International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 6 (2018) pp. 241-244

Development of Mathematical Models for Bead Geometry of Al6061 surfaced using GTAW

Prashant Vashishtha, Neha Bhadauria
KIET Group of Institutions, Ghaziabad, U.P., India

Abstract

Aluminium has remarkable properties due to which it has the widest applicability in every sector. There are numerous alloys of aluminium in various 8 series categorised according to the alloying elements used. In spite of all these properties, aluminium and its alloys have low hardness due to its ductile nature. Thus there is a need to improve the surface hardness for applications requiring high wear resistance along with the other properties of aluminium. In the current work, a trial is made to deposit the Al6061 wire of 2.4 mm diameter on Al6061 plate of 6 mm thickness using GTAW which will enhance the surface hardness. This paper includes the optimisation of process parameters to obtain the required bead geometry GTAW has been one of the most reliable techniques for surfacing as well as other welding applications. Mathematical models have been developed to predict the set of process parameters to obtain required bead geometry.

Keywords: Al6061; Bead Geometry; GTAW; Surfacing.

Introduction

TIG welding is an arc welding process that uses a non-consumable tungsten electrodeto produce an arc. The weld area is protected from atmospheric contamination by inertshielding gas. An electricarc is then created between the tungsten electrode and the work piece which melts the parent metal and the filler material creating a weld pool. TIG welding produces clean and highquality weld beads. A wide range of metals can be welded by it. [1,2]

Surfacing is the modification process for improving the properties of the top surface of a material as per the desired application. Surfacing may be done to improve the hardness, wear resistance, corrosion resistance and other surface properties. The effect on other bulk properties of the material however should be controlled. [3]

Aluminium is one of the most widely used materials due to its excellent characteristics including light weight, corrosion resistance and many more. The properties of aluminium which needs to be improved is its resistance to wear and surface hardness. A trial is made to do so in the current work.

Bead geometry including bead width, bead height and penetration are greatly influenced by welding process parameters such as welding current,welding speed, electrode gap and shielding gas flow rate. Bead geometry also plays an important role in determining the mechanical properties of the weld such as Tensile strength, hardness, etc.[4,5] It is necessary to find an optimal process condition capable ofproducing desired weldquality. However, this optimization should be performed in such a way that all the objectivesshould be fulfilled simultaneously. Such an optimization technique is called multi-responseoptimization.

Material Selection

Aluminium alloys have been of wide use due to their exceptional properties taken from different alloying elements along with the advantage of having light weight to power ratio of the pure aluminium base. Al 6061 is one of the most widely used alloy and it finds applications in various sectors including camera lenses, Driveshafts, Brake components, Valves, Couplings, Aircraft and aerospace components, Marine fittings, Transport and Bicycle frames. Al 6061 was thus selected due to its diverse applications, excellent properties and reasonable cost. The filler used is 2.4 mm diameter Al6061 wire which is chemically same as the base metal to avoid the dilution of two different compositions.

Experimentation

Tungsten inert gas welding is used in DC mode with electrode negative. Three parameters were varied in the current study as they had major effect on the weld geometry as per the trials carried and the literatures available. Current, Welding speed and gas flow rate aretaken.

In the first phase of experimentation, trial runs have been carried out to obtain the range of parameters in which defect free bead is obtained.2% thoriated electrode is used. It isused for thick sections with desired result of increased penetration and travel speed. It has beststability at medium currents, good arc starts and medium tendency to split with mediumerosion rate.The range of parameters obtained from trial runs is:

Current: 85-120 A

Gas flow rate: 10-20 l/min

Welding speed: 0.1-0.2 m/min

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 6 (2018) pp. 241-244
© Research India Publications. http://www.ripublication.com

For final experiments, design of experiments has been used with three levels of each parameter. Central composite design of response surface methodology has been applied to get the run order using a software. [6,7]The run order obtained for the experiments is given in the table 1.

Table 1 Run order of experiments

Experiment No.	Current(A)	Welding speed(m/min)	Gas flow rate (l/min)
1	85	0.15	15
2	85	0.2	10
3	102.5	0.15	15
4	102.5	0.15	15
5	102.5	0.2	15
6	85	0.1	10
7	85	0.2	20
8	102.5	0.1	15
9	120	0.2	10
10	102.5	0.15	20
11	102.5	0.15	15
12	102.5	0.15	10
13	102.5	0.15	15
14	120	0.1	10
15	120	0.15	15
16	102.5	0.15	15
17	85	0.1	20
18	120	0.2	20
19	120	0.1	20
20	102.5	0.15	15

The experimentswere performed in the order of obtained run order and the welded workpieces were cut along the cross-section to obtain three samples from each bead. The workpieces were polished to make the surface smooth using polishing machine and emery papers of grades 120, 220, 400, 500 and 800. The polished surface was cleaned and etching was done with an etchant solution (here 10% acidicsolution of HNO3 was used) in order to make the bead visible. The etching was done by swabbing the etchant for 15 seconds and then rinsed with water and dried. The etched workpieces were scanned on scanner for measuring the dimensions of the bead. The bead geometry parameters were measured for the three cross sections of each workpiece and average values were calculated which are given in the table 2.

Table. 2 Measured bead Geometry

Experiment No.	Bead Penetration (mm)	Bead Height (mm)	Bead Width (mm)
1	0.52	2.09	6.4
2	1.56	1.2	6.61
3	1.48	1.74	5.28
4	0.59	1.71	5.86
5	0.42	1.71	8.05
6	0.67	2.11	7.15
7	0.62	1.7	5.84
8	0.96	2.01	8.92
9	0.72	1.84	6.73
10	0.7	2.15	6.28
11	0.45	2.63	7.63
12	0.94	1.85	7.08
13	0.68	1.9	5.48
14	1.78	1.87	10.87
15	0.85	2.2	9.51
16	0.47	2.77	5.44
17	0.71	2.42	6.03
18	0.97	1.97	7.18
19	0.54	2.36	5.29
20	0.77	2.04	6.55

Results

The variation of the bead penetration, bead height and bead width can be seen from the fig. 1, 2 and 3.

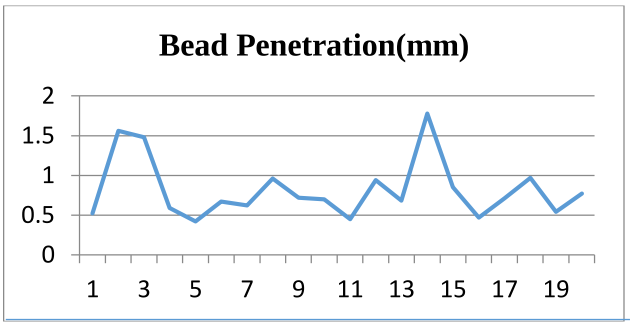

Fig.1 Variation of Bead Penetration

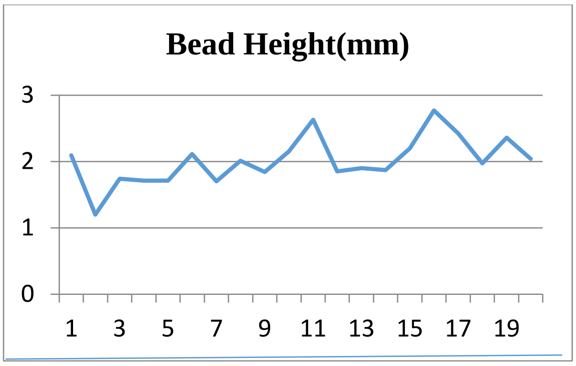

Fig.2 Variation of Bead Height

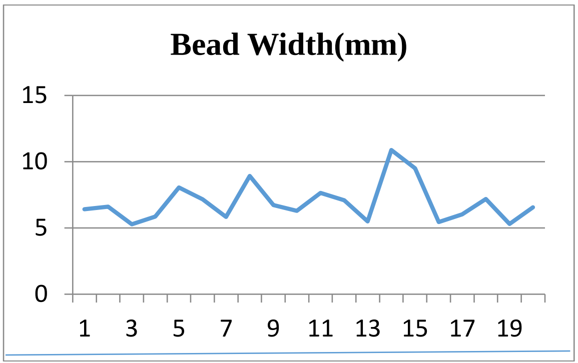

Fig.3 Variation of Bead Width

The values of the responses were fed into the software to obtain the mathematical relations of bead geometry parameters in terms of process parameters of the welding process using the regression analysis. The accuracy of the models was checked using the F-Test. The mathematical model for bead penetration (p), bead height (h) and bead width (w) are:

Maximise:
p =0.715909+0.08C - 0.073WS+ 0.008GFR-0.7875C*WS + 0.09625C*GFR+0.22125 WS*GFR
Minimise:
h = 1.95782- 0.062C + 0.129WS + 0.18GFR +0.19C*WS + 0.115C*GFR -0.0125WS*GFR

Maximise:
w =6.004455- 0.425C – 0.849WS + 0.003GFR – 1.03C*WS +0.8375C*GFR – 0.475WS* GFR

From the given mathematical models, if the non-significant parameters are removed, the models will become:
Maximise:
p = 0.715909 + 0.08C - 0.073WS + 0.008GFR - 0.7875C*WS

Minimise:
h = 1.95782 - 0.062C + 0.129WS + 0.18GFR + 0.19C*WS + 0.115C*GFR

Maximise:
w = 6.004455 - 0.425C – 0.849WS – 1.03C*WS + 0.8375C*GFR

The optimised values of process parameters at optimised bead geometry were also obtained from the software. Results of optimization of bead penetration, bead width and reinforcement height are obtained as:
Bead penetration: 1.260 mm
Bead height: 0.823 mm
Bead width: 4.424 mm

The process parameters corresponding to the optimised bead geometry are:
Current: 122.540 A
Gas flow rate: 7.141 l/min
Welding speed: 0.3 m/min

Conclusion

The surfacing of Al 6061 was successfully done and defect free bead was obtained. The interpretation of individual effects can conclude the following:With the increase in current, the penetration increases due to high heat input from the higher current. Due to the wider weld pool created by high heat, bead height reduces and the width increases.The increase ofwelding speed reduces penetration due to reduction of time of heat supply. Bead height and width reduces due to lesser melting time duration.Gas flow rate increase leads to reduction of bead penetration and increase in height due to less heat allowed to enter the workpiece,hence reducing base metal melting and deposition of filler on top. Width reduces due to the high-pressure gas envelope restricting the area.Interaction effects also have major effects which are depicted from the mathematical relations.

References

1. Taban E., & Kaluc E. (2007). Comparison between microstructure characteristics and joint performance of 5086-H32 aluminium alloy welded by MIG, TIG and friction stir welding processes. Kovove Materialy-Metallic Materials, 45(262), 241–248.
2. Liang Y., Shen J., Hu S., Wang H., & Pang J. (2018). Effect of TIG current on microstructural and mechanical properties of 6061-T6 aluminium alloy joints by TIG–CMT hybrid welding. Journal of Materials Processing Technology, 255, 161–174.
3. Fahimpour V., Sadrnezhaad S. K., & Karimzadeh F. (2012). Corrosion behavior of aluminum 6061 alloy joined by friction stir welding and gas tungsten arc welding methods. Materials and Design, 39, 329–333.
4. Shaikh I. A., & Veerabhadra Rao M. (2014). www.ijser.in Evaluation of Tensile Strength and Distortion Control in GTAW Weldment of AA 6061 by Taguchi and Grey Relational Approach. International Journal of Scientific Engineering and Research (IJSER) ISSN (Online Impact Factor, 3(7), 2347–3878.
5. Prakash A., Bag R. K., & Raju S. S. (2016). Parametric Optimization of Tungsten Inert Gas (TIG) Welding by using Taguchi. International Journal of Research in Engineering and Technology, 5(2), 3630–3638.

6. Benyounis K. Y., &Olabi A. G. (2008). Optimization of different welding processes using statistical and numerical approaches - A reference guide. Advances in Engineering Software, 39(6), 483–496.
7. Dutta P., & Pratihar D. K. (2007). Modeling of TIG welding process using conventional regression analysis and neural network-based approaches. Journal of Materials Processing Technology, 184(1–3), 56–68.