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Influence of Shielding Gas on Aluminum Alloy 5083 in Gas Tungsten Arc Welding

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Abstract

The influence of shielding gas parameter was affect to mechanical properties and microstructures of heat-affected zone and fusion zone on gas tungsten arc welding (GTAW) in aluminium alloy AA 5083. The factorial experiment was designed for this research. The factors of AA 5083 weld used in the study types of shielding gas in argon and helium, gas flow rate at 6, 10 and 14 litres per minute. Then the results were using microstructure and vickers hardness test. The result showed that types of shielding gas and gas flow rate interaction hardness at heat-affected zone and fusion zone with a P–value < .05. The factor which was the most effective to the hardness at heat-affected zone and fusion zone was argon with a flow rate of 14 litres per minute at heat-affected zone with 74.27 HV and fusion zone with 68.97 HV. The helium was high thermal conductivity, resulting in a large amount of heat. The grain size was grain growth in larger grain size. This can result in decreased of hardness. Experimental results showed that the argon condition provided smaller grain size, suitable size resulting in higher hardness both in weld metal and HAZ. This research can be used for data on considering on gas tungsten arc welding of aluminium alloy 5083.

Keyword; Aluminum Alloy AA 5083, Shielding gas, Hardness, Microstructures

1. Introduction

Aluminium - Magnesium alloys of the 5xxx series are strain hardenable, and have moderately high strength, excellence corrosion resistance even in salt water, and very high toughness even at cryogenic temperature to near absolute zero. They are readily welded by a variety of technique. Shielding gas is directed by the torch to the arc and weld pool to protect the electrode and molten weld metal from

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atmospheric contamination. Backup purge gas can also be used protect the underside of the weld and its adjacent base metal surface from oxidation during welding. [1]

The gas tungsten arc welding (GTAW) process is accomplished with the heat of an electric arc operating between a tungsten electrode and the work in a shield of inert gas. The inert atmosphere prevents oxidation of the molten aluminium so no flux is required. The gas is usually argon for AC and DCEP GTA welding, and helium for DCEN GTA welding. In the inert atmosphere, the tungsten electrode is practically non-consumable. Actually, it is dissipated slowly by the arc and requires occasional dressing to maintain a hemispherical tip contour. For all practical purposes, however, the tungsten electrode imparts no metal to the weld pool under normal operating condition. [2, 3, 4]

During AC welding, portions of the welding cycle are spent on both electrode negative and positive polarity. The work piece now produces the electrons during the EP cycle of the waveform. Typical construction materials such as steel and aluminium melt at temperatures much lower than that necessary for thermionic emission. Hence, these materials are no thermionic and are often termed "cold cathodes." Field emission processes, whereby electrons are removed from the base materials due to the strong localized voltage gradients, are facilitated by an increase in the cathode fall voltage during electrode positive polarity. The electrode positive cycle during AC welding permits the removal of tenacious surface oxides from aluminium alloys by "cathode sputtering." This phenomenon produces clean weld surfaces and good fusion characteristics in both the gas tungsten arc welding (GTAW) and plasma arc welding (PAW) processes. [5]

Previous arc physics studies suggest that maximum weld depth and fusion volume occur on electrode negative polarity, when electrons stream toward the metal being welded. This is supported by early energy balance work on the GTAW process using DC electrode negative (DCEN) polarity, where approximately 60–80% [6] of the heat generated is absorbed at the anode. [7, 8]

The present work was to study the effect of type of shielding gas and gas flow rate for aluminium alloy 5083. Optimum value variables for type of shielding gas and gas flow rate are determined by design of experimental using full factorial design. In this case, each single variable: type of shielding gas and gas flow rate as well as their interaction were determined. [9]

2. Methodology

2.1 Materials and Methods

The work material used as the test specimen was aluminium alloy AA 5083. Plates of specimens 6 mm. thickness and 50x50 mm. were used for the tests. Details of the material chemical composition are given in Tables 1

Table 1 Chemical Composition of AA 5083 alloy by weight (%)

Mg	Fe	Cu	Ti	Si	Zn	Mn
4.63	0.26	0.26	0.017	0.11	0.007	0.76

The Alloy 5083 samples were welded by using gas tungsten arc welding without filler metal addition. Welding current was set constant 100 Amps and alternating current (AC). The welding travel speeds was at 12 mm/sec. Tungsten electrode (EWP) diameter of 2.4 mm. was used in this study. Argon and helium was selected as a shielding gas with the flow rate of 6, 10 and 14 liters / minute.

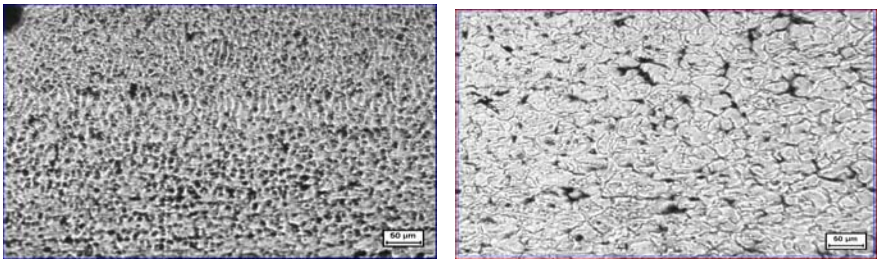
2.2 Microstructure and mechanical test

Welded samples were sectioned transversely to the weld and polished using standard metallographic techniques. The FZ and HAZ microstructures were examined and analyzed by an inverted reflected-light microscope equipped with the optical microscope. Polished samples for optical microscope were etched by using for HF 75 ml., HNO3 25 ml. 15 seconds. [10] The micro- hardness (HV) using a load of 500 g in order to determine response of influence shielding gas.

3. Results and Discussion

3.1 Results of microstructure

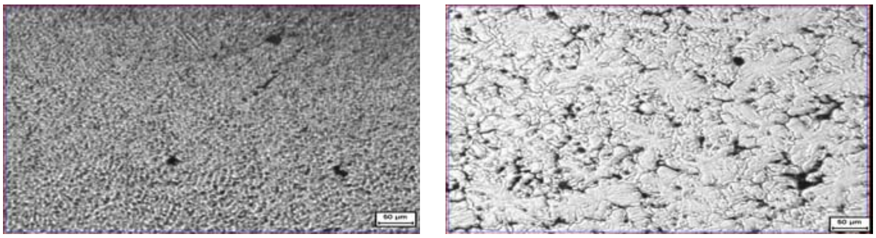
Optical microscope has been conducted for all joints, in order to determine the microstructure across the heat affected zone region.



(A) (B)

Fig 1 Optical micrograph, showing microstructure of heat affected zone (A) Argon shielding and gas flow rate 14 l/min (B) Helium shielding and gas flow rate 6 l/min image size 50x

The examination of the microstructure focused in heat affected zone. Helium was appreciably higher than that with argon. Since heat in the arc was roughly measured by the product of current, helium offers more available heat than argon. As showed Fig 1(A). The results showed that fine grain size effect to high hardness. The helium was high thermal conductivity, resulting in a large amount of heat. The grain size was grain growth in larger grain size. The hardness decreases from Fig. 1(B).



(A) (B)

Fig 2 Optical micrograph, showing microstructure of fusion zone (A) Argon shielding and gas flow rate 14 l/min (B) Helium shielding and gas flow rate 6 l/min image size 50x

Besides grain size and also showed that the density of the Mg_2Al_3 precipitate formed at the grain boundary [11] and Mg_2Al_3distribution of parent phase show Fig. 2 (A),(B) it was found that the distribution of Mg_2Al_3 less. The results can be concluded that the grain size and precipitation Mg affect the hardness of sample.

3.2 Results of hardness in heat affected zone

Mechanical property test, hardness of penetration by micro vicker hardness at heat affected zone, 5 points was determined from the average of 18 samples.

Table 2 General linear model: Hardness versus type of shielding gas and gas flow rate

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Type of shielding gas	1	20.267	20.267	20.267	149.35	0.000
Gas flow rate	2	42.603	42.603	21.302	156.98	0.000
Type of shielding gas and Gas flow rate	2	1.226	1.226	0.613	4.52	0.035
Error	12	1.628	1.628	0.136		
Total	17	65.725				

S = 0.368375 R-Sq = 97.52% R-Sq(adj) = 96.49%

As shown Table 2, General linear model of the hardness versus type of shielding gas and gas flow rate. Found that the type of shielding gas and interaction hardness at the level of confidence 95% (P-Value <0.05). Performance analysis of the results of the main factor is type of shielding gas and gas flow rate. Factors could explain the variability of the response of hardness 96.49%

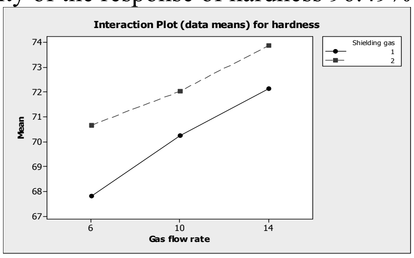


Fig.3 Interaction plot for hardness in HAZ

As show Fig. 3 interaction plot of hardness, Found that the type of shielding gas flow rate interaction hardness. The pull factors that result in a hardness most argon and gas flow rate 14 l/min. Factors used in the type of shielding gas and gas flow rate of the P-Value of factors was 0.000 (<0.05). The result showed that the type of shielding gas and gas flow rate with electrification interaction significance at the maximum hardness was 74.27 HV.

3.3 Results of hardness in fusion zone

Probability plot of hardness in fusion zone the data has normal distribution P value > 0.05

Table 3 General linear model: Hardness in fusion zone versus type of shielding gas and gas flow rate

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Type of shielding gas	1	22.534	22.534	22.534	131.10	0.000
Gas flow rate	2	34.221	34.221	17.110	99.54	0.000
Type of shielding gas and Gas flow rate	2	1.749	1.749	0.874	5.09	0.025
Error	12	2.063	2.063	0.172		
Total	17	60.567				

S = 0.414595 R-Sq = 96.59% R-Sq(adj) = 95.18%

General linear model of the hardness was versus type of shielding gas and gas flow rate. Found that the type of shielding gas and interaction hardness at the level of confidence 95% (P-Value <0.05) show in Table 3.This indicated that data could be predicted using model that was to be generated. The R^2 of this collected data was about 95.18% which response could be described by the experimental factors.

The result showed that the type of shielding gas flow rate interaction hardness in fusion zone. The pull factors that result in a hardness most argon and gas flow rate 14 l/min. Factors used in the type of shielding gas and gas flow rate of the P-Value of factors was 0.000 (<0.05). The result showed that the type of shielding gas and gas flow rate with electrification interaction significance at the maximum hardness in fusion zone at 68.97 HV.

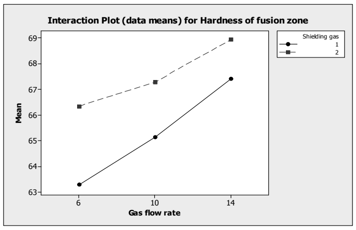


Fig. 4 Interaction plot of hardness in fusion zone.

4. Conclusion

This research aims at studying types of shield gas and gas flow rate which affect to mechanical properties and microstructures of HAZ and fusion zone on gas tungsten arc welding (GTAW) in aluminium alloy AA 5083. The factorial experiment was designed for this research. The factors of AA 5083 weld used in the study types of shielding gas in argon and helium, gas flow rate at 6, 10 and 14 litres per minute. Then the results were using microstructure and vickers hardness test. The result showed that types of shielding gas and gas flow rate interaction hardness at HAZ and fusion zone with a P–value < .05. The factor which was the most effective to the hardness HAZ and fusion zone was argon with a flow rate of 14 litres per minute at HAZ with 74.27 HV and fusion zone with 68.97 HV. The helium was high thermal conductivity, resulting in a large amount of heat. The grain size was grain growth in larger grain size. This can result in decreased of hardness. Experimental results showed that the argon condition provided smaller grain size, suitable size resulting in higher hardness both in weld metal and HAZ. The results can be concluded that the grain size and precipitation Mg affect the hardness of sample. This research can be used for data on considering on gas tungsten arc welding of aluminium alloy 5083.

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