International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.3 Issue No: Special 1, pp: 148-150 22nd March 2014

Investigation of Process Parameters of Friction Stir Welded AA7075 Aluminium Alloys

N.Arun kumar[1] C. Elanchezhian[2] and B.Vijaya ramnath[3]

[1]PG Student CAD/CAM, Sri Sairam Engineering College, west -Tambaram, Chennai, India-44.

[2,3]Professor, Department of Mechanical Engineering, Sri Sairam Engineering College, west-Tambaram Chennai, Tamil Nadu, India-600044.

Corresponding Email: arunasaime@gmail.com

Abstract— **Friction stir welding (FSW) is a new innovative solid state joining technique for joining similar and dissimilar metal which has been used in aerospace, rail, automotive and marine industries. This paper to optimized the effect of the tool shape and welding parameter on 6.35mm thick 7075-T651 aluminium plates. The process parameters are optimized by using the ANOVA technique based on L9 orthogonal array. Experiments have been conducted based on three process parameters, namely, the tool rotation rate (rpm), welding speed and axial force at three different levels. Impact Strength has been predicted for the optimum welding parameters and their percentage of contribution in producing a better joint is calculated, by applying the effect of the signal-to-noise ratio and analysis of variance. The results indicate that the rotation rate (rpm), welding speed and axial force are the significant parameters in deciding the Impact Strength of the joint.**

Keywords— Aluminium alloy; friction stir welding; tensile strength; impact strength; Analysis of Variance; signal-to-noise ratio.

I. Introduction

The need for joining materials having higher hardness property and tensile strength has arisen with the present advancement in science and technology. Friction stir welding (FSW) is a recent addition to the welding process and it is a solid state joining technique (Patil et al., 2010; Muthukumaran et al., 2006); it was performed on Al and its alloys is now carried out on copper, magnesium and different material combinations. Different tool pin profiles have been used to weld aluminum alloys (Elangovan et al., 2007; Palanivel et al., 2012), and it has been found that the tapered pin gave defective welds when compared to other profiles. When FSW of steels is performed by straight pin profiles, pin failure takes place before the complete insertion, and moreover, the weld joint could not be formed due to rapid tool wear. The tapered pin has been reported to give better joint strength because of the easy penetration of the pin inside the steel plate with reduced pin failures (Lakshminarayanan et al., 2010 & 2012). The amount of friction heat produced for a better weld depends mainly on the process parameters, such as the tool Rotation rate (rpm), plunge depth, plunge force, tool tilt angle and travel speed (Lakshminarayanan et al., 2008).Tensile strength is the powerful mechanical property to optimize the process parameter of the weld to achieve a better joint (Balaji et al., 2011). The most efficient and simple way of designing an experiment can be achieved by the Taguchi method (Kumar et al., 2012) which helps to find out the most significant process parameter among the parameter combinations, by using the analysis of variance (ANOVA) and signal-to-noise ratio (S/N). The effect of the process parameters by welding with a shorter conical pin on the strength properties has been studied with the influence of the process parameters and their combinations to produce a defect free weld. L9 orthogonal array of the Taguchi design method has been used, because it is easy to use and solve complex problems more efficiently. The calculation of the S/N ratio and mean response, by the ANOVA gives the most influential process parameter, while the mean effects of the plot for the S/N ratio and mean response predicts the optimum process parameter. Thus, the present optimization serves two main objectives; the first objective is to estimate the contribution of the individual process parameters, and to determine the optimum combination of the process parameters for better possible strength. The second objective is to analyze the hardness, and the micro and macrostructure for the optimum parameter.

II. Material and Methodology

FSW Material

Aluminium alloy AA7075- T6 (Al–Zn–Mg–Cu) where T6 heat treatment consists of solution heat treated and artificially aged at 190°C for 12 h, and H321 denotes strain hardened and stabilized condition, with the alloy approximating the quarter-hard state after the thermal stabilisation treatment. AA7075- T6 is one of the strongest aluminum alloys in industrial use today The alloy derives its strength from precipitation of Mg2Zn and Al2CuMg phases. The AA 7075-T6 alloy is used in this work is with a chemical composition of aluminum alloy (by weight percent) given in Table-1.The yield and tensile strengths is given in Table-

2. Plates having the dimensions of 70 mm (width) × 145mm (length) × 63.5 mm (thickness) were friction stir welded.

FSW tool geometry

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. Show in the figure.1 as material made on the high carbon high chromium steel which is using maximum melting point 1421 °C.

Selection of Orthogonal Array

The experimental design proposed by ANOVA involves using orthogonal arrays to organize the parameters affecting the process and the levels at which they should be varies. Instead of having to test all possible combinations like the factorial design, the ANOVA techniques tests pairs of combinations.

According to the L9 orthogonal array, three experiments in each set of process parameters have been performed on IS: 3039 plates. The three factors used in this experiment are the rotation rate (rpm), welding speed and axial force. The factors and the levels of the process parameters are presented in Table.3 and these parameters are taken based on the trials to weld the FSW of steels.

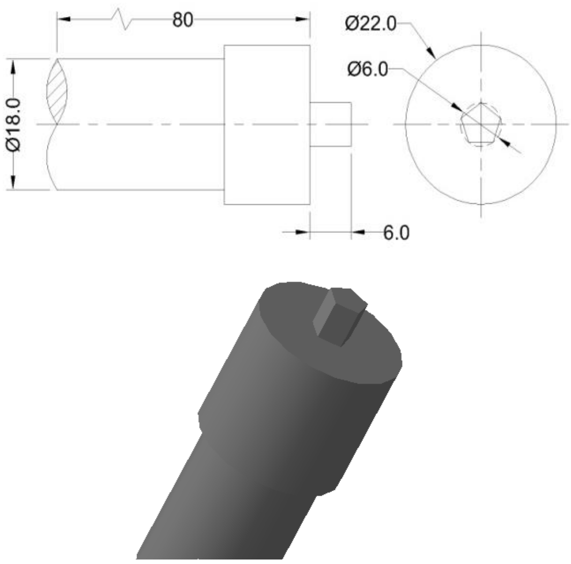

Fig.1 FSW Pentagonal tool

Table.3 factors and the levels of the parameter taken

Parameter	Factor	Level		
		1	2	3
Rotation rate (rpm)	A	1200	1600	2000
Welding speed (mm/min)	B	50	62	74
Axial Force (KN)	C	2.0	2.5	3.0

III. Results and Tables

Experimental Layout of L9 Orthogonal Array

The experiment's notation is also included in the L9 orthogonal array which results in an additional column, in order to represent the parameters, as presented in Table.4

Table4. Experimental layout of L9 Orthogonal array

Experiment's Notation	Input Parameter			Impact Strength (Joules/mm2)
	A	B	C	
A_1	1200	50	2	0.8224
A_2	1200	62	2.5	0.5421
A_3	1200	74	3	0.6729
B_1	1600	50	2.5	0.4112
B_2	1600	62	3	0.5981
B_3	1600	74	2	0.4112
C_1	2000	50	3	0.4486
C_2	2000	62	2	0.7664
C_3	2000	74	2.5	0.5607

Mean and Signal to Noise ratio

The Mean and signal to noise ratio are the two effects which influence the response of the factors. The influencing level of each selected welding parameter can be identified. The Rockwell hardness of the FSW weld is taken as the output characteristic. The response table for the S/N ratio shows that the Welding Feed ranks first in the contribution of good joint strength, while axial force and Rotation rate (rpm) take the second and third ranks. The same trend has been observed in the response table of the mean which is presented in Table.6 respectively. The responses for the plot of the S/N ratio and Mean. The Impact Strength is estimated to be the maximum at 1200 rpm Rotation rate (rpm), 62mm/min welding speed and 2.0KN axial force which is optimal from the plots obtained.

Table5. Different level process parameter

Level		Input parameter	
1	Low level	A	Rotation rate (rpm)
2	Medium level	B	Welding speed(mm/min)
3	High level	C	Axial force (KN)

Analysis of Variance

The analysis of variance for tensile result shows that the welding speed is the most influential parameter with a percentage of 35.81%, followed by the rational speed of 7.49% and Axial force of 22.23%. The optimum parameter obtained can be due to the two following possibilities; either the combination of the process parameters as prescribed may be present in the experimental combination, or may not be present in the combination. The optimum parameter for higher Impact Strengthobtained by the Taguchi method is presented in Table.6. Inclination of tool thus helps to provide a good plastic deformation at the weld zone, and better material flow can be achieved. The combination of the process parameters of 1200 rpm tool Rotation rate (rpm), 62 mm/min welding speed and 2 KN Axial force has been predicted to give the Impact Strength of 43.89.

Table6. ANOVA for Impact Strength (Mean)

Source	DOF	Seq SS	Adj SS	Adj MS	F-test	% contribution
Rotation rate (rpm)	2	0.06	0.06	0.03	1.04	35.81
Welding feed	2	0.01	0.01	0.005	0.22	7.49
Axial force	2	0.04	0.04	0.02	0.64	22.23
Error	2	0.06	0.06	0.03		34.48
Total	8	0.18	0.18			

Note: DOF- Degrees of Freedom, Seq SS – Sequential Sum of Squares, Adj SS – Adjusted Sum of Squares, Adj MS – Adjusted Mean Square, F test of hypothesis, Percentage of contribution

IV. Conclusion

The ANOVA techniques has been used to optimize the welding parameters of friction stir welding to weld a 6.35mm plate the conclusions drawn from the present study are listed below:

1. The Analysis of Variance for the Impact Strength result concludes that the welding speed is the most significant parameter with a percentage of 35.81%, followed by the rational speed of 7.49% and Axial force of 22.23%.
2. The optimum combination of parameters obtained from the main effect plot for mean is process parameters of 1200 rpm tool Rotation rate (rpm), 62 mm/min welding speed and 2.0 KN Axial force has been predicted to give the Impact Strength of 43.89.

   Impact Strength= $RS_1 + WS_2 + AF_1 - 2T$

   $= (0.68 + 0.64 + 0.67 - 2x0.58) = \mathbf{0.83}$
3. The welding speed of 62mm/min is favorable to weld 7075 aluminium alloy with good mechanical and metallurgical properties.

Reference

i. Balaji G.K., Muthukumaran S., Kumaran S.S and Pradeep A. "Optimization of friction welding of tube to tube plate using an external tool with filler plate" Journal of Materials Engineering and Performance. Vol. 21, pp. 1199-1204, 2012.

ii. Elangovan K and Balasubramanian V, "Influences of pin profile and Rotation rate (rpm) of the tool on the formation of friction stir processing zone in AA2219 aluminium alloy". Materials Science and Engineering A. Vol. 459, pp. 7–18, 2007.

iii. Jayarama M, Sivasubramanian R, Balasubramanian and Lakshminayanan A K. "optimization of process parameters for friction stir welding of cast aluminum alloy A319 by Taguchi method". Journal of scientific and industrial research, vol.68,pp36-43, 2009.

iv. Kumar C.V., Muthukumaran S., Pradeep A and Kumaran S.S, "Optimizational study of friction welding of steel tube to aluminium tube plate using an external tool process", International journal of Mechanical and Materials Engineering. Vol. 6, pp.300-306, 2011.

v. Lakshminarayanan A. K., Balasubramanian V and Salahuddin M, "Microstructure tensile and impact toughness properties of friction stir welded mild steel" Journal of Iron and Steel Research International, Vol. 17, pp. 68-74, 2010.

vi. Lakshminarayanan A.K and Balasubramanian V, "Assessment of sensitization resistance of AISI 409M grade ferritic stainless steel joints using modified Strauss test" Materials and Design, Vol 39, pp. 175-185, 2012.

vii. Lakshminarayanan A and K., Balasubramanian V,"Process parameters optimization for friction stir welding of RDE-40 aluminium alloy using Taguchi technique", Transaction of Non ferrous Metals .Society of China. Vol. 18, pp. 548-554, 2008.

viii. Muthukumaran S. and Mukherjee S. K, "Two modes of metal flow phenomenon in friction stir welding process". Science and Technology of Welding and Joining, Vol. 11, p. 337, 2006.

ix. Palanivel R., Mathews P. K., Murugan N and Dinaharan I, "Effect of tool Rotation rate (rpm) and pin profile on microstructure and tensile strength of dissimilar friction stir welded AA5083-H111 and AA6351-T6 aluminum alloys", Materials and Design. Vol.40, pp. 7–16, 2012.

x. Pradeep.A and Muthukumaran.S "An analysis to optimize the process parameters of friction stir welded low alloy steel plates", International Journal of Engineering, Science and Technology. Vol. 5, pp.25-35, 2013.

xi. Patil H. S and Soman S. N "Experimental study on the effect of welding speed and tool pin profiles on AA6082-O aluminium friction stir welded butt joints", International Journal of Engineering, Science and Technology. Vol.2, No. 5, pp. 268-275, 2010.