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An Evaluation of TIG Welding Parametric Influence on Tensile Strength of 5083 Aluminium Alloy

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Abstract**—**Tungsten Inert Gas (TIG) welding is a high quality welding process used to weld the thin metals and their alloy. 5083 Aluminium alloys play an important role in engineering and metallurgy field because of excellent corrosion properties, ease of fabrication and high specific strength coupled with best combination of toughness and formability.

TIG welding technique is one of the precise and fastest processes used in aerospace, ship and marine industries. TIG welding process is used to analyze the data and evaluate the influence of input parameters on tensile strength of 5083 Al-alloy specimens with dimensions of 100mm long x 15mm wide x 5mm thick. Welding current (I), gas flow rate (G) and welding speed (S) are the input parameters which effect tensile strength of 5083 Al-alloy welded joints. As welding speed increased, tensile strength increases first till optimum value and after that both decreases by increasing welding speed further. Results of the study show that maximum tensile strength of 129 MPa of weld joint are obtained at welding current of 240 Amps, gas flow rate of 7 Lt/min and welding speed of 98 mm/min. These values are the optimum values of input parameters which help to produce efficient weld joint that have good mechanical properties as a tensile strength.

Keywords**—**5083 Aluminium alloy, Gas flow rate, TIG welding, Welding current, Welding speed and Tensile strength.

I. Introduction

TUNGSTEN Inert Gas (TIG) welding is a welding process used for high quality welding of a variety of materials with the coalescence of heat generated by an electric arc established between a non-consumable tungsten electrode and the metal. The process of melting the work piece and filler rod to form a weld results in the formation of fumes and gases. Helium and argon used as shielding gases because they does not chemically react [1]. Most commonly, Argon, helium and their mixture are preferred to use as a shielding gases for better welding because of does not chemically react or combine with each other. The inert gas : i) shield the welding area from air, preventing oxidation, ii) transfer the heat from electrode to metal and iii) helps to start and maintain a stable arc due to low ionization potential [2]. Aluminium alloy has excellent performance so used in aerospace industry, aviation, marine industry, automobile, defence and others [3]-[5]. TIG welding parameters such as welding current, gas flow rate and welding speed are taken into account which influences the tensile strength of aluminium alloy joint [6]. Filler wires are continuously feed into weld pool for proper filling the welding seams for good joint. Welding parameters are controlled with electronic control units [7], [8].

AC power supply is preferred for aluminium alloy as compare to DC power supply because aluminium alloy melt at low temperature. The principle of DC power source is to deliver 70% of energy in the form of heat always on positive side. But in case of AC power supply, the average of energy output on both terminals will be the same. This is because for one half of wave cycle, positive terminal will have 50% of energy and for second half of wave cycle, 50% of energy will be on negative terminal [9]-[11]. In Electrode positive polarity, electrons are moved from base metal to electrode due to strong voltage gradient build up by increased voltage at cathode [12].

Tensile strength of aluminium alloy joint is mainly affected by welding parameters such as welding current, gas flow rate and welding speed. Tensile strength of aluminium alloy increases by increasing the welding current as well as gas flow rate. But tensile strength may increase or decrease with the variation of welding speed in increasing order. At optimum range of welding current, tensile strength increases first by increasing the welding speed. But tensile strength decreases by further increment of welding speed [13]. The negative effect of welding speed on weld bead geometry i.e. the depth of penetration increases; but, weld bead width decreases with increase in speed [14]. Heat input parameter influences the cooling rate, weld bead size, and mechanical properties of the weld [15]. Good strength property achieved because of low HAZ present in weld bead. Fatigue strength of cast aluminium alloy is affected by the existence of defects as cracks, pores and inclusions in the welded joint which results in decrease in fatigue life of aluminium alloy [16]. Basically, TIG weld quality is strongly characterized by the weld pool geometry because the weld pool geometry plays an important role in determining the mechanical properties of weld [17], [18].

II. Experimental Material and Method

Experimental material is 5083 Al-alloy of 5mm thickness, which is welded by TIG welding. The chemical compositions of 5083 Al-alloy stated by producer are shown in Table I below:

TABLE I
CHEMICAL COMPOSITION OF 5083 AL-ALLOY

Al	Mg	Mn	Si	Fe	Cu	Zn	Cr	Ti
92.4-95.6	4.0 – 4.9	0.40 – 1.0	max. 0.40	max. 0.40	max. 0.10	max. 0.25	0.05 – 0.25	max. 0.15

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Physical and mechanical properties of 5083 Al-alloy stated by producer are shown in Table II below:

TABLE II
PHYSICAL AND MECHANICAL PROPERTIES OF 5083 AL-ALLOY

Density (g/cc)	Tensile Strength (MPa)	Brinell Hardness (HB)	Yield Strength (MPa)	Modulus of Elasticity (GPa)
2.66	317	85	228	71

The filler wires used to transfer the extra material to fill the gap b/w the joints of same composition of base metal. There are different types of filler wires (5183, 5356, 5554, 5556 and 5654) available in the market on the basis of base metal compositions of 5083 Al-alloy. In this study, the filler metal of 5356 graded is used for welding the specimens because of its good physical, mechanical properties for obtaining the best joint shown below in Table III.

TABLE III
PHYSICAL AND MECHANICAL PROPERTIES OF 5356 FILLER WIRE

Density (g/cc)	Melting range (°F)	Corrosion resistance	Hardness (BHN)
2.657	1060 - 1175	Excellent	105

The chemical compositions of 5356 filler wire stated by producer are shown in Table IV below:

TABLE IV
CHEMICAL COMPOSITION OF 5356 FILLER WIRE

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
0.25	0.40	0.10	0.05 - 0.20	4.5-5.5	0.05 - 0.20	0.10	0.06 - 0.20	remaining

TIG welding method is adopted to carry out the experiment. 5083 Al-alloy is welded by TIG welding machine at three different welding modes on the basis of current levels listed in Table V:

TABLE V
WELDING PARAMETERS

Welding Modes	Welding Current (Ampere)	Gas Flow Rate (Lt/min)	Welding Speed (mm/min)
1	210	6	89
2	225	6.5	98
3	240	7	102

The three numbers of variables are taken into account for conducting the experiment with the help of Taguchi L-9 method. This Taguchi L-9 method helps for selecting the input parameters and number of trials as shown in Table VI.

TABLE VI
TAGUCHI L-9 METHOD FOR EXPERIMENTAL TRIALS

Experimental runs	**Parameter 1 Welding current (I)**	**Parameter 2 Gas flow rate (G)**	**Parameter 3 Welding speed (S)**
1	I_1	G_1	S_1
2	I_1	G_2	S_3
3	I_1	G_3	S_2
4	I_2	G_2	S_2
5	I_2	G_3	S_1
6	I_2	G_1	S_3
7	I_3	G_3	S_3
8	I_3	G_1	S_2
9	I_3	G_2	S_1

Cleaning up the surface of aluminium alloy sheet and carve the sheet into eighteen number of specimens with dimension of 50mm long x 15mm wide x 5mm thick for welding. Make v- grove in between each two specimens at 60° before welding shown in Fig. 1.

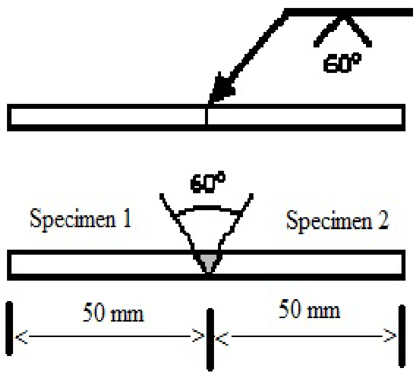

Fig. 1 V-groove b/w specimens for welding

The welding parameter ranges taken into account for welding are welding current of 210 – 240 amps, gas flow rate of 6 – 7 Lt/min and welding speed of 89 – 102 mm/min. After welding, prepare dumble shape of all welded specimens for performing tensile test on UTM machine.

III. RESULTS AND ANALYSIS

Results and analysis of the study describes the influence of input parameters on the output parameters such as tensile strength of 5083 Al-Alloy weld joint.

A. Tensile Strength

After making dumble shaped specimens perform tensile test on UTM machine for each specimens one by one and get the results of tensile strength which are listed in Table VII. The specimen C gives minimum tensile strength of weld joint and specimen H gives maximum tensile strength of weld joint. The table of tensile strength values clearly shows that maximum tensile strength is obtained with welding current value of 240 amps followed by gas flow rate of 7 Lt/min and welding speed of 98 mm/min.

TABLE VII
TENSILE STRENGTH BY UTM MACHINE

Specimen ID	Welding Current (Amps)	Gas Flow Rate (Lt/min)	Welding Speed (mm/min)	Tensile Strength (MPa)
Specimen A	210	7	89	115
Specimen B	210	6.5	102	107
Specimen C	210	6	98	103
Specimen D	225	6.5	98	115
Specimen E	225	6	89	105
Specimen F	225	7	102	127
Specimen G	240	6	102	109
Specimen H	240	7	98	129
Specimen I	240	6.5	89	118

The effect of welding input parameters on tensile strength of the weld joint is discussed as below:

1. Effect of Welding Current on Tensile Strength of Weld Joint

This phase reveals the effect of welding current of different levels such as 210 amps, 225 amps and 240 amps on mechanical properties of weld joint such as tensile strength. Fig. 2 shows the effect of welding current on tensile strength of weld joint. As welding current increases at constant gas flow rate, the tensile strength increases till optimum value of 240 amps current that shows the maximum tensile strength of 129 MPa of weld joint.

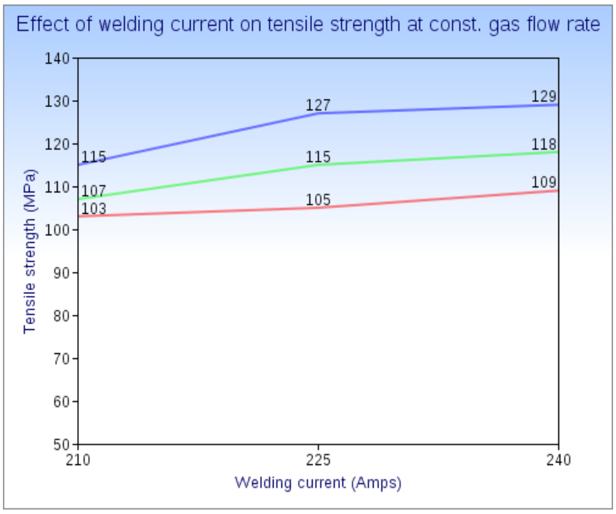

Fig. 2 Welding current Vs Tensile strength

2. Effect of Gas Flow Rate on Tensile Strength of Weld Joint

In this, the effect of shielding gas flow rate of 6 Lt/min, 6.5 Lt/min and 7 Lt/min of three different levels on mechanical properties as a tensile strength of weld joint is described. Fig. 3 shows the effect of gas flow rate on tensile strength of weld joint at constant current. The tensile strength increases by the variation of shielding gas in increasing order till an optimum value of 7 Lt/min that shows the maximum tensile strength of 129 MPa of weld joint.

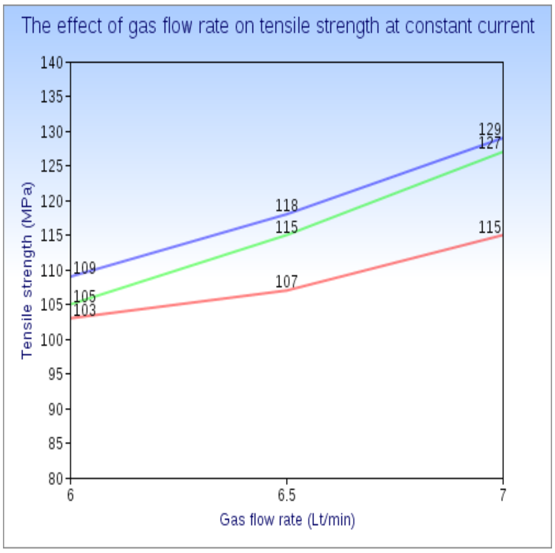

Fig. 3 Gas flow rate Vs Tensile strength

3. Effect of Welding Speed on Tensile Strength of Weld Joint

This phase reveals the effect of the different values of welding speed on mechanical properties of weld joint such as tensile strength. The effect of welding speed on tensile strength of weld joint is shown below in Fig. 4. The tensile strength increases by increasing the welding speed at constant current till optimum value of 98 mm/min at current of 240 amps that shows the maximum tensile strength of 129 MPa of weld joint. After that tensile strength starts to decrease by further increment of welding speed.

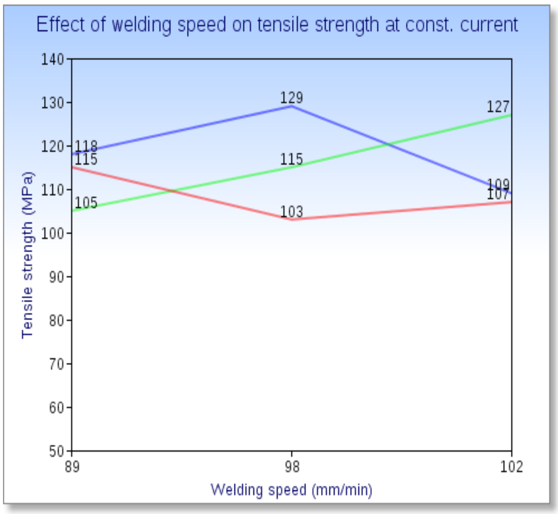

Fig. 4 Welding speed Vs Tensile strength

IV. CONCLUSION

All the experimental trials are analyzed under precautionary measures in order to keep the error factors low and optimize the reliability of results to produce the efficient weld joint with 5083 Al-alloy specimens. The following conclusions are drawn from the analysis of collected data of input and output parameters:-

1. Maximum tensile strength of 129 MPa is obtained at welding current of 240 amps, gas flow rate of 7 Lt/min and welding speed of 98 mm/min.
2. The tensile strength of weld joint in 5083 Al-alloy plate increases by increasing welding speed up to an optimum value of 98 mm/min for current of 240 amps and after that tensile strength decreases by further increasing welding current.
3. The optimum range of input parameters are evaluated as 240 amps of welding current, 7 Lt/min of gas flow rate and 98 mm/min of welding speed by which efficient weld joint is produced with good tensile strength of weld joint.

The future scope of the study is discussed in steps such as shown below:

1. In the present study, welding current, gas flow rate and welding speed are taken into account as input parameters. The other welding parameters such as arc voltage, heat input, stand of distance can be investigated on same as well as different alloys of aluminium.
2. Further post weld heat treatment can be applied on same or different materials to achieve better results [19].

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