Investigation on Effect of Welding Process Parameters during TIG Welding of AA 6061

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***Abstract*—** In this study welding of AA 6061 has been done. TIG welding method for welding has been used. The process parameters selected are gas flow rate and welding current. Effect of different combinations of these process parameters has been found out in the terms of ultimate tensile strength. In addition to that two non-destructive tests such as visual inspection and dye penetrate test has been performed to identify the surface defects of weldments. Rockwell hardness test also has been performed for each weldment to investigate the effect of different combinations of process parameters.

***Keywords*— TIG welding, AA6061, Gas flow rate, welding current, tensile strength.**

I. INTRODUCTION

Aluminium is light in weight, yet some of its alloys have strengths exceeding the mild steel. It retains good ductility at sub-zero temperatures, has high resistance to corrosion, and is not toxic. Among all wrought alloys of aluminium 6XXX series show high corrosion resistance, excellent extrudability and moderate strength. So it is used in building and construction, highway, marine, automotive applications. This makes study of welding important for AA 6XXX series.

Ahmed Khalid Hussain et. al. investigated the effect of welding speed on tensile strength of the welded joint by TIG welding process of AA6351 Aluminum alloy of 4 mm thickness. The strength of the welded joint was tested by a universal tensile testing machine. Welding was done on specimens of single v butt joint with welding speed of 1800 -7200 mm/min. From the experimental results it was revealed that strength of the weld zone is less than base metal and tensile strength increases with reduction of welding speed.

Kumar Gaurav studied hardness, impact energy and microstructure of AA6061 T6 aluminium alloy plates welded by TIG. From this investigation, the following important conclusions have been derived, Hardness is lower in the base metal (WM) region compared to the HAZ and weld bead regions. The hardness increase after welding and the highest hardness obtained at 100 amp and 5 lt/min parameters. Among the entire nine specimen, the specimen no 5 has highest hardness and specimen no 9 has lowest hardness

M. Ishak et. al. investigated the effects of different filler wires used in the TIG welding process. Based on the present investigation, the following conclusions can be drawn. First, it was found that welding using filler ER5356 produced a finer grain size at the FZ of 25.69 μm compared to fillers ER4043 and ER4047 with grain sizes of 52.75 μm and 76.78 μm, respectively. Using filler ER5356 also produced the highest hardness value of 72.9 HV compared to the ER4043 and ER4047 counterparts, with 59.3 HV and 57.6 HV, respectively. As for the tensile test result, the weld joints using filler ER5356 had the highest strength of 171.53 MPa compared to the weld joints using fillers ER4043 and ER4047 with values of 167.34 MPa and 168.03 MPa, respectively?

It can be concluded that TIG welding using ER5356 filler yields better joints compared to ER4043 and ER4047. In addition, for further study, deep investigation into the effects of preheating is proposed in order to ascertain the best quality joint

Manpreet Singh et. al. carried out butt welding of aluminium alloy 6061-T6 by tungsten inert gas (TIG) welding, at various levels of welding current, gas flow rate and preheat of samples. The responses considered are the ultimate tensile strength and Microstructure of joints.

Pawan Kumar et. al. found experimental results coupled with ANOVA results proved that pulse current is having pronounced effect on multiple quality characteristics of the mechanical properties of AA6061.

Pawan Kumar et. al. conducted study to understand the effect of process parameters of pulsed current GTA welding on aluminium alloy weldments. Five important process parameters of pulsed current GTA welding were used with gas mixtures to optimize the four quality characteristics of mechanical properties. Modified Taguchi Method was used with success to identify the optimum parameters. Experimental results coupled with ANOVA results proved that pulse current is having pronounced effect on the multiple quality characteristics of the mechanical properties and microstructural characterization. Generation of fine dendritic microstructure resulted in improvement of mechanical properties. The confirmation experiments conducted with predicted levels of factors proved to be worthy.

Sumit jain et. al. evaluated the welding performance of friction stir welding by using vertical milling machine on aluminium alloy 6082 T-6. All the experiments trials, planning and analysis were executed using Taguchi design of experiment. The purposes of DOE method applied in this study were to determine the optimum condition of welding parameters and the significance of each parameter to the performance of welding characteristics. The total experiment runs performed in this study was nine trials using randomized parameters which done by MINITAB 16 software.

K Srinivas et al. have carried out TIG welding for AA 6063.The Dimensions of plate are (150x60x6) mm^3. 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.

From above it can be observed there is need to study the effect different filler material ER 5356 during TIG welding of AA 6061.

II. METHODOLOGY

Aluminium alloy 6061 plate of 6 mm thickness was procured from GIDC, V.U.nagar. The size of sheet material was 300 mm X 200 mm. From the spectroscopy test it was ensured that the material was AA 6061. The spectroscopy test was done at Metal heat treaters and engineers, GIDC, V.U.nagar. The further process of shearing was done at HN Industry, GIDC, V.U. nagar. The sheared pieces are shown in Figure 1.

Fig. 1 Sheared pieces of AA 6061

After the shearing of sheet material TIG welding was to be done. The welding parameters selected from the literature review were gas flow rate and welding current. 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 the parameters. 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.

TABLE I
COMBINATION OF WELDING PARAMETERS

Sr. No.	Current (A)	Gas flow rate (l/min)
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

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 at GIDC Makarpura, Vadodara. The weldments number 1 to 9 prepared as per the table has been shown in figure 2.

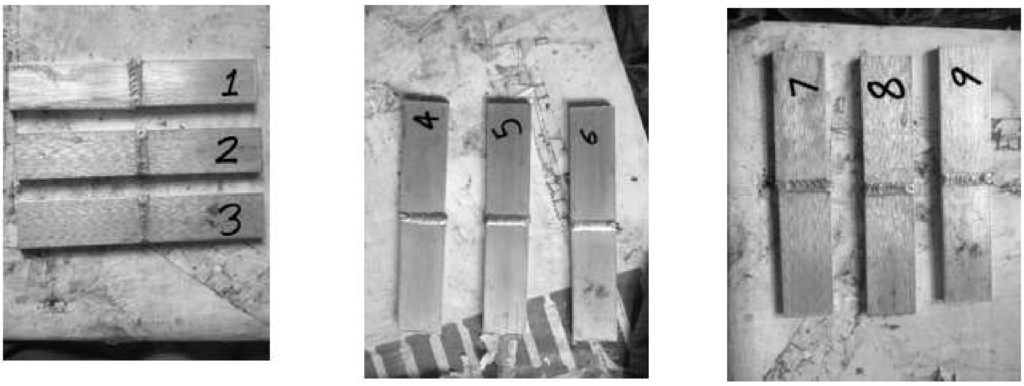

Fig. 2 Prepared weldments of AA 6061

The welding process was followed by visual inspection test. From the visual inspection by naked eyes of weldment no. 2, 4 and 6 it was observed to have minor cracks. At lower values of welding current minor porosity (weldment no 1 & 2) was observed.

For further inspection another non-destructive test, dye penetrate test was done as shown in figure 3. 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 2, 4 & 6.

Fig. 3 Dye penetrate test done on prepared weldments of AA 6061

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 available at civil engineering department, CHARUSAT, Changa as shown in figure 4.

Fig. 4 Rockwell hardness tester available at CHARUSAT.

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.

TABLE 2
HARDNESS TEST RESULTS

Specimen no.	Hardness number (front)	Hardness number (Back)
1	37	35
2	38	36
3	36	39
4	39	38
5	40	39
6	42	40
7	45	44
8	39	40
9	38	37

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.

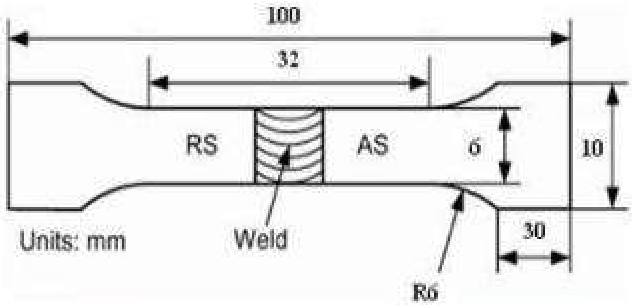

Fig. 5 Dimensions as per ASTM E8 standard for tensile testing.

The tensile specimens were prepared in dumbbells shape from weldments as per the size given in figure no. 5 as per ASTM E8 standards. Prepared tensile specimens are shown in figure no. 6.

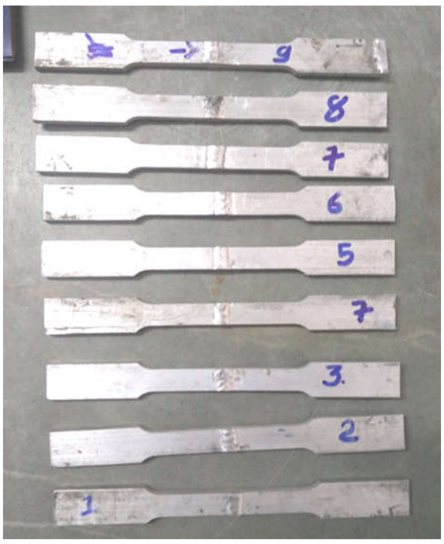

Fig. 6 Tensile specimens prepared for testing.

The tensile test was performed on tensile testing machine (figure no. 7) available at department of mechanical engineering, CHARUSAT, Changa.

Fig. 7 Tensile testing machine available at CHARUSAT, Changa.

Fig. 8 Weldments after tensile testing

Figure 8 shows the weldments after tensile testing. It can be observed that all the weldments were broken from weld part. The results of tensile testing has been shown in table 3.

TABLE 3

ULTIMATE TENSILE STRENGTH

Weldment No.	Strength (MPa)
1	44
2	43.8
3	40
4	56.2
5	45.9
6	47.8
7	46
8	43
9	44.4

From the above table we can see the highest ultimate tensile strength is available for fourth weldment, i.e. at 150 amp. of welding current (moderate) and 15 lit/min. gas flow rate(lower). For all weldments prepared at lower current and higher (130 amp. and 170 amp.) shows less amount of UTS with respect to weldments prepared at moderate welding current (150 amp).

III. CONCLUSIONS

In this study a try has been made to find the combination of welding current and gas flow rate at which better tensile strength can be obtained. The result show that at moderate welding current and at lower gas flow rate better values of UTS is available.

With addition to that hardness for each weldment also has been found out on both the sides of double v butt joint. Results of hardness test suggests to have higher welding current and lower gas flow rate for better values of hardness.

Visual inspection test and dye penetrate tests also has been performed as non-destructive tests to check the quality of testing and to identify amount and type of surface defect. Both the tests gives same results. At moderate values of current and higher values of gas flow rate cracks has been found in both the NDTs. At lower values of welding current minor porosity (weldment no 1 & 2) was observed

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