International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 6 (2018) pp. 238-240

Optimization of parameters of GTAW for surfacing of AISI 304

Neha Bhadauria[1], Prashant Vashishtha[1], Smriti Mishra

[1]*Department of Mechanical Engineering, KIET Group of Institutions, Ghaziabad, U.P., India*

Abstract:

GTAW uses a power source, a shielding gas and a hand piece. It is one of the most reliable welding technique giving sound and strong welds. There are various process parameters like Current, voltage, gas flow rate, welding speed etc. which can be varies and they affect the bead geometry (bead penetration, reinforcement height and width of bead). To obtain desired characteristics and bead geometry, there is a need to optimise these process parameters. In the presented work Response Surface Methodology is applied where the experiments were designed using fractional factorial design. Surfacing of Stainless steel 304L has been done on AISI 304 which is commonly used for all purpose products of stainless steel. The mathematical relations between the varied parameters and bead geometry variables have been developed. Optimisation of parameters to obtain the values of the parameters (current, gas flow rate, welding speed) corresponding to the optimum geometry (bead penetration, reinforcement height, bead width) has been done.

Keywords: AISI 304; GTAW; RSM: Surfacing

Introduction:

The gas tungsten arc welding process uses a non-consumable tungsten electrode to produce the weld. Process produces coalescence of metals by heating them with the arc between a tungsten electrode and the work. A shielding gas protects the weld area from atmospheric contamination and the process may be done with or without using a filler.

The gas tungsten arc welding process is very versatile. This process may be used to weld ferrous and a wide variety of non-ferrous metals. It is an all-position welding process. It is most commonly used for welding thin sections of stainless steel and non-ferrous metals such as aluminium, magnesium, and copper alloys. [1,2]

This process has an arc and a weld pool clearly visible to the welder. It produces no slag for entrapment in the weld, and no filler metal carries across the arc, so there is little or no spatter. TIG welding generally produces welds far superior to those produced by metallic arc welding electrodes.

Stainless steel is a widely applied material in applications where corrosion resistance is of importance. The corrosion resistant nature of stainless steels has its origin in the presence of the alloying element Cr, which forms a very stable passive layer that protects the steel. Unfortunately, stainless steel suffers from extensive wear which hinders a wider applicability of the material and may cause problems in existing applications. Common practice for improvement of surface properties of steels, with respect to wear, comprises surface engineering. [3,4]

This surface engineering may be employed using various techniques including thermochemical nitriding, surface alloying, surface hybrid composite forming and so on. In this work, the improvement of surface is tried using TIG arc and same composition of filler material to reduce dilution with other material.

This work has the study of the effect of process parameters of the GTAW used for surfacing the discussed material to obtain the desired bead geometry.

Material Selection:

The material considered for the study is AISI 304. It is the most versatile and most widely used stainless steel in a wide range of products. It has excellent forming and welding characteristics.

Stainless steel 304L which is a low carbon version of AISI 304 grade is used as filler with a diameter of 1.6mm. It is taken due to its low carbon content which may reduce brittle nature of the weld bead.

Experimentation:

GTAW with direct current straight polarity (DCSP) was used for the welding. Argon was used as shielding gas. Electrode diameter used was 3mm.

The parameter selection was done based on study of the effect of various parameters and the literatures on similar works about TIG and its parametric study. [5,6]

Trial runs were performed to obtain the range of process parameters used for surfacing. The range was taken according to the study of weld bead geometry required and the non-destructive tests applied for sound welding check. 2% thoriated electrode was used as it is most suitable for Stainless steel welding. It is used for thick sections with desired result of increased penetration and travel speed. It has best stability at medium currents, good arc starts and medium tendency to split with medium erosion rate. The range of process parameters obtained from trial runs is given in Table 1.

Table 1 Range of Process Parameters

Parameter	Lower Limit	Upper Limit
Current (A)	100	130
Gas flow rate (l/min)	5	10
Welding Speed (mm/sec)	3	4

From the range of process parameters, three levels of each were taken. The levels taken are shown in Table.2

Table 2 Levels of process parameters

Parameter	Level	Level 2	Level
Current (A)	100	115	130
Gas flow rate (l/min)	5	7.5	10
Welding Speed (mm/sec)	3	3.5	4

For the final experimentation, fractional factorial design (Central composite design) was used and the run order was obtained by feeding the range of process parameters. Optimization was done by using the optimisation module of the software for central composite design. [7] The run order obtained is given in Table 3.

Table 3. Run order obtained for experimentation

Experiment No.	Current (A)	Welding Speed (mm/sec)	Gas Flow Rate (l/min)
1	115	3.5	5
2	100	4	10
3	100	3	10
4	115	3.5	7.5
5	115	3.5	7.5
6	100	4	5
7	115	3	7.5
8	100	3.5	7.5
9	115	3.5	7.5
10	115	3.5	7.5
11	130	3	5
12	130	3.5	7.5
13	130	4	5
14	100	3	5
15	115	3.5	7.5
16	115	4	7.5
17	115	3.5	10
18	130	4	10
19	115	3.5	7.5
20	130	3	10

Results:

The experiments were done according to the generated run order. The surfacing was done on three replicates of each run. The bead was deposited by moving the TIG arc over the cleaned workpiece along with filler wire. For measurement of bead geometry parameters, the surfaced work pieces were cut along the cross section. The extracted bead cross section samples were polished and etched using 10% acidic solution of HNO_3 as etchant in order to make the bead visible. The measurement of bead geometry was done using a scanner. The average value of the measured geometry for the three replicates was calculated and is given in the table 4.

Table 4. Average values of Response parameters (Bead, penetration, height and width)

Experiment No.	Bead Penetration (mm)	Bead Height (mm)	Bead Width (mm)
1	3.37	2.2	3.67
2	2.33	2.5	2.2
3	2.86	2.73	2.23
4	3.5	2.5	3.43
5	3.43	2.57	3.56
6	2.47	2.3	2.37
7	3.6	2.43	3.56
8	2.4	2.33	2.23
9	3.6	2.43	3.56
10	3.33	2.5	3.73
11	4.57	2.6	4
12	4.2	2.93	3.77
13	3.96	3.17	3.56
14	2.73	2.57	2.4
15	3.33	2.37	3.46
16	3.2	2.67	3.2
17	3.36	2.5	3.23
18	3.77	3.2	3.33
19	3.46	2.37	3.53
20	4.27	2.93	3.8

Results were fed into the design of experiments response table in the software and the coefficients were obtained for the direct and interaction parameters. As the aim of the work was to improve the surface properties by depositing top layer on the base metal surface, the bead penetration was to be maximised to obtain strong bead and bonding. To increase the span area and to decrease the number of passes for surfacing, the bead width was maximised. The bead height however was minimised as it increases the machining time and cost. By using the conditions and the value of measured bead parameters, the Mathematical relations were developed by using the regression analysis obtained from the software. The mathematical relation for bead penetration, height and width are given by equations 1, 2 and 3.

Maximise:

$$p = 3.4143 + 0.798C - 0.23WS - 0.05GFR - 0.04C*WS - 0.06C*GFR - 0.02WS*GFR \quad (1)$$

Minimise:

$$h = 2.4373 + 0.24C + 0.058WS + 0.102GFR + 0.1375C*WS - 0.0325WS*GFR \quad (2)$$

Maximise:

$$w = 3.5092 + 0.703C - 0.133WS - 0.121GFR - 0.1062C*WS - 0.0112C*GFR - 0.0037WS*GFR \quad (3)$$

The parameters with significant relation were considered from the relations and the final relations developed are given in equation 4, 5 and 6.

Maximise:

$$p = 3.4143 + 0.798C - 0.23WS \quad (4)$$

Minimise:

$$h = 2.4373 + 0.24C + 0.058WS + 0.102GFR + 0.1375C*WS \quad (5)$$

Maximise:

$$w = 3.5092 + 0.703C - 0.133WS - 0.121GFR - 0.1062C*WS \quad (6)$$

Multi Optimisation of the results was done using the optimisation interface of the software. The best possible (optimised) values of bead geometry parameters is:

Bead penetration = 4.19 mm

Bead height =2.445 mm

Bead width = 4.001 mm

The level of process parameters used to obtain the above bead geometry was found to be:

Current = 123.703 A

Gas flow rate = 5 l/min

Welding speed = 3 mm/sec

Conclusion:

From the presented work, the surfacing of Stainless steel 304L has been successfully done on AISI 304 steel. The effect of process parameters can be concluded. [8] With increase in current the penetration increases which is due to the higher input energy, height decreases due to higher penetration and the width increases due to large fusion zone produced due to high input energy. With the increase in the welding speed, the penetration, height decreases due to less melting of filler wire and width decreases. All these are due to the lesser time available for heat input on a certain area. Gas flow rate has less effect as compared to the other parameters. With the increase in gas flow rate, the penetration reduces, height increases and width decreases. Two order interaction effects also play a major role in predicting the bead geometry. Some of the results thus deviate from the direct effect of parameters in other literatures. Optimised values of the bead geometry parameters are obtained. The mathematical models are also developed and verified by experiments.

References:

1. Ranjbarnodeh E., Serajzadeh S., Kokabi A. H., & Fischer A. (2011). Effect of welding parameters on residual stresses in dissimilar joint of stainless steel to carbon steel. Journal of Materials Science, 46(9), 3225–3232.
2. Tseng K. H., & Hsu C. Y. (2011). Performance of activated TIG process in austenitic stainless steel welds. Journal of Materials Processing Technology, 211(3), 503–512.
3. Siva K., Murugan N., & Logesh R. (2009). Optimization of weld bead geometry in plasma transferred arc hardfaced austenitic stainless steel plates using genetic algorithm. International Journal of Advanced Manufacturing Technology, 41(1–2), 24–30.
4. Ranjbarnodeh E., HankeS., Weiss S. & Fischer A. (2012). Effect of welding parameters on the heat-affected zone of AISI409 ferritic stainless steel. International Journal of Minerals, Metallurgy and Materials, 19(10), 923–929.
5. 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.
6. Giridharan P. K., & Murugan N. (2009). Optimization of pulsed GTA welding process parameters for the welding of AISI 304L stainless steel sheets. International Journal of Advanced Manufacturing Technology, 40(5–6), 478–489.
7. Greyjevo O. G. T. Z., Esme U., Bayramoglu M., Kazancoglu Y., & Ozgun S. (2009). Optimization of Weld Bead Geometry in TIG Welding Process Using Grey Relation Analysis and Taguchi Method. Materials and Technology, 43(3), 143–149.
8. 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.