A Study on GTAW of LM 25 Al/SiCp Metal Matrix Composites

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Abstract

Aluminum based MMCs have greater strength; good wear resistance and excellent elevated temperature properties. Alimnium based MMCs are being widely used in Automotive and Aerospace industries. In spite of the advantages of MMCs as described above they are not widely used due to lack of their applicability to tertiary process like welding. However, the presence of reinforcement causes difficulties in welding of these materials. Hence the present study is aimed at optimization of welding parameters for weld strength and examination of difficulties/defects during welding of these materials.
Keywords: Metal Matrix Composites, GTAW

1.0 Introduction

A composite is a combination of two or more materials, which are having distinct in terms matrix and reinforcements. Matrix is solid phase that can be possessed to embed and adherently grip a reinforcing phase (Ex: AI, Mg, Si, Fe etc.). Polymers and metals have been very successful in this role. Inorganic materials such as glass, plaster, Portland cement, Carbon and silicon have also been used as matrix materials. The Reinforcement phase carry most of the load and furnish the dominant properties (Ex: Alz03, SiC, Tic etc.) The different constituent forms of reinforcing materials are fibers, particles, laminates, flakes and fillers. Composites have superior mechanical properties like higher tensile strength, higher fatigue strength and higher stiffness. In spite of these properties, the composites have they are not widely used because of their poor weldability. Gas Tungsten arc welding is one of the fusion states welding technique to successfully weld the Aluminium metal matrix composites. In this study LM25 Al/SiCp, MMC's were (GTAW) welded and various zones at the weld near and away from the weld were analyzed for their microstructures.

2.0 Experimental Procedures

Material for experimental study is Lm 25 (A 356) AI/SiCp (Composite Metal)

Chemical Composition of Base Metal (Wt. in %)

Si 6.5 - 7.5, Fe 0.2 MnSiCp 20%, Cu 0.2, Mn 0.1, Mg 0.2 - 0.45, Zn 0.1, Ti 0.2

UTS= 70 mpa

Plate dimensions used for welding are 200 x 125 x 15 mm.

Before welding plates cleaned thoroughly to remove oils, greases and paints. Oxide on the surface of plates in joint area is removed with scraper neatly. Joint design used for experimental study is single "V" groove butt joint. Edges were prepared by milling operation. Wire brushing made of Stainless steel was done to eliminate surface oxide that would interrupt the welding operation and affect the weld quality. Care should be taken to avoid any contamination even fingerprints in the edge of the plates. After preparation of "V" groove, the plates were rigidly fixed in fixture on Stainless Steel backing plate and tack welded on both ends to avoid the misalignment.

Bead on plate is performed to study the bead geometry and cleaning action for different parameters. Welding parameters are given in Table No.1. Clear weld pool formation as in the case of normal Aluminium and Aluminium alloys was not obtained. There was a less fluidity in the weld pool with formation of oxides and gases.

Single V-Butt joints were welded. Observing the difficulties in the weld pool formation, in the bead on plate tests, the edges of the test plates for butt joints were first given, a deposition of buttering layers using ER 4043 filler wire and AC GTAW process. The buttered edges were slightly machined to provide the chamfering for V-groove. Two joints were welded with buttering of the edges and one joint was welded directly without buttering. All the joints are welded by manual AC GT A W process using ER 4043 filler wire.

(Table Nos. 2a, 2b, 2c shows the welding data's)

Electrode used for welding is Zirconated tungsten electrode.

Electrode Dia. = 2 mm and 4 mm

Nozzle Dia. = 15 mm

Filler metal specification: - (Wt %)

Filler rod	: ER4043
Si	= 4.5 - 6.5
Fe	= 0.8
Cu	= 0.3
Mn	= 0.05
Mg	= 0.05
Zn	= 0.1
Ti	=0.2

3.0 Evaluation

After welding, the joints were examined visually. Except for surface pores, no serious defects were seen. The joints were also subjected to X-ray radiography and Hardness Testing. For the given materials, Vickers Hardness Test was carried out. Micro examination was also performed on the welded joints.

The tension test was carried out in the conventional universal testing machine model UTM 60. (Table No.3 shows the tensile test data).

4.0 Result and Discussion

Considerable difficulties were experienced in welding the test plates made on MMCs. In addition to the SiC particles, the plate materials had large number of pores and entrapped gases. Due to the presence of the SiC particles and gas packets and oxides in the base material, it was difficult to get 11 clear and fluid weld pool. It was seen in the bead on plate tests. Hence, buttering of the edges for butt joints was carried out, to get clear and more fluid weld pool. Welding was somewhat easier with buttering as compared to the joint made without buttering. However, with buttering also, considerable amount of gas formation and formations of oxide were experienced in the weld pool. The weld pool was not as fluid as in the case welding of normal Aluminium (no composite).

The X-Ray radiography examination showed presence of many pores in the weld. But other serious defects like crack or lack of fusion were not observed.

The tensile strength of the weld joint (transverse tensile test) was in the range of 51 - 73 Mpa. All the test samples ftactured in the base metal location and not in the weld. Hence, the weld joints were found stronger than these LM25 / Al SiCp composite base metal.

The hardness values were found slightly higher (53 VHN) in the welds of joints made with buttering edges. The hardness values in the base metal were in the range of 40 - 42 VHN. The joint made without buttering showed lower hardness values (38 - 39 VHN) both in the weld and in the base metal.

The weld metal microstructure in both joints made with or without buttering showed typical cast dendritic structure (Photo 1). The weld made without buttering showed presence of some scattered carbide particles. The HAZ(Photo 2) and base metal(Photo 3) Micro-structures showed the typical composite metal matrix structure with presence of carbide particle.

5.0 Conclusion

It is evident that LM 25/ Al SiCp (MMCs) can be joined by TIG welding technique. However, there are problems namely high viscosities of weld pools, segregation effect on solidification, particle matrix reactions, and the evolution of occluded gases. Addition of filler metal helps to weld these MMCs. The literature has indicated that both matrix-particle reactions and particle segregation can be reduced with careful choice of consumable. The filler metal to be fed immediately into the weld pool rather than arc melting, it will accommodate the pool formation and increase its fluidity. The joint strength is obtained with the addition of ER 4043(Al + 5 % Si) filler metal was more than that of the base metal.

6.0 Acknowledgement

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Table No. 1 Bead on Plate Results

TRIAL NO	SPEED mm/ min	CURRENT Amps	VOLTAGE V	CONTROLLED VOLTAGE V	FILLER WIRE DIA	GAS FLOW RATE Kg / mm^2	ELECTROD	REMARKS
1	100	173^{+5}	17	19	5183 2 mm dia	Argon 1	Zirconium 6 mm dia	Base Metal Not melted
2	100	165^{-1}	14.6	16.2	5183 2 mm dia	Argon 1	Zirconium 6 mm dia	Base Metal Not melted
3	100	175^{-3}	15.2 [15]	16.8 [5.4]	5183 2 mm dia	Argon 1	Zirconium 6 mm dia	Excess Filler
4	100	190^{-3}	14.6	15.4	5183 4 mm dia	Argon 1	Zirconium 6 mm dia	Base Metal Not melted
5	100	200	17.6[6.9]	19.5[9.1]	5183 4 mm dia	Argon 1	Zirconium 6 mm dia	Base Metal Not melted
6	100	200^{-5}	15.2[5.5]	16.6[17.4]	5183 4 mm dia	Argon 1	Zirconium 6 mm dia	Not Stable Arc
7	74	390	23.4	16.8	5183 4 mm dia	Argon 1	Zirconium 6 mm dia	Tungsten Melted
8	74	200^{+3} 210^{+3} 230^{+3}	20.1 21.5 21.2[12.2]	12.2 12.2 12.2[12.2]	5183 4 mm dia	Argon 1	Zirconium 6 mm dia	Not Getting Stable Arc

[ ] - With Filler

Table No. 2a Welding Data First Joint

Identification	: R1 (with buttering)	Tack Weld	:
Root Gap	: 2 mm	Current	: 140 A
Gas	: Argon	Voltage	: 20.1 V
Gas flow Rate	: 20 L/min	Electrode	: Zirconium 6 mm dia

	ROOT PASS	II PASS	III, IV, V, & VI	BACK
CURRENT (AC)	180-210	220,221	230	230
VOLTAGE	21.5-22.3	22.4,22.4	22.7	22.8
FILLER WIRE & DIA	4043 2 mm dia	4043 4 mm dia	4043 4 mm dia	4043 4 mm dia

Table No. 2b Welding Data Second Joint

Identification	: R2 (with buttering)	Tack Weld	:
Root Gap	: 2.5 mm	Current	: 160 A
Gas	: Argon	Voltage	: 20.8 V
Gas flow Rate	: 20 L/min	Electrode	: Zirconium 6 mm dia

	ROOT PASS	II TO VI PASS	BACK
CURRENT (AC)	190-200	227	248, 230
VOLTAGE	21.7 -21.8	23.8	21-22
FILLER WIRE & DIA	4043 (Initially) 2mm, 4 mm	4043 4 mm dia	4 mm, 2mm

Table No. 2c Welding Data Third Joint

Identification	: R3 (without buttering)	Tack Weld	:
Root Gap	: 4 mm	Current	: 160 A
Gas	: Argon	Voltage	: 20.6 V
Gas flow Rate	: 20 L/min	Electrode	: Zirconium 6 mm dia

IDENTIFICATION	SPECIMEN SIZE IN mm	UTS Mpa	% OF ELONGATION	% OF REDUCTION	POSITION OF FAILURE
R_1T_1	20.2 x 14.1	69	1	0	Base Metal
R_1T_2	19.5 x 14.1	73	1	0	Base Metal
R_2T_1	20.3 x 14.0	61	0	2	Base Metal
R_2T_2	20.0 x 14.0	51	3	0	Base Metal
R_3T_1	19.5 x 12.8	36	0	2	Base Metal
R_3T_2	19.9 x 12.5	70	0	1	Base Metal

Table No. 3 Tensile Test Result

IDENTIFICATION	SPECIMEN SIZE IN mm	UTS Mpa	% OF ELONGATION	% OF REDUCTION	POSITION OF FAILURE
R_1T_1	20.2 x 14.1	69	1	0	Base Metal
R_1T_2	19.5 x 14.1	73	1	0	Base Metal
R_2T_1	20.3 x 14.0	61	0	2	Base Metal
R_2T_2	20.0 x 14.0	51	3	0	Base Metal
R_3T_1	19.5 x 12.8	36	0	2	Base Metal
R_3T_2	19.9 x 12.5	70	0	1	Base Metal

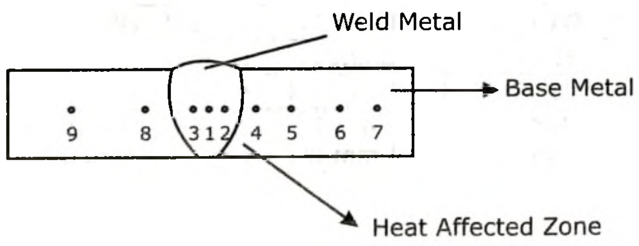

Table No. 4 Hardness Test Result

SL. NO	IDENTIFICATION : R_1H	IDENTIFICATION : R_3H
	HARDNESS VALUE HV 5	HARDNESS VALUE HV 5
1	53	38.6
2	52.6	38
3	53	38
4	42	43
5	41	45
6	42	38.6
7	42	52.6
8	40.2	39
9	42	38

MICROSTRUCTURES

Photo - 1

Weld Centre Sample without buttering magnification 320X

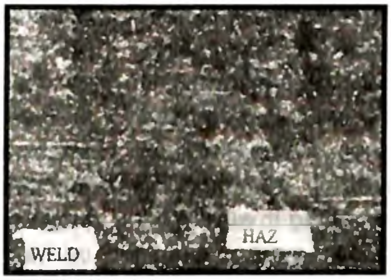

Photo - 2

Weld/Haz Interface Sample without buttering magnification 100X

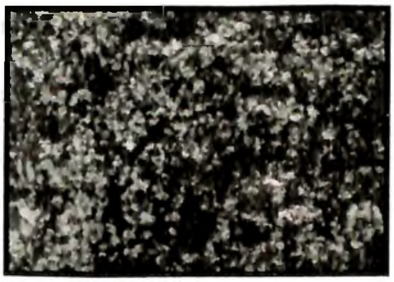

Photo - 3

Base metal magnification 100X