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Effect of Pulsed Current Tig Welding Parameters on Mechanical Properties of J-Joint Strength of Aa6351

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ABSTRACT

The rate at which automation is being introduced into welding process is astonishing and it may be expected that by the end of this century more automated machines than men in welding fabrication units will be found. To make effective use of the automated systems it is essential that a high degree of confidence be achieved in predicting the weld parameters to attain the desired mechanical strength in welded joints. Higher quality welds with fewer defects like porosity, and cracking and material properties closer to the parent metal are most required in the present manufacturing processes. The mechanical properties of the weldments of AA6351 during the Gas Tungsten Arc Welding (GTAW)/Tungsten Inert Gas Welding (TIG) with non-pulsed and pulsed current welding at different frequencies 3Hz and 7Hz is attempted in this work. The radiography and mechanical properties of the weldments have been examined and compared with non-pulse and pulsed current welding (PCW) at two different frequencies 3Hz and 7Hz. The mechanical properties like tensile strength, % of elongation, 0.2% yield strength of AA6351. No defects were found in the weldments of AA6351 and tensile strength of the joints was more in the case of pulsed current welding.

Keywords: Pulsed current welding, none pulsed current welding, tensile strength, % elongation, yield strength.

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I. Introduction

With ever increasing demand for both high production rates and high precision, fully mechanized or automated welding processes have taken a prominent place in the welding field. Until the end of nineteenth century, the only welding process was forge welding. Later on semi-automatic and automatic processes were developed and researchers continue to develop new welding methods and gain greater understanding of weld quality and properties [1]. Tungsten Inert Gas Welding is an arc process that uses a non consumable tungsten electrode to produce the weld. A constant current welding power supply produces energy which is conducted across the arc through a column of highly ionized gas and metal vapors known as plasma. The work piece is heated and fused by a non melting electrode. When the electric arc burns between the electrode and the work piece, the weld pool and the electrode are protected by a flow of shielding gas through the gas nozzle Fig.1.

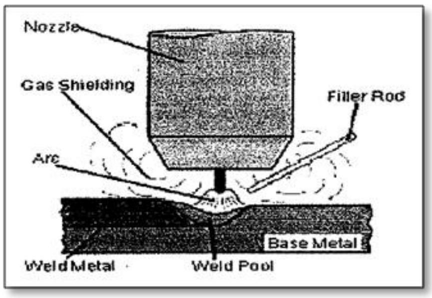


Fig.1. GTAW/TIG Welding Process

Weld fusion zones typically exhibit cores-columnar grains because of the prevailing thermal conditions during weld metal solidification. This often results in inferior weld mechanical properties and poor resistance to hot cracking. It is thus highly desirable to control solidification structure in welds and such a control is often very difficult because of higher temperatures and higher thermal gradients in welds. Techniques like surface nucleation and micro cooler additions were turned down because of the complicated welding set-ups and procedures associated with their use. In this process, relatively new techniques, termed as magnetic arc oscillation and current pulsing, have gained wide popularity because of their striking promise and the relative ease with which these techniques can be applied to actual industrial situations with only modifications of the existing welding equipment.

Pulsed current tungsten inert gas (PC TIG) welding, developed in 1950s is a TIG welding which involves cycling of the welding current from a high level to a low one 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 one of the 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 conducting into the adjacent parent material. The technique has secured a niche for itself in specific applications such as in welding of root passes of tubes, and in welding thin sheets, where precise control over penetration and heart input are required to avoid bum through [2]. Extensive researches have been performed in this process and reported advantages include improved bead contour, greater tolerance to heat sink variations, lower heat input requirements, reduced residual stresses and distortion. 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 [3]. All these factors will help in improving mechanical properties. Current pulsing has been used by several investigators to obtain refined grains in weld fusion zones and improvement in weld mechanical properties.

II. Process

In the pulsed-current mode, the welding current rapidly alternates between two levels. The higher current state is known as the pulse current, while the lower current level is called as back ground current. During the period of pulse current, the weld area is heated and fusion occurs. Upon dropping to the background current, the weld area is allowed to cool and solidifies. Pulsed - current TIG welding has a number of advantages, including lower heat input and consequently reduces distortion and warpage in thin work pieces [4]. In addition, it allows for greater control of the weld pool, and can increase weld penetration, welding speed, and quality.

During the impulses where high current is present in the pulse arc process, a large amount of heat is generated in the welding area. This results in fusion of the work material in the impulse pause where low current is preset, only a little heat is transmitted into the work piece, thus the weld pool stays comparatively cool. The low currents during the background current time only serve to maintain the arc in order to avoid interruptions and ignition difficulties. When welding with filler, the filler will be fused with the base material during the impulse phase. The impulse frequency is usually between 0.5 Hz and 6 HZ. The weld heat input can be considerably changed by the choice of times and current values. In the extreme case a weld seam can consist of fusion welding points which lie next to each other or overlap. TIG - pulsed arc welding, the area of application of the TIG - Process can be extended to low power values thus material thicknesses can be reduced and the weld seam appearance can again be improved [5].

The important four parameters in the TIG welding process are (fig. 2):
Pulse current (I_p), Background current (I_g), Pulse current time (t_p) and Back current time (t_g)
Pulse frequency (f_p) = 1/ $t_{c,}$ where tc is duration of period.

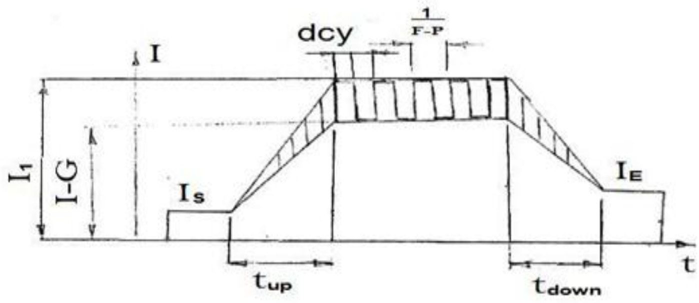


Fig. 2

I_s-Starting current, I_E-End current, t_{up}-Up slope, t_{down}-Down slope, F-P-Pulse frequency, 1/(F-P)-Time interval between two pulses, Dcy-Duty cycle, I_G-Back ground current, I-Main current.

III. Experimental Procedure

AA6351 of 6mm thick and 150mm x 300mnm J-groove (Fig.3) is considered. Welding is done by using non-pulsed and pulsed current TIG welding and AC machine is used for aluminum TIG welding. In pulsed TIG welding frequency is set as 3 Hz to 7 Hz. When welding with pulse, the pulse amperage must be set higher than the base amperage [6]. The benefits of pulse welding is the ability to control the weld pool and amount of heat absorbed by work resulting in a smaller heat affected zone which results in fewer deformations and reduced chance of cracking.

Material	Si	Mn	Mg
AA6351	17-19	4-6	0.15

Material	C	Mn	Si	Ni	Cr	Mo
ER4043	0.08	1-2.5	0.3-0.65	0.9-11	19.5-22	0.75

Table.1 Chemical Composition of AA6351 and Filler Wire ER4043

The aluminum alloy is polished with an abrasive paper and pneumatic rotary bush to remove surface impurities and then cleaned with acetone. The choice of tungsten electrode depends upon the type of welding current selected for the applications. The welding process is conducted uisng 25mm dia X 175 mm long electrode for 6mm thick plate both in non pulsed current and pulsed current. Radiography and mechanical tests are carried out on the weldments where tensile test specimens were prepared on the milling machine as per ASTM standard fig. 3. The perpendicular sections of the weldments are examined at different locations with magnitude for a clear understating of the microstructure features [7]. The parameters used in non pulsed and pulsed current welding are given in table. 2.

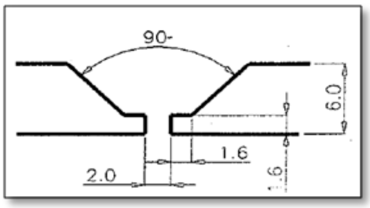


Fig. 3 J-Groove joint

Material Thickness (mm)	Weld Layer	Filler Wire dia (mm)	I (amps)	V (volts)	Arc Travel Speed (cm/min)
6	Root	2.5	120	13.5	7.5
6	1st layer	2.5	120	12.5	7.2

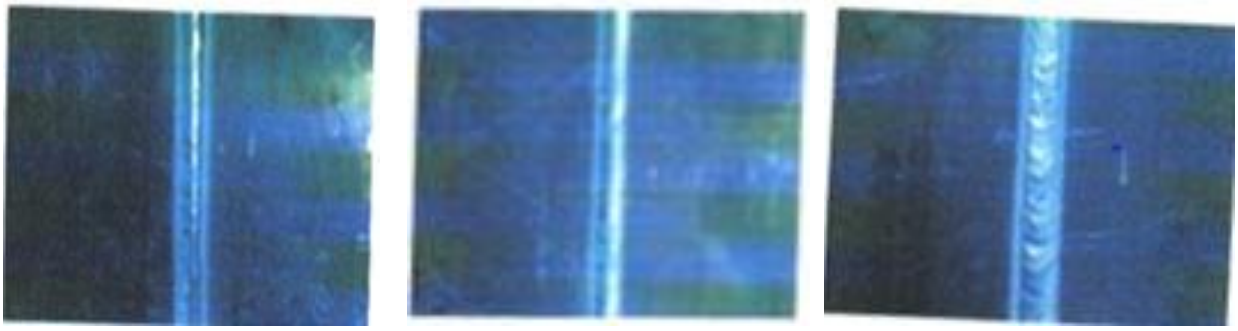
Table.2 welding parameters of Non-pulsed Current Welding for AA6351

Material Thickness (mm)	Weld Layer	Filler Wire dia (mm)	Frequency Hz	Base Current (amps)	V (volts)	Peak Current (amps)	Arc Travel Speed (cm/min)	Pulse Ratio
6	Root	1.6	3	70	13.5	120	7	50
	1st layer	2.4	3	70	17.5	140	7.6	50
6	Root	1.6	7	74	13.7	135	7.2	50
	1st layer	2.4	7	74	17	140	7.6	50

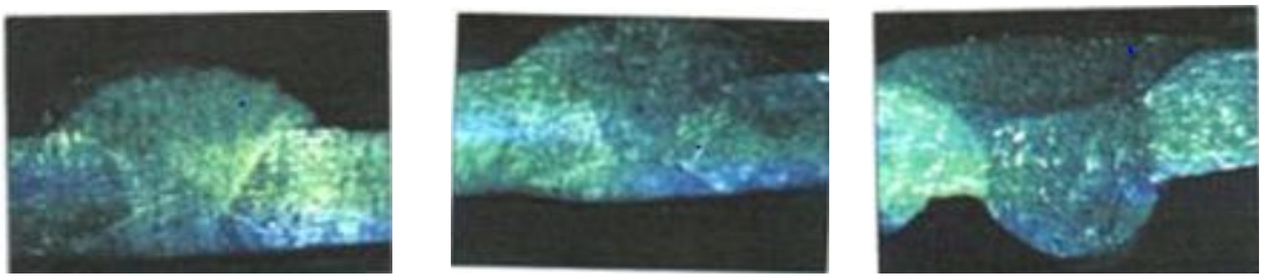
Table.3 Welding parameters of Pulsed Current Welding for AA6351

IV. Results And Discussions

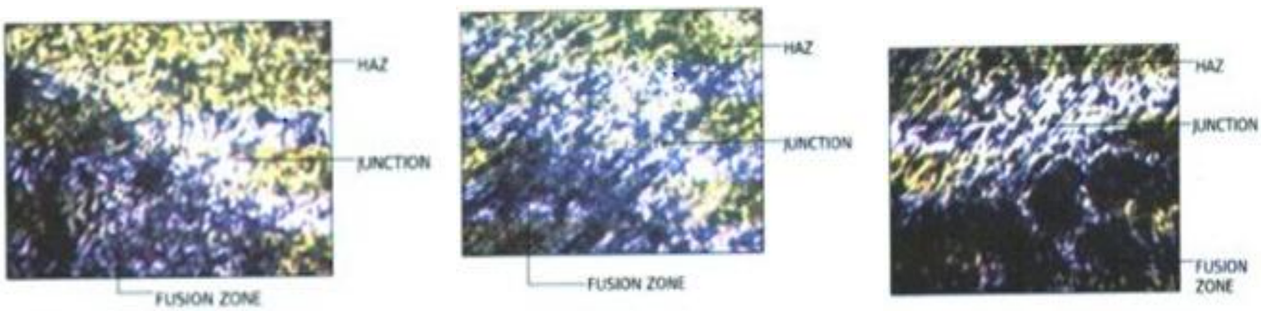
On conducting tensile test to specimens it can be concluded that the tensile strength and 0.2% yield strength of the weldments of aluminum is closer to the base metal. And the failure location of weldments occurred at Heat Affected Zone (HAZ) and from this we can say that weldments have better weld joint strength. No defects are seen in the weldments and it can be concluded that weld is done at correct angle of torch and all the parameters used are in optimum level.



NON PULSE | PULSE– 3Hz | PULSE – 7Hz



NON PULSE | PULSE – 3 Hz | PULSE – 7 Hz



NON PULSE | PULSE – 3 Hz | PULSE – 7 Hz

Fig. 5 Macrostrcuture & Microstructure of AA6351 joints with Non Pulsed and Pulsed.

The table.4 show that the tensile test results of AA6351 and the tensile strength is more in the case of pulsed current welding at frequency of 3Hz.

Sl. No.	Sample Description		UTS (M Pa)	0.2%YS(M Pa)	%Elongation
1	Base Material		178.4	169.8	5.6
2	Non-Pulsed Current GTAW		170.133	104.0	9.6
3	Pulsed Current GTAW	Pulse= 3Hz	177.35	114.98	9.6
		Pulse= 7Hz	147.73	99.73	12.8

Table.4 Mechanical properties of AA6351 welded joint

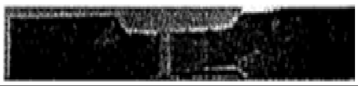
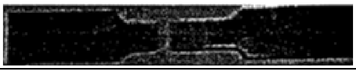
Type of Weld		UTS MPa	0.2%YS MPa	Elongation	Failure Location	
Non-Pulsed Current GTAW		170.133	104.0	9.6		HAZ
Pulsed Current GTAW	3Hz	177.35	114.98	9.6		HAZ
	7Hz	147.73	99.73	12.8		HAZ

Table.5 Failure location of weldments

AA6351 produced maximum ultimate tensile strength 177.35MPA maximum yield strength 114.98MPA with pulsed current welding frequency of 3Hz. Maximum % elongation 12.8 was obtained with pulsed current welding frequency of 7Hz. So, AA6351 should be welded with pulsed current welding process to get good results. By applying pulse welding a better depth of penetration and fusion of filler material with parent metal is obtained and by this it improves strength and ductility of weldments. The performance of pulsed current GTAW is better than non -pulsed current welding further work can be extended on fractography of tensile specimen in pulsed and non-pulsed welding. Further study can also be made on different thickness of the material at different currents and the various properties can be compared.

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