PARAMETRIC OPTIMIZATION OF FRICTION STIR WELDING OF ALUMINUM ALLOY 6082

Ankit[1], Mr. Rajesh[2]
[1]M.Tech student, Department of Mechanical Engineering, UIET MDU Rohtak, Haryana, India
[2]Assistant professor, Department of Mechanical Engineering, UIET MDU Rohtak, Haryana, India

ABTRACT- Aluminum alloys are widely used in automotive, aerospace, ship building industry. These alloys are difficult to weld with conventional welding processes. Friction stir welding, a solid state welding joins these alloys effectively and creates high strength, high quality weld with low distortion. Welding of aluminum alloy 6082 was done with the help friction stir welding and changes in its microstructure and properties were observed under varying process parameters. The process parameters are tilt angle, rotational speed and feed or traverse speed.

KEYWORDS- Friction stir welding, hardness, rotational speed, percentage elongation and Taguchi technique.

1. INTRODUCTION

Friction stir welding was invented in 1991 at The Welding Institute (TWI) in UK to weld aluminum alloys.For creating the joint a rotating tool is used on which a downward force acts .Feed is also given to tool to move it in forward direction. Due to friction between tool and workpiece heat is generated. This heat softens the material and by stirring process parts are joined. Tool shoulder and pin are made highly wear resistant to prevent them damaging from heat. The plastic deformation that occurs in material is in thin layer and refined and equiaxed grains are formed due to which high strength joint is produced. Friction stir welding is environment friendly as it produces no fumes, no flux is used and no shielding gases are used

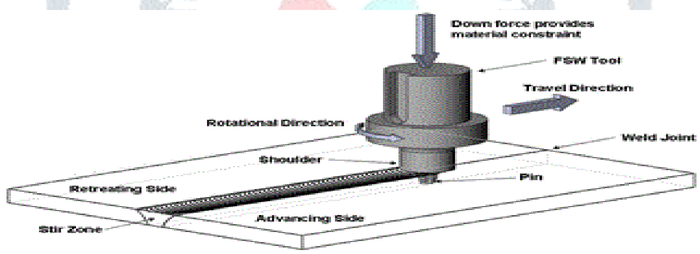


Figure 1. Friction Stir Welding Schematic

2. LITERATURE REVIEW

Hasan et al.[10] (2007) developed a model called artificial neural network (ANN) to analyze and simulate the relation between process parameters of friction stir welding and mechanical properties. Mechanical properties such as hardness of weld, elongation, and yield strength are the outputs of model while parameters such as transverse speed, rotational speed of spindle are the inputs. The results of the model were very reliable. With the help of ANN model a relation can be established between mechanical properties of joined aluminum plates and parameters like transverse speed and rotational speed of tool. The effect of both these factors on the properties of joint obtained by FSW was simulated. Then assessment was done between measured and calculated data. The results obtained from this model were very close to those obtained from measurement.

Jamshidi*et al.*[14](2010) investigated thecorrelation between heat input for FSW of AA 5086 and TMAZ. First, heat given for the purpose of welding was calculated with the aid of 3-D finite element analysis then with the help of different welding experiments the microstructure of TMAZ of the work hardened and annealed specimen was studied. The results showed that temperature field was asymmetrically distributed along the welding line. The study also showed that with decrease in heat input during FSW the grain size also reduced.

Sarsilmaz and Çaydaş[12] (2008)deliberated the effect of process parameters such as RPM of spindle and transverse velocity of tool on the properties of weld AA 1050/AA 5083 using full factorial experimental design. For this purpose properties such as hardness, maximum tensile strength (UTS) of joint were determined. Analysis of variance (ANOVA) was also used to optimize each process parameter.

Lakshminarayanan and Balasubramanian [11] (2008) used Taguchi approach to find the most important parameters that will yield better mechanical properties of weld of aluminum alloy RDE-40. The results showed that RPM of the tool, transverse velocity and force exerted by the tool in the axial direction were main deciding factors of strength of weld. So with the help of Taguchi approach optimization of these parameters was done.

F.F. Wang *et al.*[4] (2015)studied the effect of RPM on the microstructure of the weld and tensile strength. He observed that with increase in the RPM the grain size of stirred region also increased. The strength of the weld reached to maxima with increase in RPM of the tool,then it started to decrease. The efficiency of the joint at the maxima was found about 80%.

3. MATERIAL

Plates of size 100x50x5mm of aluminum alloy 6082 are used for investigation. AA6082 has the following composition.

TABLE.1 AA6082 Chemical composition

ELEMENT	%
Si	0.7-1.3
Mg	0.6-1.2
Fe	0.0-0.5
Mn	0.4-1.0
Cu	0.0-0.01
Zn	0.0-0.2
Ti	0.0-0.1
Al	BAL

3.1 TOOL DESIGN

A tool of cylindrical shape which consists of a probe or pin and shoulder is used. The material for tool is selected in such a way that it should have high resistant to wear, high fatigue strength, low coefficient of thermal expansion and good machinability.

TABLE.2 Tool Geometry Parameters

PARAMETER	DESCRIPTION
Shoulder diameter in mm	18
Pin diameter in mm	6
Threads pitch in mm	0.5
Pin length in mm	5.5

FIGURE 2. Welding Tool

3.2 PROCESS PARAMETERS

Following are the process parameter-

(1) Rotational Speed

(2) Transverse Speed and

(3) Axial force

In addition to these three, another parameter that controls the quality of weld is the shape of the tool but in this the effect of only these three is studied.

3.3 WELDING PROCEDURE

After preparing the specimen of size (100x50x5mm) it is loaded on the machine and fixed firmly using fixture. Tool is made to rotate in clockwise direction and is given feed along the length of specimen. Below is the image of the machine on which specimen are welded.

FIGURE 3. Welding Machine

TABLE 3. Welding Variables

SPECIMEN NO.	AXIAL FORCE(KN)	ROTATIONAL SPEED(RPM)	TRANSVERSE SPEED(MM/MIN)
1	6	900	80
2	7	900	100
3	8	900	120
4	7	1100	80
5	8	1100	100
6	6	1100	120
7	8	1300	80
8	6	1300	100
9	7	1300	120

❖ Below is the image of samples after welding.

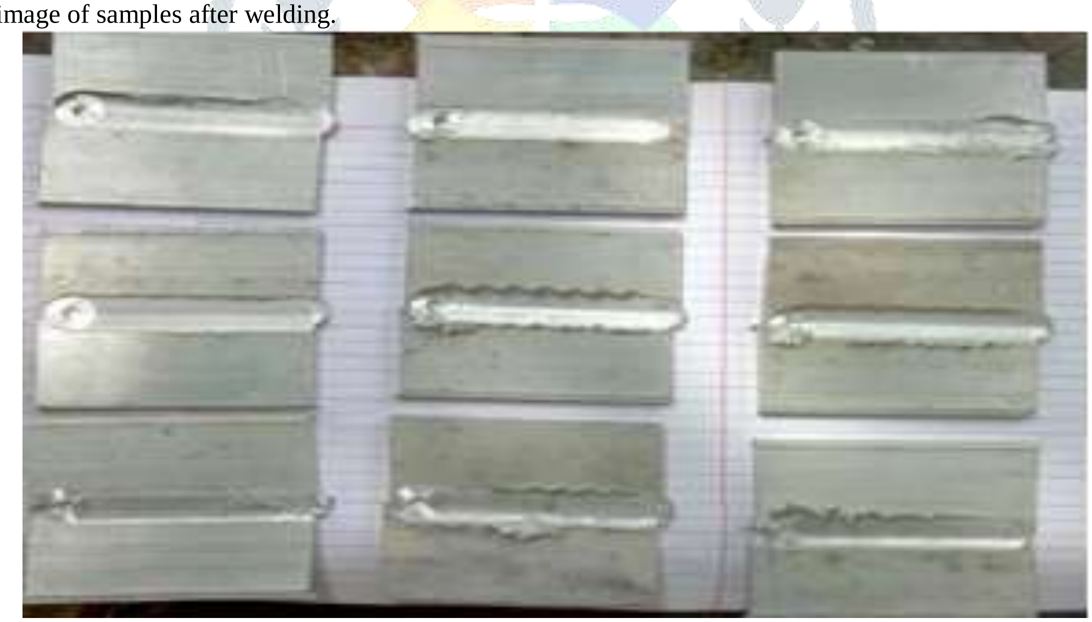


Figure 4. Welded Samples

❖ After welding,samples are tested on the machine

Figure 5. Samples before testing

Figure 6. Samples after testing

4. RESULTS AND DISCUSSION

Specimens were tested on various machines and ultimate tensile strength, signal to noise ratio and percentage elongation were calculated. Based on analysis and observations specimen no. 9 with rotational speed 900 rpm, transverse speed 120mm/min was found to be having highest ultimate tensile strength, 201Mpa. Variation of percentage elongation is shown in the table and is also plotted on graph.

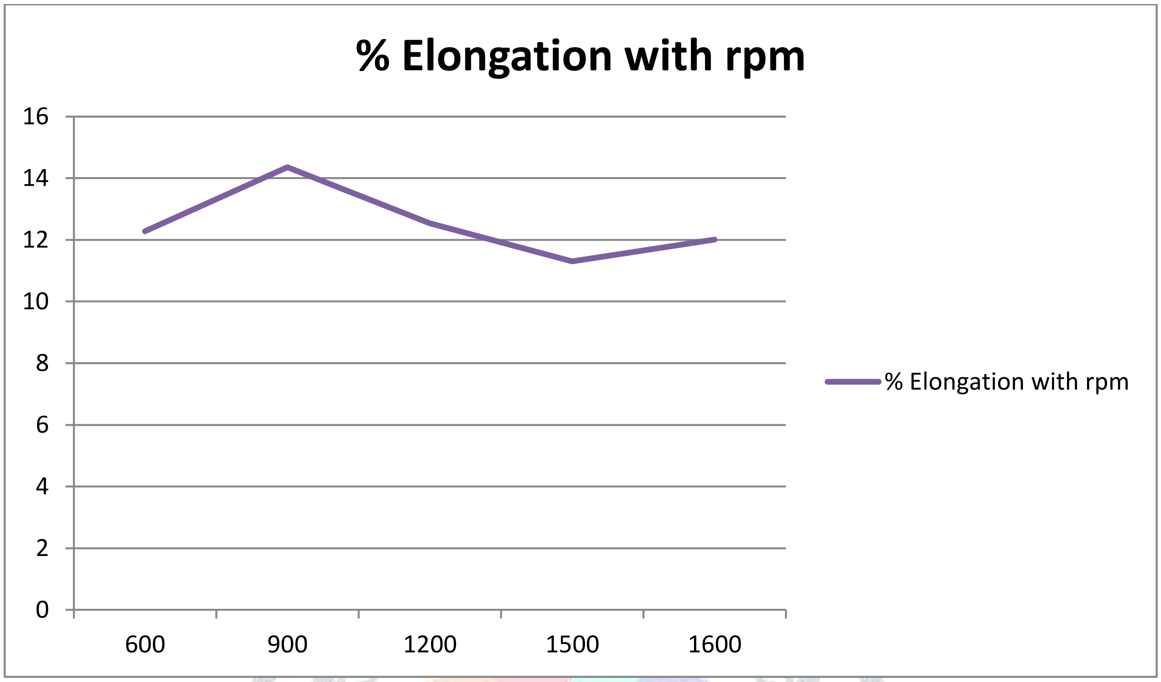
Table 4. Ultimate Tensile Strength of different welds

SPECIMEN NO	ROTATIONAL SPEED	TRANSVERSE SPEED(mm/min)	AXIAL FORCE (KN)	UTS(MPa)	SIGNAL TO NOISE RATIO
1	900	80	6	179	45.2014
2	900	100	7	187	45.5751
3	900	120	8	194	45.8893
4	1100	80	7	174	45.2964
5	1100	100	8	184	45.4368
6	1100	120	6	197	46.0639
7	1300	80	8	185	45.4832
8	1300	100	6	190	45.7111

9	1300	120	7	201	46.1926

Table 5. % Elongation of different weld specimens

SPECIMEN NO	1	2	3	4	5	6	7	8	9
% ELONGATION	12.28	11.76	14.36	10.98	12.54	11.95	11.30	10.41	12.01



Variation of % elongation with rpm

4.1 HARDNESS TEST RESULTS

TABLE 6.Hardness of different weld specimen

SPECIMEN NO	1	2	3	4	5	6	7	8	9
LOAD(KG)	100	100	100	100	100	100	100	100	100
HRB	54.35	61.58	79.21	54.85	66.64	77.13	57.12	57.02	75.18

4.2 RESULTS OF STUDY OF MICROSTRUCTURE

TABLE 6. RESULTS OF STUDY OF MICROSTRUCTURE

Sample no.	Crack	Blow Holes	Heat Affected Zone	Effect on grain structure
1	Observed	Not observed	Observed	Elongated grains observed
2	Not observed	Not observed	Observed	Elongated grains observed
3	Not observed	Not observed	Observed	Elongated grains Observed
4	Observed	Observed	Observed	Elongated grains Observed
5	Not observed	Not observed	Observed	Elongated grains Observed
6	Not Observed	Not observed	Observed	Elongated grains Observed
7	Not Observed	Not observed	Observed	Elongated grains Observed

8	Observed	Not observed	Observed	Elongated grains Observed
9	Not Observed	Not observed	Observed	Elongated grains observed

5. CONCLUSION

Taguchi method and ANOVA analysis were used to study the effect of rotational speed, translational speed and microstructural change on the tensile strength, hardness and percentage elongation of joint. Maximum tensile strength was observed for specimen 9 at rotational speed of 1300 rpm, translational speed 120 mm/min and at a axial force of 7 KN . Percentage elongation of specimen 3 was observed maximum because no blow holes and cracks were present in the microstructure. Also for specimen 3, maximum hardness was observed. ANOVA table indicated that rotational speed had maximum impact on the hardness followed by axial force and translation speed.

REFERENCES

[1] AArora, A Deb, T DebRoy.Toward optimum friction stir welding tool shoulder diameter. ScriptaMaterialia 2011, 64, 9–12.
[2] A M Khourshid, I Sabry. Friction Stir Welding on aluminium pipe. International Journal of Mechanical Engineering and Robotics Research 2013;2:331-9.
[3] A Razal Rose, K Manisekar, V Balasubramanian. Effect of axial force on microstructure and tensile properties of friction stir welded AZ61A magnesium alloy. Trans. Nonferrous Met. Soc. China 2011,21, 974-84.
[4] A. K. Lakshminaryanan, V. Balasubramanian.Process parameters optimization for friction stir welding of RDE-40 aluminium alloy using Taguchi technique. Trans. Nonferrous Met. Soc. China 2008;18:548-54.
[5] Devantahan, A. Murugan, A. Suresh Babu. Optimization of process parameters in friction stir welding of Al 6063. International Journal of Design and Manufacturing Technology 2013;4:42-8.
[6] H. Su, C. S. Wu, A. Pittner, M. Rethmeier. Simultaneous measurement of tool torque, traverse force and axial force in friction stir welding. Journal of Manufacturing Processes 2013;15:495-500.
[7] HarpreetSidhar, Nelson Y. Martinez, Rajiv S. Mishra1, Juergen Silvanus. Journal of materials and design.2016; 731-6.
[8] Inderjeet Singh, Harjot Singh, Ankit Chopra. Effect of tool rotational speed on tensile and impact strength of friction stir welded joints of aluminium 6063 alloy. International Journal of Research in Mechanical Engineering and Technology 2014;4:47-9
[9] Indira Rani M., Marpu R. N., A. C. S. Kumar. A study of process parameters of friction stir welded AA 6061 aluminium alloy in O and T6 conditions. ARPN Journal of Engineering and Aplied Sciences 2011;6:61-6.
[10] M. Jayaraman, R Sivasubramanian, V Balasubramanian, A K Lakshminarayanan. Optimization of process parameters for friction stir welding of cast aluminium alloy A319 by Taguchi method. Journal of Scientific and Industrial Research 2009;68:36
[11] Mukuna P, Mubiayi. Friction stir welding of dissimilar materials between aluminium alloys and copper. Proceedings of the World Congress on Engineering 2013 Vol III.
[12] P Cavaliere , A De Santis, F Panella, A Squillace. Effect of welding parameters on mechanical and microstructural properties of dissimilar AA6082–AA2024 joints produced by friction stir welding.Materials and Design 2009, 30, 609–16.
[13] P. Karthikeyan, K. Mahadevan. Study on the weld quality of the friction stir welded Al-6063 plates using square and pentagonal profiled tools. Journal of Applied Sciences 2012;10:1026-31.
[14] R S Mishra, Z Y Ma. Friction stir welding and processing. Materials Science and Engineering 2005, R 50, 1–78.
[15] R. K. Kesharwani, S. K. Panda, S.K. Pal. Multi objective optimization of friction stir welding parameters for joining of two dissimilar thin aluminium sheets. Procedia Materials Science 2014;6:178-87.