparation

#### 3.2 Microstructure

After that the FSW welded specimen was etched with freshly prepared Keller's reagent of solution containing 190ml of water, 5ml HNO<sub>3</sub>, 3mm HCL and 2ml HF to reveal the microstructures.

#### 3.3 Micro hardness

Micro hardness across the welded joint, have been carried out in polished and etched sections, as per the standard ASTM E 384-99. The hardness was carried out with Micro hardness tester using 0.5Kg weight for aluminium 6082-T6 and 5083-H111 with dwell time of 10s.

### 4. RESULTS AND DISCUSSION

#### 4.1 ULTIMATE TENSILE STRENGTH

The table was showing the FSW AA 5083 and AA 6082 the value of ultimate tensile strength, percentage of elongation, yield strength, and also fracture location was observed for all specimens. They high tensile values of 217 MPa in optimized parameters on tool rotation 700rpm, travel speed 110mm/min, and tilt angle are 2°

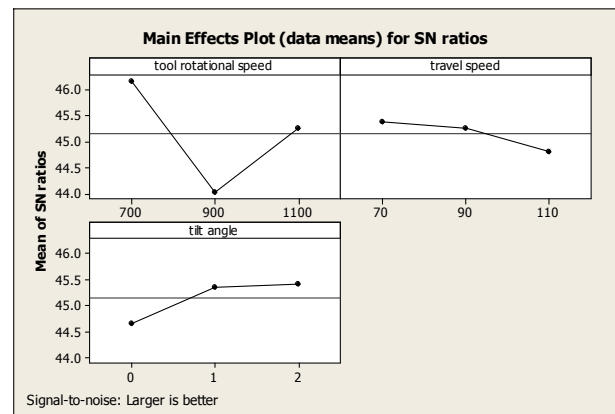
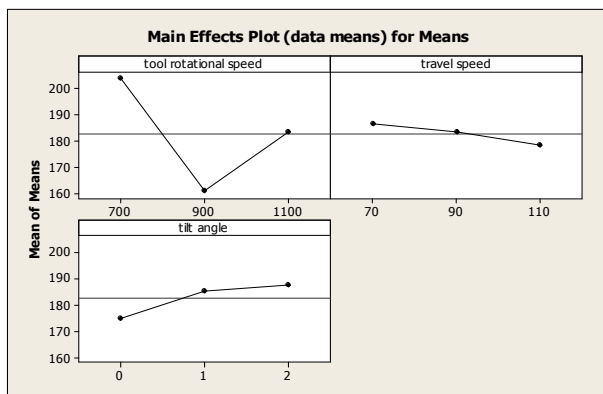
**Table -4.1:** Tensile test results of dissimilar friction stir welded samples.

S.NO	Yield strength	UTS	% Elongation	Fracture location
1	135	186	15.10	Weld
2	118	176	14.75	Weld
3	146	217	21.50	Weld

4	120	169	13.75	HAZ
5	116	172	11.5	Weld
6	123	192	15.50	Weld
7	100	170	9.50	Weld
8	120	207	17.25	HAZ
9	115	191	13.75	HAZ

#### 4.2 Taguchi analysis:

They taguchi method are used optimization on parameter for friction stir welding are below mention the optimized parameter and plot graph on mean and SN/ratio shown



Main effects plot (data means)for means

#### 4.3 Microhardness test

Micro hardness across the welded joint, have been carried out in polished and etched sections, as per the standard ASTM E 384-99. The hardness was carried out with MMTX3 Micro hardness tester using 0.5Kg weight for aluminium 6082-T6 and 5083-H111 with dwell time of 10s.

s.no	6082 Base	6082 HAZ	6082 THMZ	Stir Zone	5083 THMZ	5083 Base
1	53.0	34.1	36.7	42.7	41.0	44.1
2	52.5	37.1	35.6	42.0	38.9	44.8
3	52.4	37.9	35.0	46.0	39.6	43.7
4	52.1	38.0	36.3	43.6	38.2	44.5
5	49.5	38.4	35.9	41.9	37.8	44.0
6	51.1	37.4	34.4	42.5	38.0	43.0
7	51.0	35.3	35.5	43.3	40.3	44.7
8	49.5	35.7	36.3	44.2	39.7	37.1
9	49.4	34.4	36.5	42.0	37.5	36.5

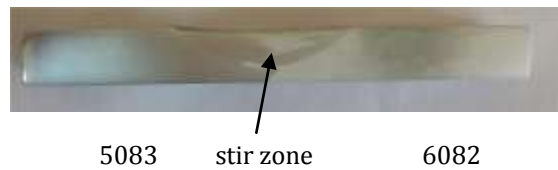
#### 4.4 Bending test

A bend test is a method for measuring stiffness and yield properties of certain material, Bend test for ductility provide a simple way to the evaluate the quality of material by their ability to resist cracking or surface irregularities during one continuous bend, In certain cases the bend test can determine tensile strength

Sl no	Trial No	Continuous load (MPa)	Bending angle °	Bending Time (sec)
1	3	350	30	130 sec
2	6	330	35	120sec
3	8	70	45	60sec

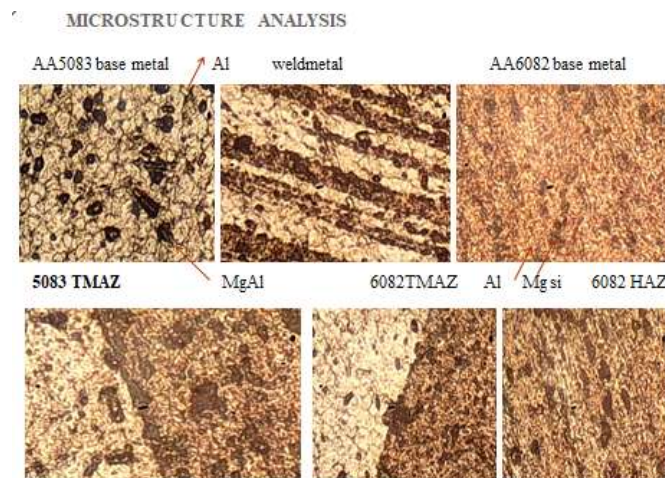
#### 4.5 Macro Structure

After that the FSW welded specimen was etched with freshly prepared Keller’s reagent of solution containing 190ml of water, 5ml HNO<sub>3</sub>, 3mm HCL and 2ml HF to reveal the microstructures



#### 4.6 Microstructure analysis

We observe 5083 base metal, 5083 thermo mechanical heat affected zone, weld metal, 6082 thermo mechanical heat affected zone, heat affected zone 6082, base metal 6082.



#### 5. CONCLUSIONS

It is concluded that efficiency of the welded joint, hardness of dissimilar alloys tested is superior to the similar aluminium alloys (5083&6082)

- The taguchi method is used to optimized the parameters on tool rotation 700 rpm, travel speed 110mm/min, and tilt angle 2 degree is highest tensile test value is 217 MPa obtained.
- The optimized parameter is used to analysis bend test, micro hardness, macro, micro structure to evaluvated.

#### REFERENCES

[1] H M anil kumar, V.venkatramana, mayrur pawar experimental study on dissimilar friction stir welding of aluminum alloy (5083-H111 and 6082-T6) to investigate the mechanical properties

[2]. J. Murali, K.T. Thilagham, P. Sundararaj , Optimization of Process parameters on Friction Stir Welding of AA2014 & AA6082 Aluminium Alloy [2018]

- [3]. P. Cavaliere, A. De Santis, F. Panella, A. Squillace, Effect of welding parameters on mechanical and microstructural properties of dissimilar AA 6082 and AA 2024 joints produced by friction stir welding [2009].
- [4]. R.Ramesh, S.M.Sivagami, A.A.Muhammad Irfan, 4N.Murugan, evaluation of metallurgical and mechanical properties of dissimilar aluminium alloy 2014- t6 & 6082-t6 joints produced by friction stir welding[2014].
- [5]. suresh d. meshram, g. madhusudhan reddy, and a. venugopal rao, role of threaded tool pin profile and rotational speed on generation of defect free friction stir AA2014 aluminium alloy welds[2016]
- [6]. Akos Meilinger, Imre Torok, The importance of friction stir welding tool [2013].
- [7]. Y. N. Zhang, X. Cao, S. Larose and P. Wanjara, Review of tools for friction stir welding and processing [2012].
- [8]. Kudzanayi chiteka, friction stir welding and processing tool materials and selection [2013].
- [9]. T. Debroy and h. k. d. h. Bhadeshia, friction stir welding of dissimilar alloys – a perspective [2010]