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CORRELATION BETWEEN MICROSTRUCTURE AND MICROHARDNESS ON AL-SIC COMPOSITE WELDED USING PULSED CURRENT TIG WELDING

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ABSTRACT

Study of pulsed current TIG welding parameter on Al - 8% SiC composite about micro hardness, microstructure and correlation between micro hardness and microstructure. Experiment was designed using Taguchi L_9 orthogonal array techniques to reduce the number of experimental run from 81 to 9. Micro hardness values observed form weld centre to heat affected zone. Microstructure was also observed on weld zone and heat affected zone. Correlation between micro hardness and microstructure was studied and the following results were observed. Coarse grain microstructure gives micro hardness value around 60HV and Fine grain microstructure gives micro hardness value around 70HV. Pulsed current TIG parameter such as peak current of 160A, base current of 60A, pulse on time - 50% and pulse frequency was 5Hz showed fine grain microstructure with micro hardness value of 75HV. Weld zone showed microstructure's grain size which is finer than the heat affected zone microstructure's grain size.

Keywords: micro structure, micro hardness, PCTIG welding, Al - SiC composite.

INTRODUCTION

In aluminium metal matrix composite uses SiC, TiB_2, TiC, B_4C are ordinarily utilized reinforcement [1]. In this above reinforcement silicon carbide used as major reinforcement for aluminium due to higher wear resistant [2], higher strength to weight ratio [3].

Stir casting procedure is mostly utilized for to produce the aluminium silicon carbide (Al-SiC) composite because of its higher production rate [4]. Stir casting could be attained to by minor changes in traditional casting procedure [5]. It is the most suitable and efficient method for delivering Al-SiC composite when compared with other manufacturing process such as powder metallurgy route and spray coating process [6].

TIG welding on aluminium composite gave reduced weld strength because of higher heat generation in weld zone [7] and lesser cooling rate [8] of weld pool which brings about coarse grain structure in weld zone and residual stresses developed in heat affected zone [9].

TIG welding of Al-SiC composite, SiC is separated into Silicon (Si) and Carbon (C). This carbon joins with aluminium (Al) phase to forms (aluminium carbide) Al_4C_3 + (Silicon) Si. Al_4C_3 stage is more brittle in nature, in this manner brought about significant misfortune in weld quality [9]. Aluminium carbide development in TIG welding on Al-SiC composite have chance for enhanced in weld quality [10].

The issue of coarse grain microstructure amid TIG welding on aluminium combinations could be redressed by utilizing surface nucleation [11], microcooler expansion [12], arc oscillation [13], impact of pulsed current system on Aluminium alloy 6061 fatigue strength [14] and pulsed current on aluminium alloy 7075 tensile strength [15] to acquire fine grain microstructure. Among this pulsed current system has wide acknowledgement, as it can be utilized continuously improve mechanical applications with least changes in the existing system [16].

In pulsed current TIG (PCTIG) welding, peak current gives satisfactory entrance and globule shape [17]. Base current keeps up stable arc. Pulse on time gives enough time to exchange the heat from weld zone and heat affected zone to base material region [18].

PCTIG welding parameters gives decreased heat input, higher cooling rate and fine grain microstructure, micro hardness which enhance the weld quality in aluminium composite pulsed current TIG welding. In this way, the study on the PCTIG welding parameters on Al-SiC composite has noteworthy vital.

EXPERIMENTATION

To study the mean effect, interaction effect experiment should be designed according to Taguchi L_9 orthogonal array. PCTIG welding parameters and its levels for Taguchi L_9 orthogonal array, on 5mm plate of Al - 8% SiC composite. Here 4 factors and 3 levels as given in the Table-1 were designed for various conditions were shown in 2.

Table-1. PCTIG welding parameters and levels.

Parameter	Levels		
	1	2	3
Peak current (A)	140	150	160
Base current (A)	40	50	60
Pulse on time (%)	40	50	60
Pulse frequency (Hz)	2	5	10

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Table-2. Experimental conditions for PCTIG welding.

PCTIG welding condition	**Peak current** (A)	**Base current** (A)	**Pulse on time** (%)	**Pulse frequency** (Hz)
1	140	40	40	5
2	140	50	50	10
3	140	60	60	2
4	150	40	50	2
5	150	50	60	5
6	150	60	40	10
7	160	40	60	10
8	160	50	40	2
9	160	60	50	5

Autogenous welding was performed on Al-8%SiC composite material with a plate thickness of 5mm using ADOR CHAMPTIG 300AD welding machine as shown in Figure-1. Welded sample were shown in Figure-2.

Figure-1. PCTIG welding machine with DAQ system.

Figure-2. PCTIG welded samples.

Using standard metallographic procedure the welded samples were prepared for microstructure observation. Microstructures were observed in different magnification ranges using high transmission trinoculur metallurgical microscope as shown in figure 3. It consists of a computer coupled CCD camera for capturing and storing microstructure images. Micro hardness of different region such as weld zone, heat affect zone and base material were measured using Shimadzu micro Vickers hardness tester as shown Figure-4, according to the standard of ASTM E 384.

Figure-3. Microscopic image analyser.

Figure-4. Vickers micro hardness tester.

RESULTS

Micro hardness

Micro hardness of different pulsed current TIG welding parameters were recorded and shown in Figure-5. PCTIG welding condition 7 and condition 8 showed micro hardness value close to the CCTIG welding micro hardness value which is near to 61HV. PCITG welding condition 1 and condition 9 showed hardness above 70 HV on weld centre. Other conditions such as condition 4 and condition 6 showed values near 62HV to 63 HV. Condition 2, condition 3 and condition 5 showed micro hardness value between 65HV to 67 HV.

By this result this 9 PCTIG welding condition was classified into 4 types, they are:

a) PCTIG welding parameter with no effect (condition 7 and condition 8),

b) PCTIG welding parameter with minimum effect (condition 3 and condition 4)

c) PCTIG welding parameter with normal effect (condition 2, condition 5 and condition 6)

d) PCTIG welding parameters with maximum effect (condition 1 and condition 9)

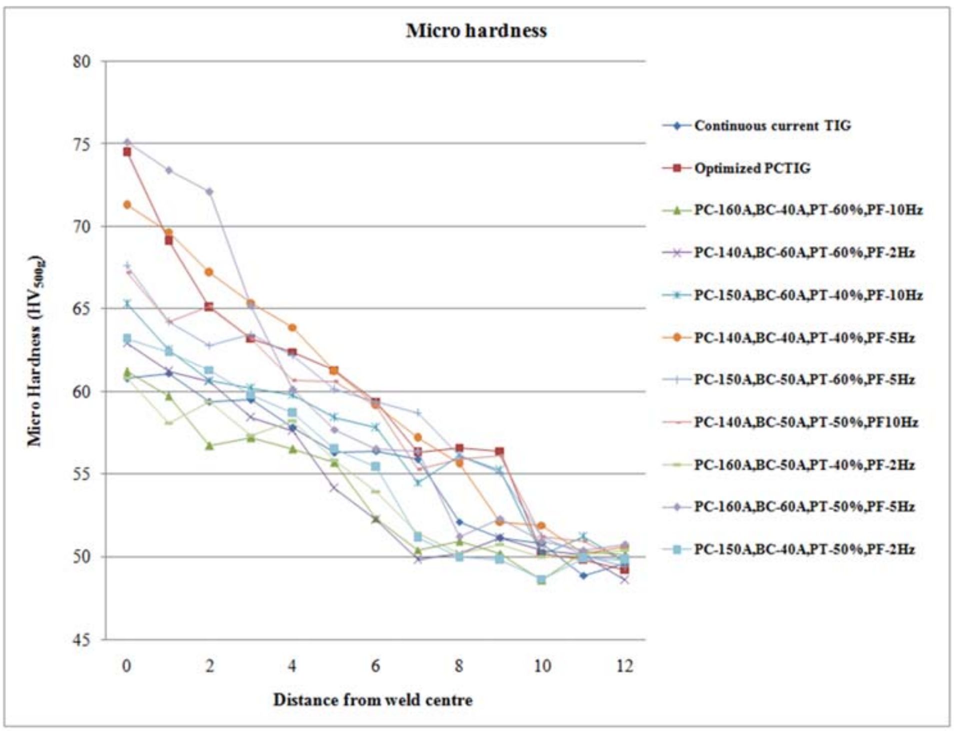

Figure-5. Micro hardness of pulsed current TIG welded samples.

Microstructure

From Figure-6, the following results were observed. Condition 1 showed fine grain microstructure and grain size in HAZ was also reduced. Condition 3 showed coarse grain structure which is similar to CCTIG welded microstructure. Intermediate size between fine and coarse microstructure was found in condition 2. Figure-7 showed the microstructure from condition 4 to 6. Here condition 4 had intermediate size between fine and coarse micro structure similar to condition 2 is found. Fine grain microstructure was found in condition 5 and condition 6. In Figure-8, fine grain micro structure was found for condition 9. For condition 7 and condition 8, microstructure observed was coarse grain microstructure. Figure-9 showed the microstructure of CCTIG welded sample as coarse grain structure, PCTIG weldment showed fine grain microstructure. Base material showed very fine grain microstructure.

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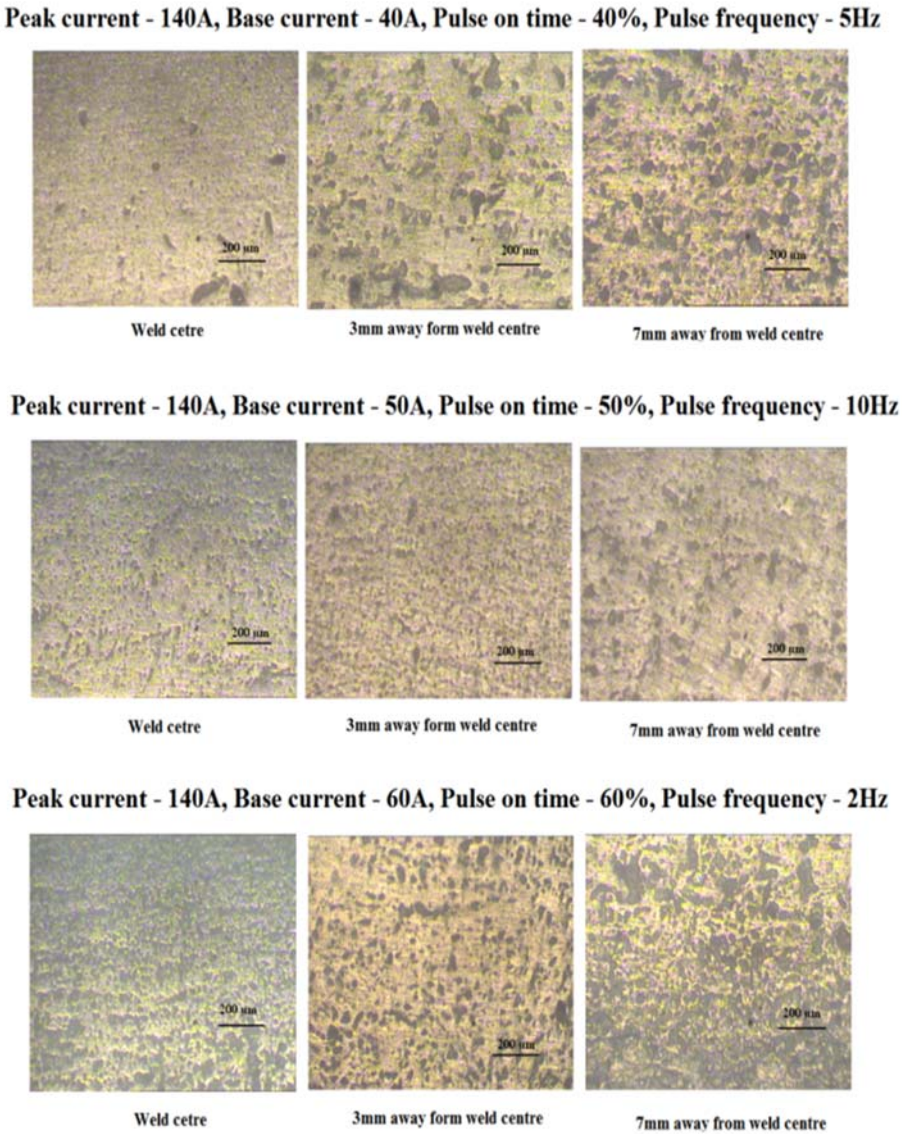

Figure-6. Microstructure of PCTIG welded samples – (condition 1 to 3).

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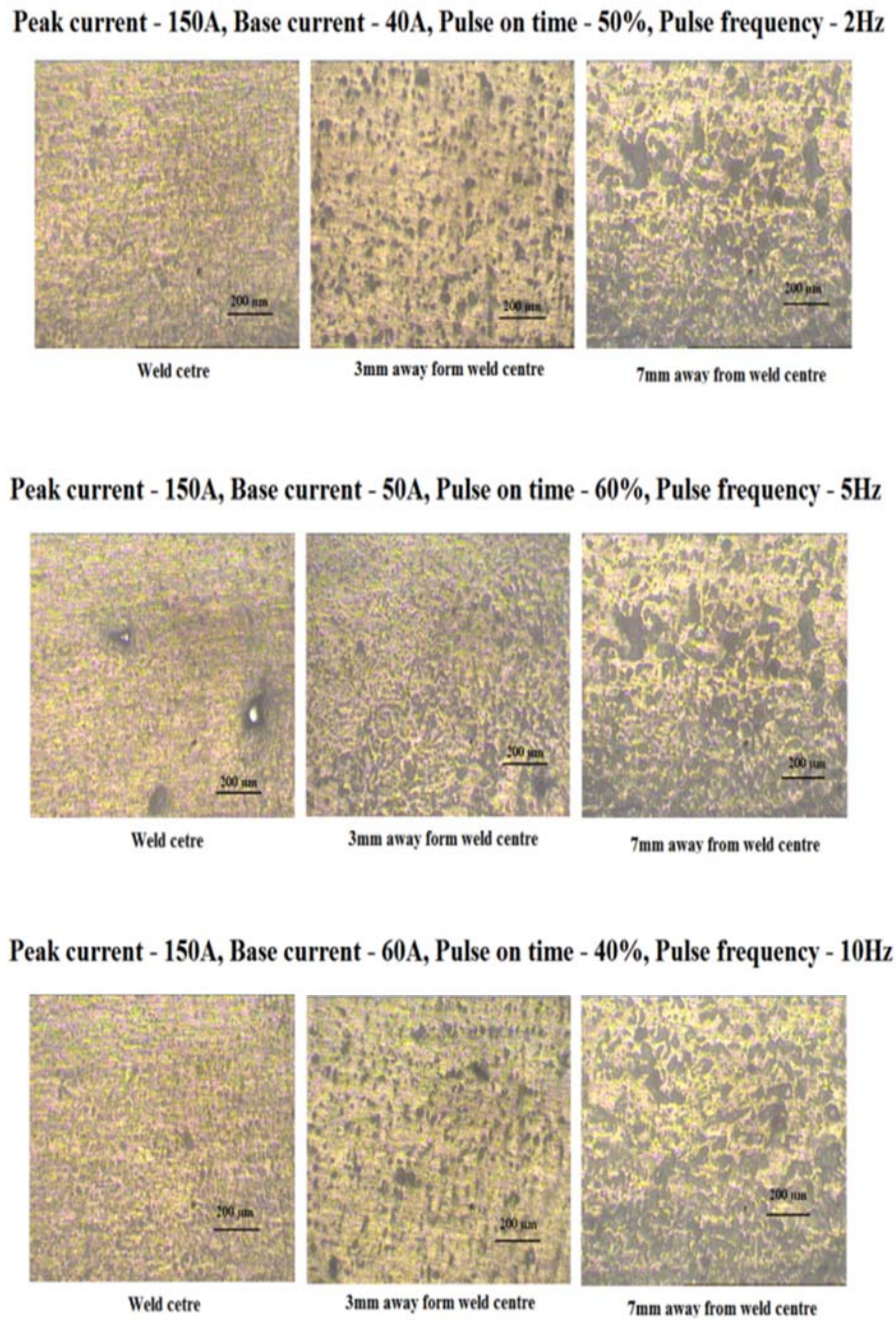

Figure-7. Microstructure of PCTIG welded samples - (condition 4 to 6).

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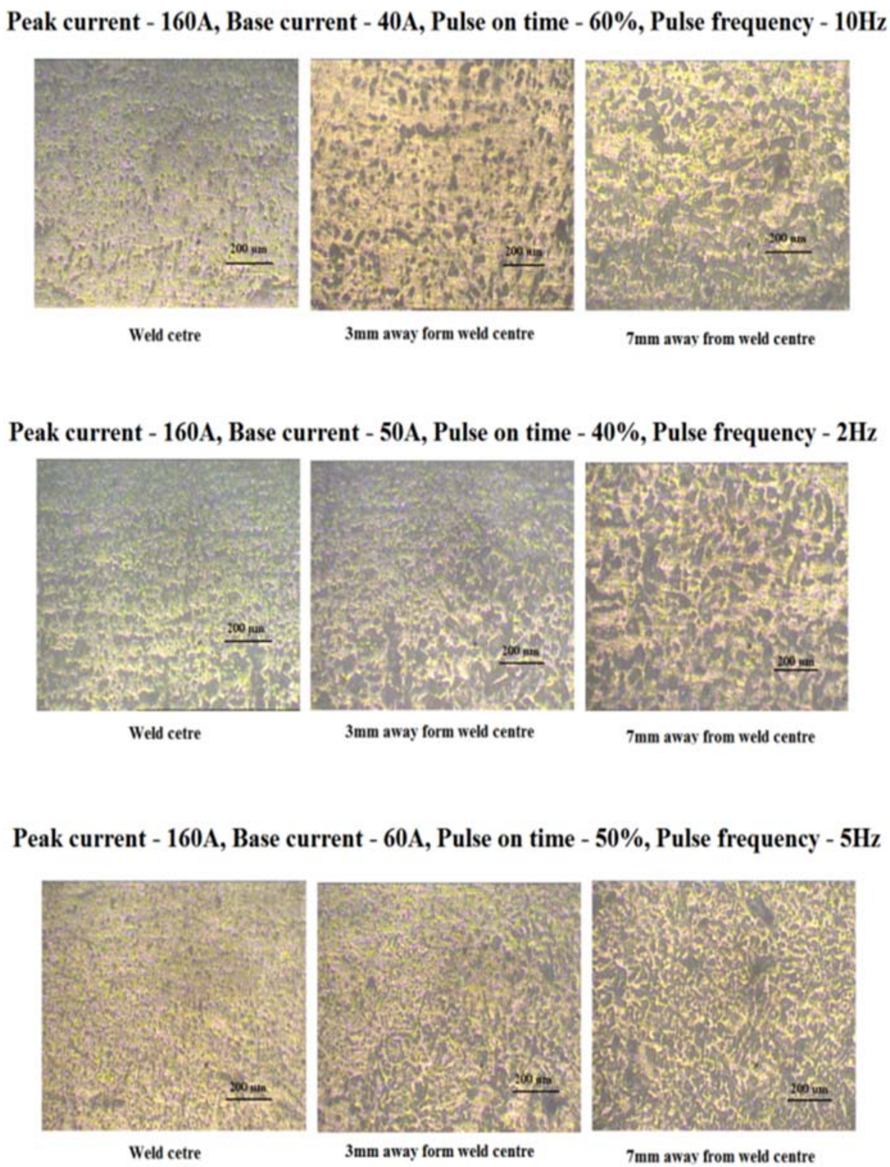

Figure-8. Microstructure of PCTIG welded samples - (Condition 7 to 9).

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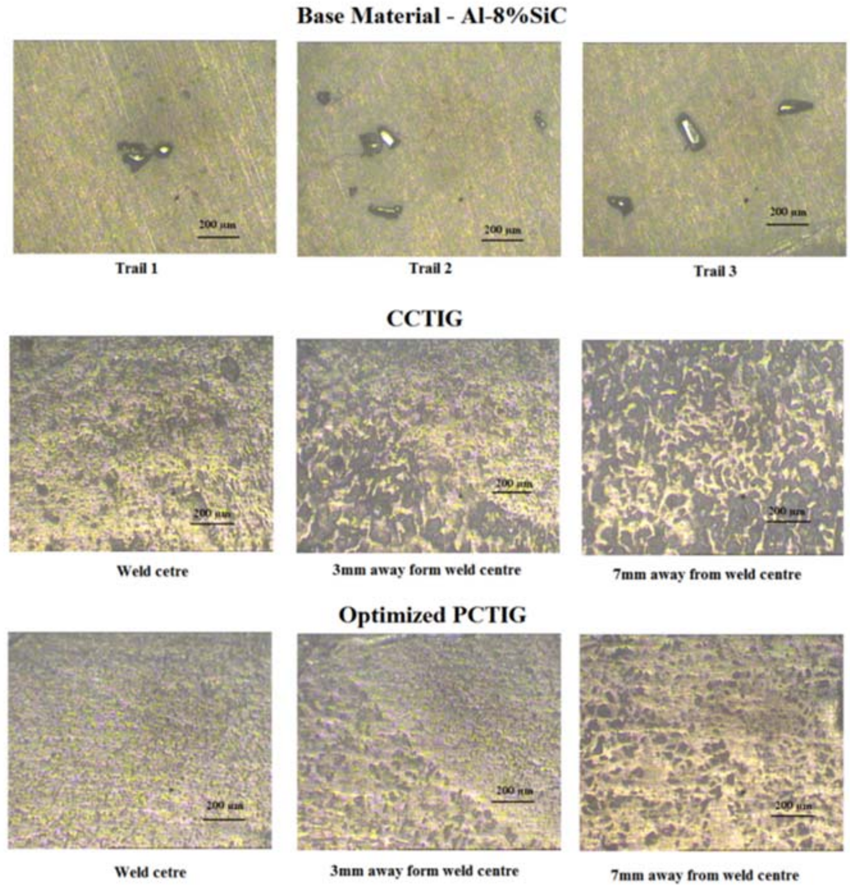

Figure-9. Microstructure – (Base material - Al - 8% SiC, CCTIG, optimized PCTIG).

In all the welded samples, heat affected zone had bigger grain size microstructure than the weld zone microstructure. This was reason for decrease in micro hardness value when micro hardness value taken away from weld centre was increased.

DISCUSSIONS

PCTIG welding parameter with no effect (condition 7 and condition 8) showed coarse grain microstructure with reduced micro hardness value around 60HV - 61HV. This showed the PCTIG welding parameters on condition 7 and condition 8 did not had any significant effect on the mechanical properties and microstructure. PCTIG welding parameter with minimum effect (condition 3 and condition 4) showed slight effect pulsed current parameter such increase in micro hardness 65HV value coarse grain size was get reduced compared to condition 7 and condition 8. This implies that pulsed current TIG welding parameters on this condition have slight effect on the mechanical properties and microstructure.

PCTIG welding parameter with normal effect (condition 2, condition 5 and condition 6) showed increase in micro hardness up to 67HV with significant fine grain microstructure than the other condition discussed above. PCTIG welding parameters with maximum effect (condition 1 and condition 9) showed fine grain microstructure than other PCTIG welding condition. Micro hardness value was found near to 70HV this is due grain refinement in the weld zone and heat affected zone.

CONCLUSIONS

Correlation between micro hardness and microstructure was studied for pulsed current TIG welding on Al - 8% SiC composite. Coarse grain microstructure gives micro hardness value around 60HV and Fine grain microstructure gives micro hardness value around 70HV. Pulsed current TIG parameter such as peak current of 160A, base current of 60A, pulse on time - 50% and pulse frequency was 5Hz showed fine grain microstructure with micro hardness value of 75HV. Weld zone showed microstructure's grain size which is finer than the heat affected zone microstructure's grain size.

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