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RESEARCH ARTICLE

INVESTIGATING THE EFFECT OF PARAMETRIC INFLUENCE ON TIG WELDING ALUMINUM ALLOY 5083

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ABSTRACT

Gas Tungsten Arc Welding [GTAW] of aluminum requires high skill due to high thermal conductivity. In this research, pulsed mode welding is carried out to find out the best possible parameters for obtaining high tensile strength and maximum weld quality. Here AA5083 is considered for it large area of applications. It is welded with AA 5183 filler wire by pulsed mode at different pulse frequencies like 5 pulses/sec, 10 pulses/sec, and 15 pulses/sec, this report investigates the weld quality through nondestructive testing (NDT) to study the porosity and surface cracks and also the mechanical properties like, ultimate tensile strength (UTS), and elongation. To find the weld joint efficiency of the welds and hardness test have been critically analyzed and the properties were summarized correlating with microstructure.

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INTRODUCTION

Welding is a permanent joining process used to join different materials like metals, alloys or plastics, together at their contacting surfaces by application of heat and or pressure. TIG welding was developed during 1940 at the start of the Second World War. It was demonstrated first by Russell Meredith for welding aluminum and magnesium in aircraft industry. TIG's development came about to help in the welding of difficult types of material. GTAW is the most common method of joining aluminum alloys used in various industrial processes. Gas tungsten arc welding (GTAW) process is widely used for joining aluminum alloys for various applications in the aerospace, defense, and automotive industries. Fusion welding leads to physical, chemical, and metallurgical changes in aluminum alloys. One of the reasons for the chemical changes in the fusion zone of welds is due to the different chemical compositions of the filler materials used. GTAW is a widely applied method to join aluminum alloys and detailed studies on the effect of alternate current pulsing technique on mechanical behavior of AA5083alloys are not fully available in the literature. Hence, in this investigation an attempt has been made to study the effect of pulsing on mechanical properties (hardness and tensile strength) and microstructure of AA5083 alloy welds and therefore assumes special significance since such detailed studies are not hitherto reported.

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This work aims at the analysis and optimization of joining similar grades of aluminum alloys by TIG welding. The parameters like current and pulsing frequency are variables in this study. Continuous Current Gas Tungsten Arc Welding (CC GTAW) processes are very often used for welding Aluminum alloys and Cu-Ni alloys in ship building industries. Compared to continuous current Gas Tungsten Arc Welding where high heat energy required to melt the base material and this excessive heat input imposes the problems such as melt through, distortion and vaporization of Magensium takes place etc. Pulsed Current Gas Tungsten Arc Welding (PC GTAW) produces a best quality welds by overcoming above CC GTAW problems. In PC GTAW process, the current is supplied in pulses rather than at a constant magnitude. The aim of pulsing is mainly to achieve maximum penetration without excessive heat build-up, the high current pulses to penetrate deeply and then allowing the weld pool to dissipate some of the heat during relatively longer arc period at a low current. PC GTAW is a variation of Tungsten Inert Gas (TIG) welding which involves cycling of the welding current from a high level to a low level at a selected regular frequency. The high level of the peak current is generally selected to give adequate penetration and bead contour, while the low level of the base or background current is set at a level sufficient to maintain a stable arc. This permits arc energy to be used efficiently to fuse a spot of controlled dimensions in a short time producing the weld as a series of overlapping nuggets and limits the wastage of heat by conduction into the adjacent parent material. Metallurgical advantages of pulsed current welding frequently reported in literature include refinement of fusion zone grain size and substructure, reduced width of HAZ, control of segregation, etc. All these factors will help in improving mechanical properties. Current pulsing has been used by several investigators to obtain grain refinement in weld fusion zones and improvement in weld mechanical properties.

Experimental setup

For Welding procedure coupons of base metal AA 5083 were sheared to 110mmx55mmx6mm and the weld was completed in single pass butt joint Welds were made using conventional gas tungsten arc welding process for welding AA5083 using Tig welding machine GB kore arc TIG 315BP which has ducts for cooling, Pulse gas tungsten arc welding process is used to weld AA5083 alloy to study the effect of pulsing mode. Non-treatable 4 mm diameter AA5183 was used as filler. With Pure argon of 99. 6% purity is used as the shielding gas with flow rates ranging from 7 to 8 liters /min. Cracking and porosity are major concerns in welding Aluminum alloys. To reduce the defects and to have good weld ability, Argon as shielding gas was used which plays an important role in reduction of generation of defects and protection of weld poor from oxidation (Aluminum being very reactive with oxygen contained in the atmosphere). Three sets of plates were welded together with different current and pulse settings but at a constant voltage the experiments are conducted within the working range of welding parameters for all specimens. The coolant flow rate is kept constant using a single phase mono block type centrifugal pump with maximum head of 15 meters and allowed to pump continuously to maintain optimum temperature of the machine. The room temperature is maintained at normal. The weld speed is constant below is the tabulated details of all the welding parameters. In this study, TIG welding technique was adopted with three different welding currents for the Aluminum plates i.e., welding at 125volts 150volts and 175volts and Pulsed welding at 0 Hz, 5Hz, and 10Hz respectively and these welded joints were further subjected to the following mechanical tests. Below is the tabulation of the various parameters followed for this experimental procedure.

Table 1. Tabulation of followed parameters of weld procedure

Pulses/sec (Hz)	Current	Pulses		Input current	V (volts)	Arc travel speed (cm/min)
		Ip	Ib			
0	150	25	100	175	250	42.28
5	175	25	100	175	250	40.34
10	150	25	100	175	250	42.43
0	150	25	100	175	250	40.44
5	125	25	100	175	250	42.94
10	125	25	100	175	250	44.01
0	125	25	100	175	250	38.75
5	175	25	100	175	250	40.20
10	175	25	100	175	250	42.14

Tensile tests welds

This study is done to evaluate the transverse tensile properties namely tensile strength, 0.2% yeild strength of CC GTAW and PC GTAW welds. All the specimens were tested To identify the weakest portion of the welded joint transverse tensile test was carried out. Samples fortensile tests were sheared into rectangular columns of 110mm x10 mm tension test specimen .A mechanical Universal Tensile testing machine kamal metal tester of 40 ton capacity is selected to conduct the tests. With proper calibration, counter load of 10kgs tests were utilized. All the samples failed at weld zone with cup and cone type of failure provided that both metals being highly ductile in nature. And the results were tabulated in the table below

Table 2. Results obtained by tensile test failure load and elongation

Sample No	Failure load	Elongation
SPECIMEN 1	7.5 KN	0.4 MM
SPECIMEN 2	4.25 KN	0.2 MM
SPECIMEN 3	9.25KN	0.4 MM
SPECIMEN 4	10 KN	0.3 MM
SPECIMEN 5	5 KN	0.2 MM
SPECIMEN 6	4.7 KN	0.3 MM
SPECIMEN 7	6 KN	0.1 MM
SPECIMEN 8	5.2 KN	0.2 MM
SPECIMEN 10	5.64 KN	0.1 MM

Figure 1. Failed tensile test specimen showing cup and cone type fracture

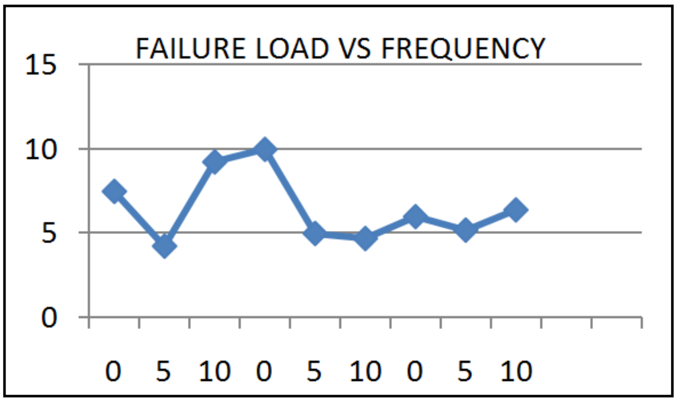

Figure 2. Graph of failure load vs frequency

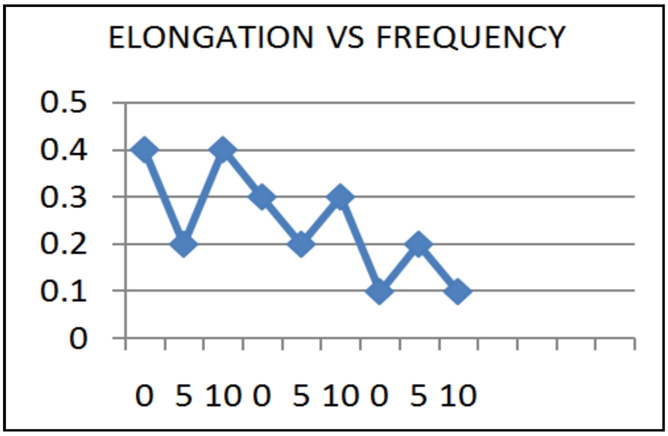

Figure 3. Graph of elongationvs frequency

From the tabulated results we can notice that there is an increase and decline with the increse in current phase reveals the effect of the different values of voltage on mechanical properties of weld joint such as tensile strength can be acknowledged.

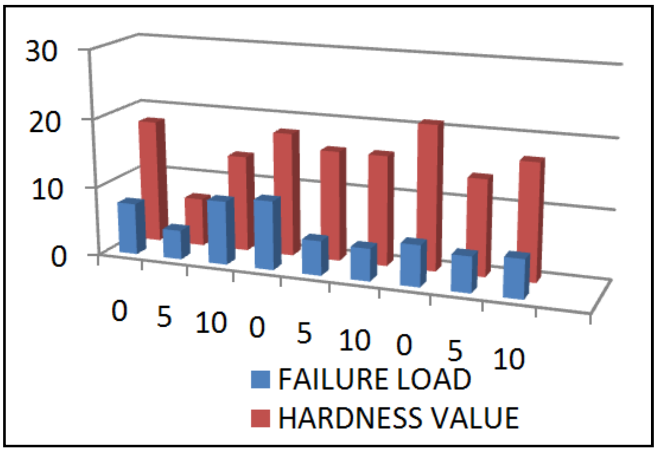

Figure 4. Failure load and elongation vs frequency

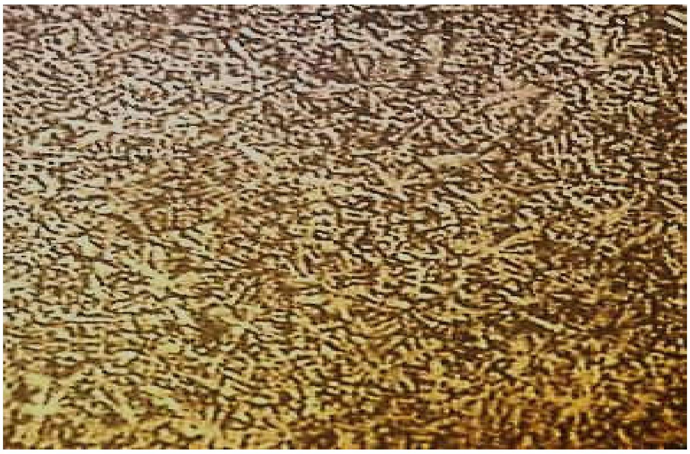

Figure 5. Microstructure of sample1

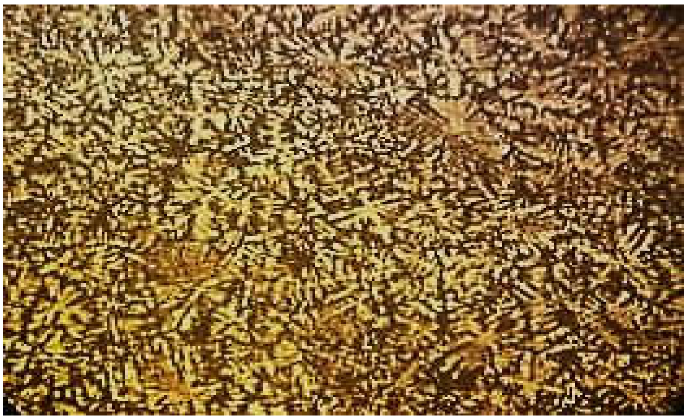

Figure 6. Micro structure of sample 7

Figure 7. Micro structure of sample 10

The effect of frequency on tensile strength of weld joint is shown. The tensile strength increases by increasing the voltage at constant frequency till optimum value of 150 v, and frequency at 0pulses/sec to 5 pulses/sec that shows the maximum tensile strength of 20MP a of weld joint. After that tensile strength starts to decrease by further increment of voltage.

Microstructure

Preparation of Samples: To make samples for micro structure first the weld zone is cut into a squares of 10mmx10mm then it is mounted to a Bakelite cast at 100^0c and at a pressure of 40 PSI. This process enables us to hold and grip the specimen in a firm manner. .In such a way 9 specimen were made to undergo the process of grinding to reveal the microstructure. Then the samples are etched using poultons reagent. The samples were then viewed under an optical microscope and with magnification of 100x the samples are viewed the micrograph images were captured using a smartphone mounted to the optical microscope and then later developed using Adobe Photoshop 7.0TM. A macrostructure study is conducted with the welded specimens of various combination ranges of welding parameters. The macrostructures are shown Consider Fig - sample 1, with magnification 100X. herewe can see the white portion which is aluminium and black portion is magnesium. Tiny dendrites are formed in the weld metal it can be seen clearly in the magnified figure. The figure also shows heat affected zone (HAZ) of sample 1, in which we can see that HAZ is minimum and there is good bonding. Samples 1,7,10 are better than the other entire samples from the microstructure study.

The grain structure results showed that the pulse parameters such as pulse frequency, pulse duration and peak current affect the grain structure of weld metal appreciably. Influence of the pulsed current and frequency on the microstructure is shown in It was observed that the grain refinement at 125pulsed current (PC) GTAW at frequency 10 Hz was better to all other pulsed current (PC) GTAW. The specimen from higher current has more clear dendritic structure, this seems the particles become finer this may be the reason that has produced high tensile strength, % of elongation and hardness.

Hardness test

The specimens used for hardness measurements were casted by cutting a piece from weld zone and hard casting it in heat press hot mould of Bakelite they were then sanded by emery papers and then treated with etchant. The exposed area is then identified to undergo the process of hardness testing is done with zwick wickers hardness testing machine. Hardness values are measured using 1/16’’ ball with load 100 Kgf in the weld zone and the results were tabulated as follows.

Table 3. Result of hardness test

Sample no	Load value
Condition 01	18 BHN
Condition 02	07 BHN
Condition 03	14 BHN
Condition 04	18 BHN
Condition 05	16 BHN
Condition 06	16 BHN
Condition 07	21 BHN
Condition 08	14 BHN
Condition 10	17 BHN

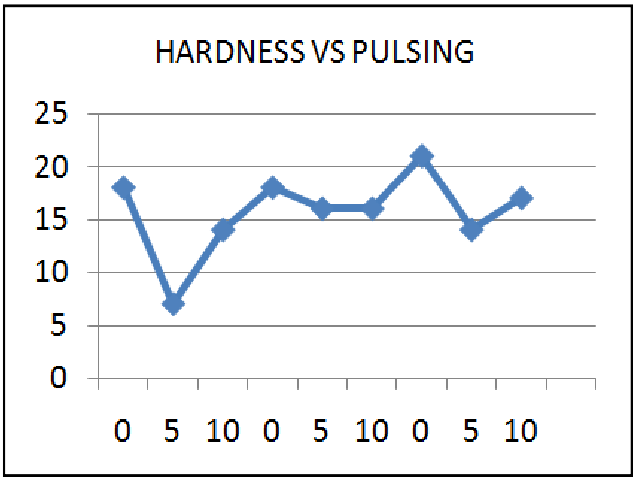

Figure 8. Graph of hardness vs frequency line graph

From the micro hardness values it is observed that there is slight vary in the hard values at different currents and filler materials. The maximum hardness value is observed at condition 8 i.e, 175 volts and frequency 5 pulses per second gave the best hardness value among other conditions followed by condition 1 i.e.150volts and frequency 0 pulses per second. From the hardness values it is observed that the pulsed current has produced high hardness than non-pulsed current. The filler wire 5356 has produced high hardness due to fine grain structure and the composition of filler wire 5356. In the filler wire 5356 there is a more percentage of magnesium available. The presence magnesium will increase the strength and hardness of parent material. Based on this test we can conclude that less frequency gives the best hardness value. Hence to achieve good hardness it is necessary to lower the pulses or frequency value

Non destructive testing

Table 4. Tabulation of liquid penetrant results

Specimen no	Flaw type	Flaw length	Remarks
02	Two Pores	2MM Dia	acceptable
03	Single Pore	2MM Dia	acceptable
10	Single Pore	2MM Dia	acceptable

Liquid Penetration Test LPT is carried out on all the coupons after welding. Results shows that no flaws were found and their quality were just acceptable according to NDE Codes and Standards Acceptance / Rejection Criteria. For machined components, any rounded indication greater than 3/16” (4.8 mm) shall be considered unacceptable. Hence the result obtained through dye penetrant shows that it the welds are found to be flawless.

Conclusion

This research was done to know values of optimum welding parameters for above mentioned grades of aluminum alloy AA 5083 during experimental work welds will be prepared using Gas Tungsten Arc Welding (GTAW) technique of AA 5083 alloy. In the experiment welding parameters such as Voltage, Welding current, were altered suitably and their effect on mechanical properties which include Hardness, Ultimate Tensile Strength, and Elongation were investigated. Process parameters are optimized to increase the strength of the joint. Based on the test results we can conclude that the effect of frequency is only up to some extent later we can see depletion hence we can conclude that increase in voltage and pulse frequency has negative effect. Hence it is advisable to maintain the current between 150 and 175 volts and pulses frequency from range of 0 pulses /second to 5 pulses /second to get the best output in terms of hardness and tensile strength for the welded joint Maintaining of lower parameters not only provides us a good weld but also reduces he welding and machine life which in turn helps in reducing the cost of production and also environmental friendly Hope this research helps in better manufacturing and production areas

Future scope

Either same parameters or others parameters can be included and researched to improve the weld strength furthermore and optimized to give the best weld quality

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