IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 5, May 2021

DOI: 10.17148/IARJSET.2021.85119

OPTIMIZATION OF PROCESS PARAMETERS IN FRICTION STIR WELDING OF DISSIMILAR ALUMINIUM ALLOYS

SUNIL KUMAR.K[1], Dr.S.AYYAPPAN[2]

1. PG Scholar, Manufacturing Department, Government College of Technology, Coimbatore, India

2. Assistant Professor, Mechanical Department, Government College of Technology, Coimbatore, India

Abstract: Friction stir welding (FSW) is a method through which frictional heating and plastic deformation normally joined the work pieces at temperatures under the melting temperature of the materials. The recent trend is to join dissimilar materials to take advantage of low cost material in places where high strength high cost material is not needed. In this paper, the work is carried out to assess the impact of axial force and the mechanical properties during friction stir welding of dissimilar joint of aluminium alloys (AA6061 and AA5052 aluminium alloy). The parameters considered are tool rotational speed, tool translational speed and plunge depth. The optimum process parameters were determined with reference to tensile strength of the joint. The anticipated best value of tensile strength was confirmed by conducting the confirmation run using optimum parameters. This study shows that defect free, high efficiency welded joints with best tensile properties can be made using a proper selection of process parameters. Based on the experimental data, empirical relations among the parameters correspond to every output features have been developed using simple regression method.
Keywords**:** Friction Stir Welding, Aluminium Alloys, Simple Regression Method

I. INTRODUCTION

Friction stir welding (FSW) is a solid state joining process, the joints are created by the combined action of frictional heating and mechanical deformation using a special rotating tool. A non-consumable rotating tool is pushed into the materials to be welded and the central pin or probe, followed by the shoulder, is brought into contact with the two parts to be joined. The rotation of the tool heats up and plasticizes the material it is in contact with and, as tool travels along the joint line, the material from the front of the tool is swept around the plasticized annulus to the rear, so eliminating the interface.

II. MATERIALS

Aluminium alloy with a wide range of properties are used in engineering structure. Alloy requirement may include strength, corrosion resistance enhancement and ductility, ease of welding formability.

2.1 6061- ALUMINIUM ALLOY

Aluminium alloy 6061 is a medium to high strength heat-treatable alloy with a strength higher than 6005A. It has very good corrosion resistance and very good weldability although reduced strength in the weld zone. It has medium fatigue strength. It has good cold formability in the temper T4, but limited formability in T6 temper. The combination of magnesium and silicon in 6061 allows it to be heat treated to higher strength levels. It has good formability when in the fully soft, annealed condition and the strength can be significantly increased following a heat treatment. It has good mechanical properties and exhibits good weldability. It is one of the most common alloys for general purpose use. 6061 can be heat treated.

2.2 5052- ALUMINIUM ALLOY

5052 aluminium is popular because it is one of the most versatile aluminium alloys. Among 5052 aluminium's benefits are good weldability, very good resistance to corrosion, and high fatigue strength. it shows up in marine environments because of its resistance to corrosion, in architecture exposed to high vibration because of its high fatigue strength, and in pressure vessels and containers because of its good weldability. Aluminium 5052 also happens to be the strongest non-heat-treatable sheet and plate in common use. 5052 isn't just easily welded and highly corrosion-

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Vol. 8, Issue 5, May 2021
DOI: 10.17148/IARJSET.2021.85119

resistant, it is also tough and strong. It has good drawing properties and a high rate of work hardening. Its overall versatility, not to mention excellent value, makes it one of the most serviceable alloys available.

Table 1 Physical Properties of AA6061 and AA5052

SI.NO	PROPERTIES	VALUE	
		AA6061	AA5052
1	Density	2.70 g/cm^3	2.68 g/cm^3
2	Melting Point	650°C	607°C
3	Electrical Resistivity	0.040 Ω.cm	0.049 Ω.cm
4	Thermal Conductivity	166 W/m.K	138 W/m.K
5	Modulus of Elasticity	70 GPa	70.3 GPa

Table 2 Mechanical Properties of AA6061 and AA5052

SI.NO	PROPERTY	VALUE	
		AA6061	AA5052
1	Hardness (Brinell)	95	60
2	Ultimate tensile strength	310 MPa	228 MPa
3	Tensile yield strength	276 MPa	193 MPa
4	Elongation	12 - 17 %	12 %
5	Shear strength	207 MPa	138 MPa
6	Fatigue strength	96.5 MPa	117 MPa

III.METHODOLOGY

3.1 FABRICATION OF THE COMPOSITE MATERIAL

The experiments were conducted on a vertical milling machine where a tool is mounted in an arbor with a suitable collate. The vertical tool head can be moved along the vertical guide way (Z-axis), the horizontal bed can be moved along X and Y axis. The aluminium alloys (AA6061 and AA5052) has chosen for the study were 6mm thick plate of commercially available aluminium alloy. The weld faces of the test plates are machined and clamped in horizontal bed with zero root gaps aligned with the centre line of the FSW tool with the help of a specially designed fixture and back plate needs to be tightly clamped to one another.
The Aluminium alloy plates (AA6061 and AA5052) have been cut into the required size (100×75×6mm) by power hacksaw cutting, butt joint was configured. Before welding the plates, side and edge preparation done to fabricate FSW joints.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 5, May 2021

DOI: 10.17148/IARJSET.2021.85119

The non-consumable tools made of high carbon steel have been used to fabricate the joints. The tool dimensions are shown in Figure 4.3 One pin profiles and shoulder profile, has been used to fabricate the joints.

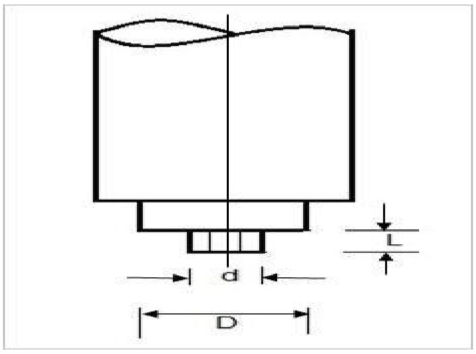


Fig 1 FSW Tool

D = 18mm — D = Shoulder diameter

d = 6mm — d = pin diameter

L = 5.5mm — L = Pin length

Table 3 Welding Parameters and Levels

Parameters	Level1	Level2	Level3
Spindle speed	900	1350	1800
Welding speed	65	100	135
Plunge depth	0.10	0.15	0.20

The plates used in the present study were AA6061 and AA5052 having thickness 6mm are joined. Nine joints has been produced according to L9 orthogonal array experiment.

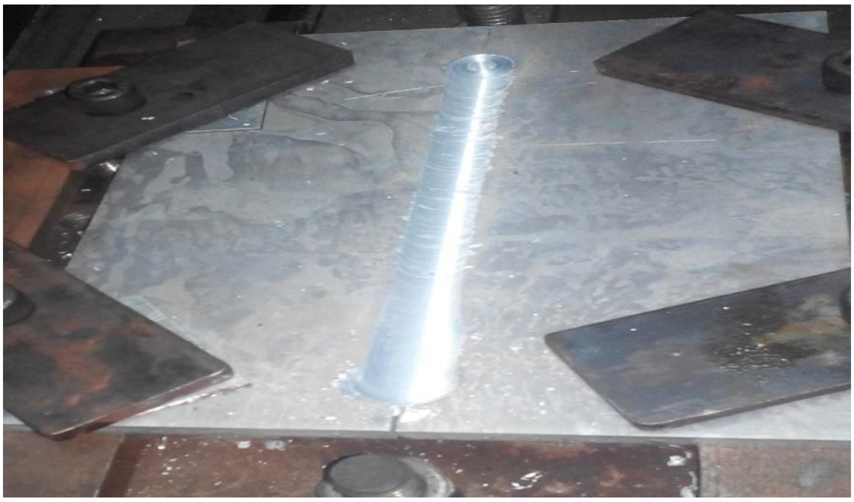


Fig 2 Experimental Setup

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Vol. 8, Issue 5, May 2021
DOI: 10.17148/IARJSET.2021.85119

Fig 3 Welded Specimen

IV. RESULTS AND DISCUSSION

4.1 TENSILE TEST

Tensile Testing is a form of tension testing and is a destructive engineering and materials science test whereby controlled tension is applied to a sample until it fully fails. This is one of the most common mechanical testing techniques. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area.

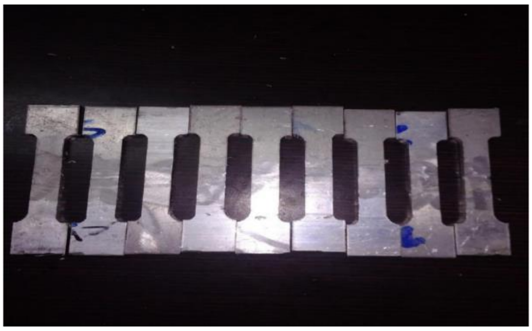


Fig 4 Specimen for before tensile test

Fig 5 Specimen for after tensile test

4.2 HARDNESS TEST

Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 5, May 2021

DOI: 10.17148/IARJSET.2021.85119

Fig 6 Hardness test Specimens

Table 4 Tensile and Hardness Results

Exp no.	Spindle speed (rpm)	Welding speed (mm/s)	Plunge Depth (mm)	Ultimate Tensile Strength (N/mm^2)	Hardness value at centre of the fusion zone (HV)
1	900	65	0.10	148	97
2	900	100	0.15	137	87
3	900	135	0.20	132	82
4	1350	65	0.15	140	95
5	1350	100	0.20	157	101
6	1350	135	0.10	132	81
7	1800	65	0.20	124	78
8	1800	100	0.10	130	80
9	1800	135	0.15	135	84

4.3 MAIN EFFECT PLOT FOR TENSILE AND HARDNESS

The main effect plot is the graph of the average or means of response at each level of the factor or input parameter. The main effect plot helps one to determine the influence of individual input parameters on the responses measured, by disregarding the effect of any other input parameter present. The main effect plots of each response are explained below.

Table 5 Main Effect on Tensile Strength (S/N Ratio)

Parameter	Level 1	Level 2	Level 3	Delta	Rank
Spindle speed	42.85	43.08	42.25	0.83	1
Welding speed	42.73	42.98	42.48	0.50	2
Plunge Depth	41.70	42.75	41.73	0.06	3

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 5, May 2021

DOI: 10.17148/IARJSET.2021.85119

Table 6 Main Effect on Hardness (S/N Ratio)

Parameter	Level 1	Level 2	Level3	Delta	Rank
Spindle speed	38.93	39.27	38.13	1.14	1
Welding speed	39.04	38.98	38.31	0.73	2
Plunge Depth	38.66	38.94	38.73	0.29	3

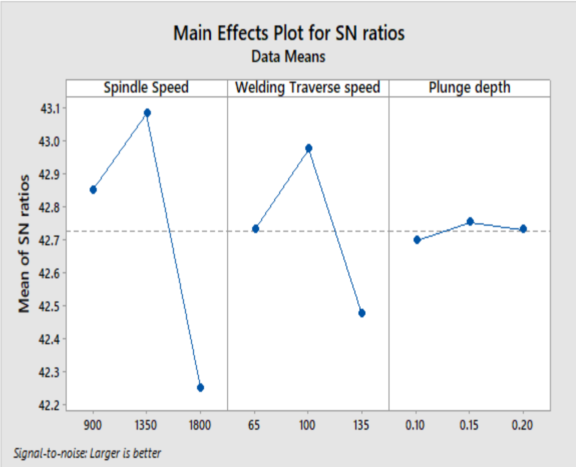


Fig 7 Main Effect Plot for Tensile (S/N Ratio)

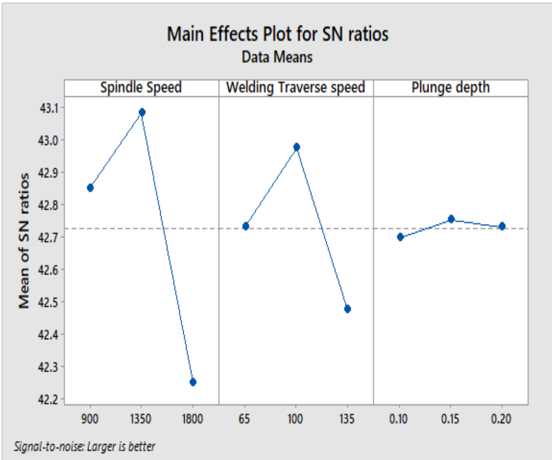


Fig 8 Main Effect Plot for Hardness (S/N Ratio)

4.4 RESPONSE TABLE FOR OUTPUTS OF TENSILE AND HARDNESS

Response table can also indicate which process parameters has greater influence on the responses measured by giving the process parameter a rank. Also one can infer the optimal condition from the response table of tensile strength.

Table 7 Main Effect on Tensile Strength (means)

Parameter	Level 1	Level 2	Level3	Delta	Rank
Spindle speed	139.0	143.0	129.7	13.3	1
Welding speed	137.3	141.3	133.0	8.3	2
Plunge Depth	136.7	137.3	137.7	1.0	3

Table 8 Main Effect on Hardness (means)

Parameter	Level 1	Level 2	Level3	Delta	Rank
Spindle speed	88.67	92.33	80.67	11.67	1
Welding speed	90.00	89.33	82.33	7.67	2
Plunge Depth	86.00	88.67	87.00	2.67	3

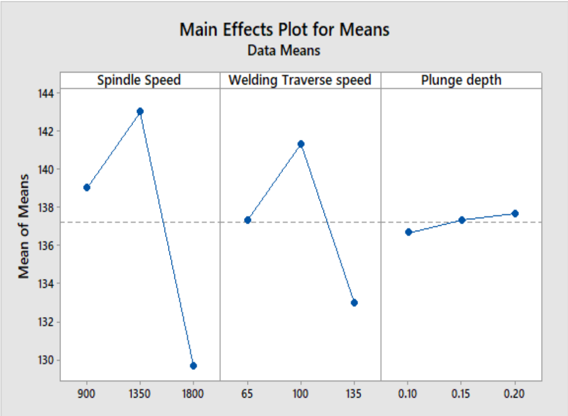
IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Vol. 8, Issue 5, May 2021

DOI: 10.17148/IARJSET.2021.85119



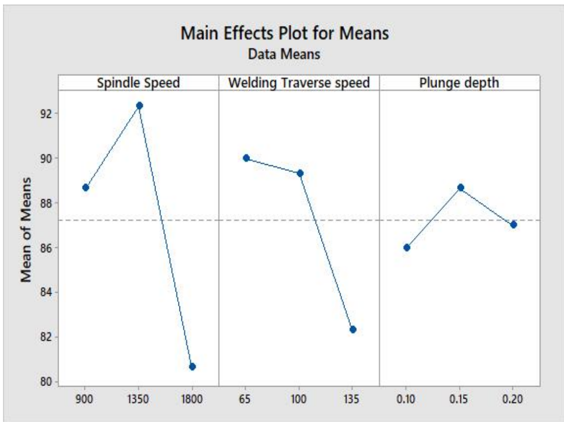


Fig 9 Main Effect Plot for Tensile (Means)

Fig 10 Main Effect Plot for Hardness (Means)

V. CONCLUSION

The analysis presents effect of spindle speed, welding speed and plunge depth on weld quality. Tensile strength and hardness of friction stir welded dissimilar aluminium alloy have been evaluated under different conditions using Taguchi experimental design.

Welding speed has found to be the most dominant parameter which affects tensile strength. The other parameters which influence the tensile strength in order of ranking are Spindle speed, Plunge Depth.

Optimum condition for high tensile strength are found to be Spindle speed= 1350 rpm, Welding speed = 100 mm/min, Plunge Depth= 0.20 mm by Taguchi analysis.

Optimum condition for high tensile strength are found to be Spindle speed= 900 rpm, Welding speed = 100 mm/min, Plunge Depth= 0.15 mm by Taguchi analysis.

REFERENCES

i. S. M. Bayazid, H. Farhangi A. Ghahramani 2015 , "Investigation of friction stir welding parameters of 6063-7075 Aluminium alloys by Taguchi method" 5th International Biennial Conference on Ultrafine Grained and Nanostructured Materials,UFGNSM15

ii. M. Koilraj , V. Sundareswaran , S. Vijayan, S.R. Koteswara Rao,2012 "Friction stir welding of dissimilar aluminium alloys AA2219 to AA5083 – Optimization of process parameters using Taguchi technique". Materials and Design 42 (2012)

iii. R. Palanivel, P. Koshy Mathews, I. Dinaharan, N. Murugan, 2014, "Mechanical and metallurgical properties of dissimilar friction stir welded AA5083-H111 and AA6351-T6 aluminium alloys"

iv. Ravikumar S, SeshagiriRao. V, Pranesh .R. V,2014 "Effect of welding parameters on Macro and Microstructure of friction stir welded dissimilar aluminium butt joints between AA7075-T651 and AA6061- T651 alloys"

v. R.I. Rodriguez, J.B. Jordon, P.G. Allison, T.Rushing , L. Garcia,2015 "Microstructure and mechanical properties of dissimilar friction stir Welding of 6061-to-7050 aluminium alloys." Materials & Design 83 (2015) 60–65

vi. Raj Kumar.V, Venkatesh Kannan.M, Sadeesh.P 2014 ,"Studies on effect of tool design and welding parameters on the friction stir welding of dissimilar aluminium alloys AA 5052 – AA 6061". MRS Singapore - ICMAT Symposia Proceedings Advanced Structural and Functional Materials for Protection

vii. M.I. Costa,D. Verdera,C. Leitão, D.M. Rodrigues 2015, " Dissimilar friction stir lap welding of AA 5754-H22/AA 6082-T6aluminium alloys: Influence of material properties and tool geometry on weld strength" Materials and Design 87 (2015) 721–731

viii. Avinash P, Manikandan M, Arivazhagan N, Devendranath, Ramkumar K, Narayanan S, 2014 "Friction stir welded butt joints of AA2024 T3 and AA7075 T6 aluminium alloys" MRS Singapore - ICMAT Symposia Proceedings 7th International conference on materials for advanced technology

ix. Yutaka S. Sato, Hiroyuki Kokawa, Masatoshi Enomoto, And Shigetoshi Jogan "Microstructural Evolution of 6063 Aluminum during Friction Stir Welding"

x. Sadiq Aziz Hussein, Abd Salam Md Tahir, MdHadzley B.A. Bakar 2015 "Characteristics of Aluminum-to-Steel Joint Madeby Friction Stir Welding: A Review"