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PCTIG Welding of 5xxx Aluminium Alloys : A Literature Review

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ABSTRACT

Aluminium alloys are alloys in which aluminium is the predominant metal. Aluminium alloys of 5xxx series and their welded joints show good resistance to corrosion in sea water. TIG welding technique is one of the precise and fastest processes used in aerospace industries, ship industries, automobile industries, nuclear industries and marine industries. In order to optimize any process it is very essential to understand the effect of its process parameters on mechanical properties of selected substrate. On the basis of the literature reviewed it has been observed that still there are limited research studies on optimizing the process parameters of Pulsed TIG welding of AA5083-H116.
Keywords: TIG Welding, AA5xxx Aluminium alloys Process parameters.

I. INTRODUCTION

Aluminum has contributed very significantly in this development as a versatile metal. Because of unique characteristics, aluminum has substituted much older and established materials like wood, copper, iron, and steel. The best-known characteristic of aluminum is its light weight, the density being about one-third that of steel or copper alloys. Certain aluminum alloys have a better strength-to-weight ratio than that of high strength steels. Aluminum has good malleability and formability, high corrosion resistance, and high electrical and thermal conductivity.

Aluminum and aluminum alloys are extensively used for wide range of industrial applications. The important sectors include, transportation, architecture, aerospace, marine and structures used in military applications. In many of these applications, welding is used as a method of fabrication.

Aluminum and most of its alloys are weldable but the Weldability characteristics of aluminum alloys widely vary from alloy system to alloy system.

Aluminum alloys of 5xxx series and their welded joints show good resistance to corrosion in sea water. 5083-H116 is one of such an excellent marine environment corrosion resistant aluminum alloy, most commonly used in North America. It is a marine grade alloy used for its excellent corrosion resistant properties.

In the ship manufacturing industries, TIG welding is used to join the different aluminum parts of the ship structure. However, the use of pulsed current TIG welding has been found to improve the tensile and impact properties of the weldments compared to those of continuous current TIG welds of this alloy.

TIG welding is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmosphere by an inert shielding gas (argon or helium) and a filler metal is normally used. The power is supplied from the power source (rectifier), through a hand piece or welding torch and is delivered to a tungsten electrode which is fitted into the hand piece. An electric arc is then created between the tungsten electrode and the work piece using a constant currant welding power supply that produces energy and conducted across the arc through a column of highly ionized gas and metal vapors. The tungsten electrode and the welding zone are protected from the surrounding air by inert gas.

The difference between TIG and pulsed TIG welding is that the welding current weaves periodically between a high (pulse current Ip) and a low (basic current I_G) value. Specially designed power supplies provide the facility of pulsing the current at predefined pulse 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.

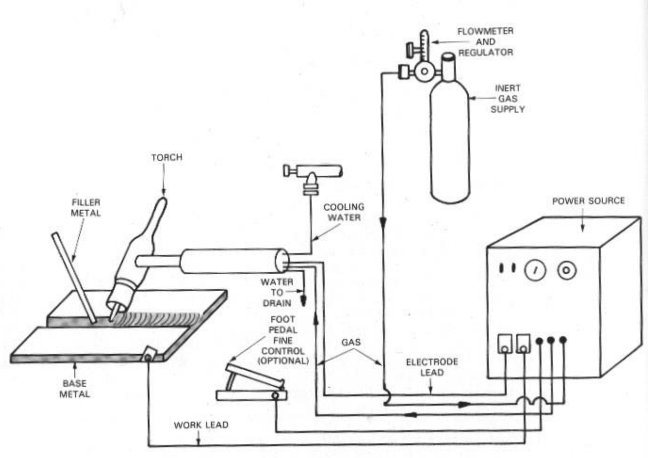

Figure 1. Schematic Illustration of PCTIG welding

II. LITERATURE REVIEW

T Senthil Kumar et al (2006) studied influences of pulsed current TIG welding parameters on the tensile properties of AA 6061 aluminum alloy. Pulsed current TIG welding process utilizes arc energy more efficiently by reducing the wastage of heat energy by conduction into the adjacent parent metal. In PCTIG welding heat required to melt the base metal is supplied only during peak current pulses for brief intervals of time, allows the heat to dissipate leading to a narrower HAZ. The results reveal that the refinement of microstructure is due to pulsed current welding is more compared to conventional continuous current welding. It is also observed that the pulsed current welding also improves mechanical properties like tensile strength & hardness.

Kumar and Sundarrajan (2009) performed pulsed TIG welding of 2.14 mm AA5456 Al alloy using welding current (40-90) Amp, welding speed (210-230) mm/min. Taguchi method was employed to optimize the pulsed TIG welding process parameters for increasing the mechanical properties and a Regression models were developed. Microstructures of all the welds were studied and correlated with the mechanical properties. 10-15% improvement in mechanical properties was observed.

Sanjeev Kumar (2010) performed TIG welding of 6 mm thick Al plate. They performed experiment in two phases in first case they used AC power supply of current (100 A, 150 A, 200 A), gas flow rate of (7 lit/min, 15 lit/min) and pulsed frequency of 4 HZ. In second case DC power supply of current (48 A, 64 A, 80 A, 96 A, 112A), gas flow rate (7 lit/min). Photomicrographs of welded specimens were taken and analyzed from the experiment it has been observed that shear strength varies with change of pulse current. This change in shear strength is due to lack of refined grain structure of weldments, responsible for poor strength. Maximum value of shear strength has been observed at pulse current of 250A, gas flow rate of 15 lit /min and base current 200 Amp.

N. Karunakaran (2010) did an investigation to compare the mechanical properties and welding profiles of TIG welded aluminum alloy joints. The effects of pulsed current on tensile strength, hardness, and microstructure and stress distribution were reported. The parameters were welding current (55-75) A. voltage (11-13.5) V and a constant welding speed were used. From the experiment it is found that pulsed welding current improve the tensile behavior of the weld compared with continuous current welding due to grain refinement occurring in the fusion zone.

P kumar, SH Mankar, CK Datta (2011) demonstrated the increase of mechanical properties and effective optimization of pulsed GTAW process parameters on aluminum alloy 6061. Welding was done with input parameters as base current (80-110) Amp, pulse frequency (50-125) HZ and pulse duty cycle (30-75) %. Taguchi method was employed to calculate experimental structure and to study process optimization parameters on mechanical properties of the joints. Result of the experiment showed that pulse current, base current, pulse duty cycle and frequency plays significant role on microstructure and mechanical properties of weld, but pulse current plays the greater role i.e. 52.55 %. In this investigation, pulse current of 120A, background current of 80A, pulse frequency of 50Hz and pulse duty cycle of 75% resulted in the maximum values of mechanical properties.

Indira Rani (2012) investigated the mechanical properties of the weldments of AA6351 during the GTAW /TIG welding with non-pulsed and pulsed current at different frequencies. Experiment carried out with plate dimension 30 mm X 150mm X 6mm, welding was performed with current 70-74 A, arc travel speed

700-760 mm/min, and pulse frequency 3 and 7 Hz. From the experimental results it was concluded that the tensile strength and YS of the weldments is closer to base metal.

Yao Liu et al. (2012) have investigated the mechanical properties and microstructure of aluminium 5083 weldment by TIG and MIG welding. Weldment produced by both is mechanically softer than the base metal. It is revealed that AA5083 weldment processed by TIG is mechanically more reliable than those by MIG welding.

Lakshman Singh et al (2013) Performed TIG welding process 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 lit/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.

Arun Narayanan et al. (2013) have investigated the effect of shielding gas on porosity formation of AlMg4.5Mn weld metals. The detailed study of the four samples A, B, C, D was conducted. The macrostructure and microstructure study was conducted with reference to the tensile test results and the micro hardness test. From the study it is found out that sample C was better than sample A, B, D. The test results of sample C included ultimate tensile strength of 281MPa, hardness of weld metal is 73.5 HVN. The sample C had a working range of welding current 200A and shielding gas flow rate 15 L/min. So the welding of Aluminium alloy 5083 performed in the experimental combination of welding current 200A and shielding gas flow rate 15 L/min is found to give a better result.

III. CONCLUSION

In order to optimize any process it is very essential to understand the effect of its process parameters on mechanical properties of selected substrate. On the basis of the literature reviewed it has been observed that still there is limited research studies on optimizing the process parameters of Pulsed TIG welding of AA5083-H116. Welding current, gas flow rate, and pulse frequency have been identified as key process parameters.

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