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STUDY DIFFERENT GRADED ELECTRODE'S INFLUENCE OVER TENSILE STRENGTH OF TIG WELDED 5083 AL-ALLOY

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Abstract: ***TIG welding is a Wolfram Inert Gas Welding (WIG) developed in Germany, is preferable for high quality welding process to weld the various metals and their alloy. In this research article, 5083 Aluminium alloys is considered for testing and analysis to find its important role in engineering because of excellent performance as corrosion resistance, 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. In this research, Analyze the collected data and evaluate the influence of input parameters on tensile strength of 5083 Al-alloy specimens with dimensions of 150 mm long x 12.5 mm wide x 6 mm thick. Filler electrode and welding current (I) are taken as input parameters which has effect on tensile strength of 5083 Al-alloy welded joints. Results of the study show that maximum tensile strength of weld joint is 136 MPa, obtained at welding current of 240 Ampere with use of 5083 graded filler electrode. This value is an optimum value of input parameters for which efficient weld joint produced that has very good tensile strength.***
Keywords: ***5083 Aluminium alloy (base material), Filler electrodes (with graded as 5356, 5556, 5183, 5554, 5083), TIG welding setup, Welding current, Tensile strength and hardness.***

I. INTRODUCTION

TUNGSTEN Inert Gas (TIG) welding is a welding process to produce high quality weld joint with the coalescence of fusion energy generated by an electric arc established between a non-consumable tungsten electrode and the base metal. The process of melting the base metal surface and filler electrode to form a weld results in the formation of fumes and gases which are protected by shielding gases such as helium and argon because they does not chemically react [1], [2]. 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 shown in fig. 1 [2]. Aluminium alloy has applications in aerospace industry, aviation, marine industry, automobile, defence and others because of excellent performance [3]-[5]. Types of filler electrodes, welding current, gas flow rate and welding speed are taken into account as TIG welding input parameters which influence the tensile strength of aluminium alloy joint [6]. Filler electrodes feed continuously into weld pool to fill the welding seams properly for good joint. Welding parameters are controlled with electronic control units shown in fig. 2 [7], [8]. There are different types of filler electrodes, available in the market in the form of grades such as 5356, 5556, 5183, 5554 and 5654 etc.

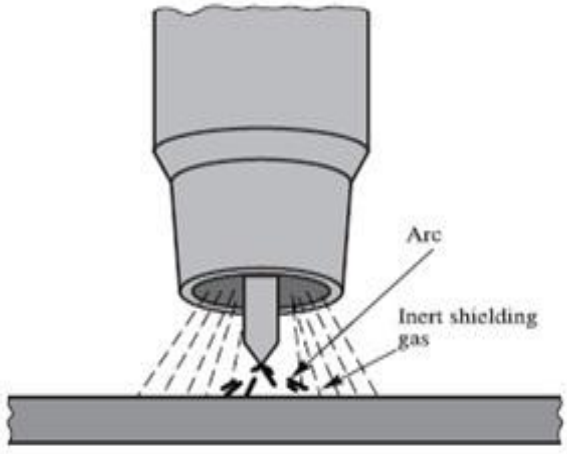

Fig. 1.TIG welding Principle

Basically, filler electrode is filler metal added in making of a joint through welding, brazing, or soldering. Four types of filler metals exist — covered electrodes, bare electrode wire or rod, tubular electrode wire, and welding fluxes. Sometimes non-consumable electrodes are included as well, but since these metals are not consumed by the welding process, they are normally excluded [9]. 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 [10]-[12]. In Electrode positive polarity, electrons are moved from base metal to electrode due to strong voltage gradient build up by increased voltage at cathode [13].

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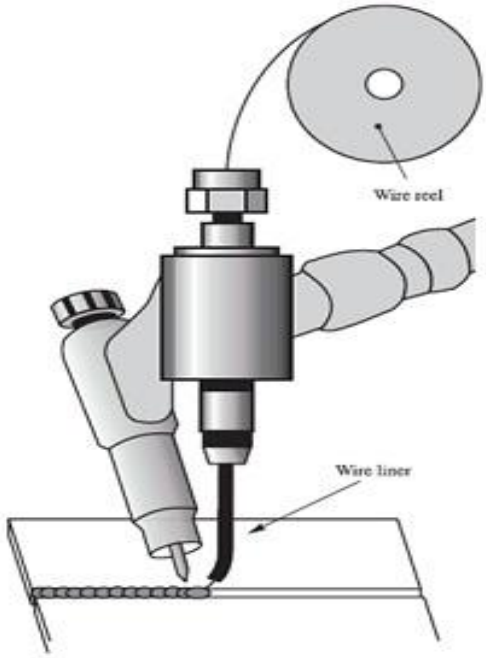

Fig. 2.Automatic Feeding of Filler electrode

Welding parameters like welding current, gas flow rate, welding speed as well as type of filler electrode play an important role to influence the mechanical properties of aluminium alloy weld joints. Tensile strength of aluminium alloy increases by increasing the welding current. Heat input parameter influences the cooling rate; weld bead size, and mechanical properties of the weld [16]. 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 [17]. 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 [18] - [21].

II. EXPERIMENTAL MATERIAL AND METHOD

5083 Al-alloy of 6mm thickness is used as experimental material that is welded by TIG welding. The chemical compositions of 5083 Al-alloy stated by producer are shown in Table I below:

TABLE 1: CHEMICAL COMPOSITION OF 5083 AL-ALLOY (Base Material)

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

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

TABLE 2: PHYSICAL AND MECHANICAL PROPERTIES OF 5083 AL-ALLOY (Base Material)

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 electrodes available in the market in the form of grades such as 5183, 5356, 5554, 5556, 4043 and 5654 on the basis of base material compositions of 5083 Al-alloy. In this study, All these different graded filler electrodes are selected for conducting experiment on the basis of their chemical, physical and mechanical properties which suitable for welding to create efficient weld joints. But 5083 graded Al –alloy is also used as a filler electrode in order to get the influence on weld joint of same graded base material. The chemical, physical and mechanical properties of filler electrodes are discussed one after one in different tables.

The chemical composition of 5356 filler electrode is discussed in table III shown below:

TABLE 3: CHEMICAL COMPOSITION OF 5356 Filler electrode

Mg	Mn	Si	Fe	Cu	Zn	Cr	Ti	Al
4.5 – 5.5	0.05 – 0.20	max. 0.25	max. 0.40	max. 0.10	max. 0.10	0.05 – 0.20	0.06 – 0.20	Remaining

Physical and mechanical properties of 5356 Filler electrode stated by producer is shown in Table IV below:

TABLE 4: PHYSICAL AND MECHANICAL PROPERTIES OF 5356 Filler electrode

Density (g/cc)	Melting range (^{0}F)	Corrosion resistance	Hardness (BHN)
2.657	1060 – 1175	Excellent	105

The chemical composition of 5556 filler electrode is discussed in table V shown below:

TABLE 5: CHEMICAL COMPOSITION OF 5556 Filler electrode

Mg	Mn	Si	Fe	Cu	Zn	Cr	Ti	Al
4.7 –	0.5 –	max 0.	max 0.	max 0.	max. 0.2	0.05 –	0.05 –	Remaining

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5.5	1.0	25	40	10	5	0.20	0.20	

Physical and mechanical properties of 5556 Filler electrode stated by producer is shown in Table VI below:

TABLE 6: PHYSICAL AND MECHANICAL PROPERTIES OF 5556 Filler electrode

Density (g/cc)	Melting range (^{0}F)	Corrosion resistance	Hardness (BHN)
4.354	1055 – 1175	Excellent	125

The chemical composition of 5183 filler electrode is discussed in table VII shown below:

TABLE 7: CHEMICAL COMPOSITION OF 5183 Filler electrode

Mg	Mn	Si	Fe	Cu	Zn	Cr	Ti	Al
4.3 – 5.2	0.5 – 1.0	max. 0.40	max. 0.40	max. 0.10	max. 0.25	0.05 – 0.25	max. 0.15	Remaining

Physical and mechanical properties of 5183 Filler electrode stated by producer is shown in Table VIII below:

TABLE 8: PHYSICAL AND MECHANICAL PROPERTIES OF 5183 Filler electrode

Density (g/cc)	Melting range (^{0}F)	Corrosion resistance	Hardness (BHN)
2.66	1075 – 1180	Excellent	102

The chemical composition of 5554 filler electrode is discussed in table IX shown below:

TABLE 9: CHEMICAL COMPOSITION OF 5554 Filler electrode

Mg	Mn	Si	Fe	Cu	Zn	Cr	Ti	Al
2.4 – 3.0	0.50 – 1.0	max. 0.25	max. 0.40	max. 0.10	max. 0.25	0.05 – 0.20	0.05 – 0.20	Remaining

Physical and mechanical properties of 5554 Filler electrode stated by producer is shown in Table X below:

TABLE 10: PHYSICAL AND MECHANICAL PROPERTIES OF 5554 Filler electrode

Density (g/cc)	Melting range (^{0}F)	Corrosion resistance	Hardness (BHN)
4.39	1115 – 1195	Excellent	133

TIG welding method is adopted to carry out the experiment. 5083 aluminium alloy is welded by TIG welding machine at three different welding current levels such as 210 ampere, 225 ampere and 240 ampere with use of each kind of filler electrode. The two numbers of variables are taken into account for conducting the experiment with the help of simple random probability method. First, Cleaning up the surface of 5083 aluminium alloy sheet and carve the sheet into fifteen number of specimens with dimension of 75 mm long X 12.5 mm wide X 6 mm thick for welding. Make v-grove in between each two specimens at 60^o before welding. The welding current levels of 210 ampere, 225 ampere and 240 ampere are taken into account for welding the specimens along with the use of different graded filler electrodes. After welding, prepare dumble shape of all welded specimens for performing tensile test on UTM machine.

III. RESULTS AND ANALYSIS

Results and analysis phase describes the influence of welding current and filler electrodes on the mechanical properties such as tensile strength of 5083 aluminium 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 XI, Table XII and Table XIII. Table XI represent the result value of tensile strength for each type of filler electrode at welding current of 210 ampere.

Table 11: TENSILE STRENGTH FOR WELDING CURRENT OF 210 AMPERE

S.No.	Welding current 210 ampere				
	5356 Filler electrode	5083 Filler electrode	5556 Filler electrode	5183 Filler electrode	5554 Filler electrode
Tensile strength (MPa)	115	121	112	115	109

Table XII represent the result value of tensile strength for each type of filler electrode at welding current of 225 ampere.

Table 12: TENSILE STRENGTH FOR WELDING CURRENT OF 225 AMPERE

S.No.	Welding current 225 ampere				
	5356 Filler electrode	5083 Filler electrode	5556 Filler electrode	5183 Filler electrode	5554 Filler electrode
Tensile strength (MPa)	127	129	119	126	113

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Table XIII represent the result value of tensile strength for each type of filler electrode at welding current of 240 ampere.

Table 13: TENSILE STRENGTH FOR WELDING CURRENT OF 240 AMPERE

S.No.	Welding current 240 ampere				
	5356 Filler electrode	5083 Filler electrode	5556 Filler electrode	5183 Filler electrode	5554 Filler electrode
Tensile strength (MPa)	128	136	123	126	121

The effect of welding input parameters on mechanical properties like tensile strength and hardness of the weld joint is discussed as below:

1. Effect of Filler electrodes on Tensile Strength of Weld Joint

This phase reveals the effect of Filler electrodes at 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. 3 shows the effect of different filler electrodes on tensile strength of weld joint. The tensile strength increases by increasing the welding current for one type of filler electrode and hence, maximum tensile strength of 136 MPa of weld joint is achieved for 5083 graded filler electrode at welding current of 240 ampere, is clearly represented in the fig. 3.

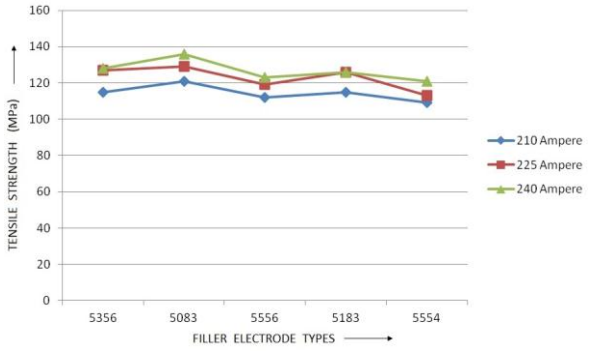

Fig. 3.Filler electrode Vs Tensile strength

2. Effect of Filler electrodes on hardness of Weld Joint

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 136 MPa is obtained for 5083 graded filler electrode at welding current of 240 ampere.
2. The optimum range of input parameters are evaluated as 240 ampere of welding current for 5083 graded filler electrode at which efficient weld joint is produced with good tensile strength of weld joint.

The future scope of the study is discussed as:

In the present study, welding current and filler electrode variations are taken into account as input parameters. The other welding parameters such as welding speed, gas flow rate, arc voltage, heat input, and stand of distance can be investigated on same as well as different alloys of aluminium. Further Researcher can apply post weld heat treatment on same or different materials to achieve better strength.

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