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EFFECT ON MECHANICAL PROPERTIES OF TIG WELDING ALUMINIUM ALLOY AA7075 JOINTS.

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Abstract: Aluminium has very unique properties of light weight and corrosion resistance and due to this it becomes very interesting metal in the field of engineering. Mainly this paper deals with effect and optimization of certain range of values of process parameters during TIG welding of aluminium alloy 7075. In the first cycle of experiment the effect of values (in wide range) of gas flow rate and welding current during TIG welding of Aluminium alloy 7075 has been found out on its mechanical properties such as ultimate tensile strength and hardness. Visual inspection and dye penetrate test also has been performed for every sample of welding. From the results for ultimate tensile strength obtained in first cycle of experiment, a try has been made to optimize process parameters in second cycle of experiment by narrowing the range of values of gas flow rate and welding current. Finally the near optimal values of gas flow rate and welding current has been found to get maximum UTS.

Index Terms **-TIG welding, gas flow rate, welding current, AA 7075, optimization of process parameters.**

I. INTRODUCTION

Aluminium and its alloy offer a wide range of capability and applicability, with a unique combination of advantages that make it the material of choice for numerous products and markets.

Ahmed Khalid Hussain et al., [1] have done TIG welding on AA6351 with Dimensions of the sheet as (4*50*200) mm3 . The Filler used is ER 6063. Experiments are conducted on specimens of single v butt joint having different bevel angle and bevel height. The Process Parameters are welding speed, bevel angle, bevel height. The depth of penetration of weld bead decreases with increase in bevel height of V butt joint. Tensile strength is higher with lower weld speed. This indicates that lower range of weld speed is suitable for achieving maximum tensile strength. Bevel angle of the weld joint has profound effect on the tensile strength of weldments. Bevel angles between 300- 450 are suitable for maximum strength. The heat affected zone, strength increased with decreasing heat input rate.

A. Raveendra et al. [2], have carried out TIG welding for AA5052.The Dimensions of sheet are (100*50*2.5) mm3 . Thefiller used is ER 4053.The parameters are arc voltage, welding current, speed of welding, gas flow rate, heat input and depth of penetration. Increasing the speed of travel and maintaining constant arc voltage and current increases penetration until an optimum speed is reached at which penetration is maximum. Increasing gas flow rate, the depth of penetration increases until an optimum value which gives maximum depth of penetration. Depth of Penetration increases linearly by increasing welding speed. It can be concluded that as the welding speed increases at constant current and voltage, the depth of penetration will increase until an optimum value which shows maximum penetration. The depth of penetration will decrease when welding speed increases beyond the optimum value.

B. Ravindar et al. [3], have done TIG welding on AA5083 with the dimensions of sheet as (100*100*4) mm3 . The Filler used is ER5356.The parameters are welding current, gas flow rate and different filler diameters. The effect of welding process parameters is analyzed by conducting of micro hardness, and Impact tests on weld joint. Micro hardness value of the welded zone was measured for all the welded specimens at the cross section to understand the change in mechanical property of the welded zone. In this paper the effect of micro hardness and Vickers hardness test with changes of welding current, gas flow rate and filler rod diameters by using pulsed tungsten inert gas welding technique is investigated. The welding current weaves periodically between a high (pulse current) and low (basic current) values. In the basic current phase, the low temperature causes a decrease in the volume of the molten pool. Hardness value of the weld zone changes with the distance from weld centre due to change of microstructure. At low welding current vickers hardness value is very low due to lack of fusion. With increase in current hardness values are almost near to the base values.

J. Tusek, and D. Klobcar [4], have done TIG welding of AA 7075-T6 in the butt joint with single-V edge preparation with Dimensions of (100*75*20) mm3 and Filler wire AA 5183. The Parameters are Preheating temperature, microstructure, tensile test. At welding at low temperature, the hot crack was deeper than at welding at high temperature. The area of the material which breaks during the tensile test indicates the tensile strength of the samples was low due big area of hot crack. The optimal preheating and interpose temperature is 200 degree Celsius. The work piece should be cooled duringwelding to avoid averaging of base metal. The TIG welding should be done with energy input from 2-6 kilo Joule/mm.

K. Kannakumar, and K. Bhuvaneswaran [5], have done TIG welding for AA8011 with Dimensions (100*100*2.14) mm3. The purpose of the present investigation is to optimize the pulsed TIG welding process parameters for in-creasing the tensile properties using Taguchi method and Grey relational Analysis. The Constant Welding Process Parameters are: Shielding gas flow rate, gas flow rate, Filler rod diameter, Electrode material, Electrode diameter, Pulse ratio, Welding speed. The Working parameters are Peak current, Background current, Pulse frequency, Pulse on time. During tensile test, all specimens were found to fracture within its weld range. Thus, it may be assumed that UTS is primarily the UTS of its weld. Essential requirements for all types of welding processes are higher tensile strength with lower elongation. This study has concentrated on the application of Taguchi method coupled with Grey relation analysis for solving multi criteria optimization problem in the field of PCTIG welding process. The GRA based on an orthogonal array of the Taguchi method was a way of optimizing the pulse current TIG welding process for aluminium alloy 8011.

K.M Eazhil et al., [6] have done TIG welding for AA 6063 plate. The Filler used is ER 4043.Taguchi method is used for optimization of TIG welding of AA 6063.The Working Parameters are Pulse current, base current, pulse frequency. The Constant Parameters are Shielding gas flow rate, shielding gas, electrode diameter, pulse ratio, pulse on time. The Taguchi method L 27 is used to optimize the pulsed TIG welding process parameters of 6063 AA weldments for maximizing the mechanical properties. ANOVA is used to find the impact of individual factors. Based on ANOVA the contribution of each parameters is calculated and pulse current is the most dominant factor. Taguchi experimental design for determining the welding parameters was successful. Accordingly, the optimal combination of welding parameter for TIG welding is included.

K Srinivas et al.[7], have carried out TIG welding for AA 6063.The Dimensions of plate are (150x60x6) mm3 . By varying weld current and maintaining all parameters constant hardness, impact and tensile strength was found. The Process Parameters are Weld current, Argon Shielding Gas. Two plates of same dimensions are joined as a square butt joint giving the resultant dimensions of (150x100x6) mm3. Welding is done in forward direction using pulsed A.C current. The increase of welding current will increase the welding heat input in AA 6063. Accordingly, the chance of defect formation such burns in Welded metal also increases. It effects on the mechanical properties and the quality of welded metal badly.

Though this much of work has been done it is needed to find the effect of gas flow rate and welding current on AA 7075 material by using different filler material ER5356. There is also need of optimization of these process parameters to find better values of tensile strength.

Methodology

The 6 mm thick sheet of AA 7075. The size of sheet material was 300 mm X 200 mm as shown in figure 1.

Figure 1. AA 7075 Sheet material

From the spectroscopy test it was ensured that the material was AA 7075.The sheared pieces are shown in Figure 2.

After the shearing of sheet material TIG welding was to be done. The welding parameters selected from the literaturereview were gas flow rate and welding current. For the first round of experiments the range of these both the parameters were selected by using the experience of welder as well as no. of tries of welding with different values of both theparameters. Three different values of both the parameters were selected. So total nine combinations of welding parameters were there. Table 1 shows the combinations of welding parameters for first round

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Figure 2. Sheared pieces of AA 7075 Sheet material

Sr. No.	Welding Current (Ampere)	Gas Flow Rate (Liter/minute)
1	130	15
2	130	17
3	130	19
4	150	15
5	150	17
6	150	19
7	170	15
8	170	17
9	170	19

Table 1. Combinations of welding parameters (phase 1)

The filler rod which was to be used during welding was ER5356. The diameter of filler rod was 2 mm. So in total 9 weldments having double V butt joint were prepared by using TIG welding process parameters as per given table 1 The weldment number 1 prepared at 130 Ampere of current in 15 L/min has been shown in figure 3. Such 9 weldments were prepared as per the combinations ofwelding parameters as per table 1.

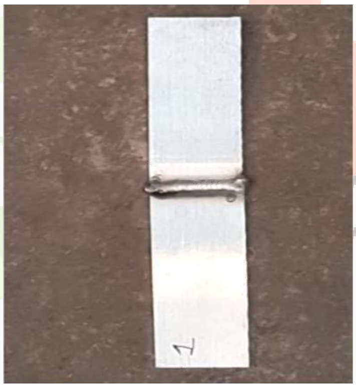

Figure 3. Weldment 1

The welding process in first phase was followed by visual inspection test. From the visual inspection by naked eyes of weldment no. 5 and 6 it was observed to have minor cracks. At lower values of welding current minor porosity (weldment no 1 & 2) was observed.

Figure 4. Dye penetrate test samples 1

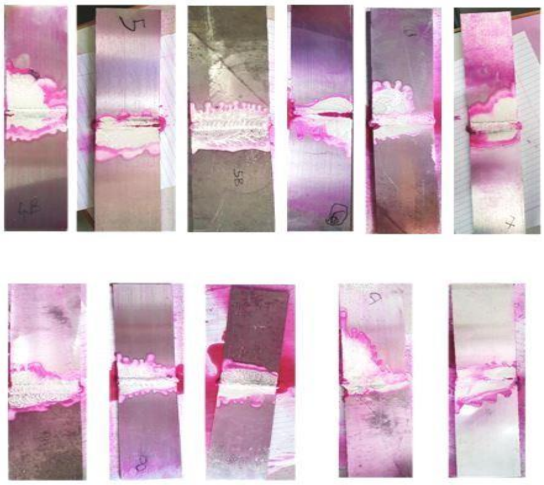

Figure 5. Dye penetrate test samples 2

For further inspection another non destructive test, dye penetrate test was done as shown in figure 4 &5. DP test was performed on both the sides of weldments. The observations made in visual inspection test were obtained by DP test also. Weldment no. 1 & 2 had porosity defect. And at moderate value of current and higher values of gas flow rate cracks has been found in weldments.

After the non destructive tests such as visual inspection and dye penetrate test, Rockwell hardness test using B scale was done on weldments on the Rockwell hardness tester as shown in figure 6.

Figure 6. Rockwell hardness tester

Hardness of weldments was measured on front side welding as well as back side welding. The result of hardness test has been shown in below table 2.

Weldment No. (F= Front side, B= Back side)	HRB
1F	33
1B	35
2F	31
2B	33
3F	43
3B	41
4F	44
4B	43
5F	38
5B	42
6F	43
6B	42
7F	47
7B	51
8F	36
8B	43
9F	41
9B	40

Table 2. Results of Rockwell hardness test for all weldments

From above table it was found to have better hardness values available at higher current (170 Amp.) and at lower gas flow rate (15 L/min). After the Rockwell hardness test the important tensile testing was performed on all weldments as per ASME E8 standards.

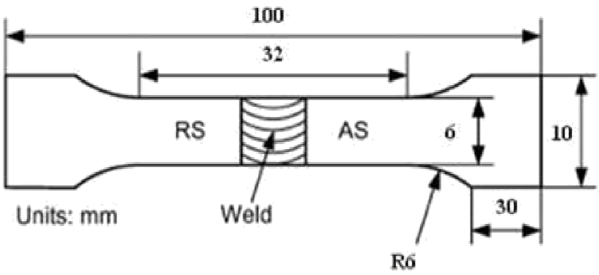

Figure 7. Dimensions of tensile specimen as per ASTM E8Standard

The tensile specimens were prepared in dumbbells shape fromweldments as per the size given in figure no. 7 as per ASTM E8 standards. Prepared tensile specimens are shown in figure no. 8.

Figure 8. Prepared tensile specimen as per ASTM E8Standard

Figure 9. Tensile testing machine.

Figure 9. Tensile specimens after tensile testing

The results of tensile testing for first cycle of experiments were as given in table 3 below.

Weldment number	UTS (MPa)
1	140
2	143
3	112
4	164
5	176
6	164
7	115
8	112
9	100

Table 3: Results of tensile strength first cycle of welding.

From above table it is observed that the highest UTS is available for the 5th weldment. This weldment was prepared with the gas flow rate value of 17 L/min. and the current valueof 150 Amp.

Now in the order to find the near optimal value of process parameters, second phase of welding was performed by selecting the nearby values of process parameters of fifth weldment. The range for selection nearby values of welding current and gas flow rate was decreased in second phase than first phase of welding. In first phase the range for welding current was 20 Ampere while in second phase it was 10 Ampere. The range for value of gas flow rate in first phase was 2 L/min. while in second phase it was selected as 1 L/min. so finally more four combinations were available to go for second phase of welding to obtain nearby optimal valuesof gas flow rate and welding current during TIG welding of AA7075. The new combinations of gas flow rate and welding current are given in table 4. By these values of process parameters once again the whole cycle was repeated and ultimate tensile strength was found as per given table 5.

Table 4. Combinations of welding parameters for phase 2welding

Sr. No.	Welding Current (Ampere)	Gas Flow Rate (Liter/minute)
O1	140	17
O2	160	17
O3	150	16
O4	150	18

Table 5. Results of tensile strength second cycle of welding.

Weldment number	UTS (MPa)
O1	183
O2	149
O3	113
O4	125

From table 5 it can be observed that the highest value of ultimate tensile strength (183 MPa) has been found at 140 ampere welding current and 17 L/min gas flow rate. By narrowing the range better results had been found.

CONCLUSION

1.From the above experiments of TIG welding performed on AA 7075 sheet material of 6 mm it can be observed that the effect of gas flow rate and welding current on ultimate tensile strength of weldments is significant. Smaller change in the value of gas flow rate and welding current gives drastic change in the value of UTS.

2.Higher gas flow rate (more than 17 L/min) can lead to weaker joint i.e. lower UTS. Lower gas flow rates also tends to provide lower UTS. Moderate values nearly 17 Lit/min helps to give better results in terms of UTS.

3.Lower values of welding current i.e. nearly 140 ampere resultsinto higher values of UTS. Higher values of welding current can give poor results in terms of UTS.

4.Finally, it can be concluded that for better UTS of weld joint of AA 7075 by TIG welding process can be obtained by selecting lower values of welding current (nearly 140 amp.) and moderate value of gas flow rate (nearly 17 L/min).

5.This work further can be extended by narrowing the range of process parameters as well as by introducing other welding parameters during welding.

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