Experimental Investigation on Al-Sic Composite Materials using TIG Welding Process

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Abstract— **Welding is a fabrication process whereby two or more parts fused together by means of heat and pressure both forming a joint as the parts cool. Tungsten Inert Gas Welding (TIG) is one of the widely used techniques for joining ferrous and non-ferrous materials. TIG welding process consists of non-consumable tungsten electrode which is used to provide arc for welding. TIG welding process is chosen because of its superior technique and better economy. The input parameters are identified based on literature survey, expert's advice, welding manual and conducting preliminary experiments. Experiments were conducted based on Taguchi L9 Orthogonal Array design. Input parameters are chosen to achieve the better strength, quality of the weld bead and production rate to produce weld bead at the time of welding process. Welding trials will be performed on AL-SiC composite materials based on input parameters Viz., Welding current, voltage and Gas Flow Rate (GFR). While making joints where additionally weld metal is needed, a filler rod is fed into the weld puddle. Aluminum rod is used as filler material for all the trials. Al-SiC composites are currently used in aircraft, aeronautics and automotive parts such as chassis because of its strength and light weight structure.**

Keywords— TIG Welding, AL-SiC composite materials, Hardness, SEM, Destructive Testing

I. INTRODUCTION

There is a constant need for improvements in material properties across a wide range of applications, such as transportation, aerospace, military engineering, etc. A specific requirement is the development of light weight high strength materials with improved mechanical properties. This can be achieved by developing a new class of materials so as to meet the challenging issues post within engineering applications. Composites are one class of materials that can impart desired customized mechanical properties.

Aluminum metal matrix composites of the varying percentage of SiC reinforcement were welded using the tungsten inert gas welding technique. For all the conditions of the specimen, the welding parameters were kept identical. The welded composites were thermally aged to peak age-hardening conditions. Significant differences in microstructure exist between aged and non-age hardened composites in terms of miss orientation, grain boundary fractions and stored energy. These differences in microstructure were seen through identical changes in the mechanical behavior of the welded composites. After aging, microstructure showed refinement in grain size and preferential orientation. Hardness and tensile strength increased at different rates with increase in SiC content indicating that hardness was a clear function of stored energy and strength had a dependence on the miss orientation. EBSD (Electron Back scanner Diffraction) measured suggests that due to age hardening, a rearrangement in dislocation substructures occurred with precipitation of Mg2Si or increasing SiC content followed by dynamic recovery of the weld metal region which leads to enhancement of hardness. The increase in tensile strength with decreased miss orientation was a clear indication that the effect of annihilation of dislocations as a result of recovery was less pronounced and precipitation strengthening was dominant

II. WORK MATERIAL SELECTION

In this study, the matrix material is aluminium alloy 6061. As reinforcements, silicon carbide is used. The properties of the matrix material and the reinforcements are listed in Table 1. For the fabrication of Aluminium Metal Matrix Composite, commercially pure Aluminum 6061 alloy is used as the matrix and 0, 6, 8, and 10 wt% 0f Silicon Carbide was used as reinforcement.

III. EXPERIMENTAL PROCEDURE

The work material chosen for the experiment are Aluminium alloy 6061 and SiC as reinforcement. The samples are having the dimension of length 75mm, breadth 50mm and thickness 10mm.The input parameters are identified based on literature survey, expert's advice, welding manual and by conducting preliminary experiments. Experiments were conducted based on Taguchi L9 Orthogonal Array design. Input parameters are chosen to achieve the better strength, quality of the weld bead and production rate to produce weld bead at the time of welding process. Welding trials will be performed on AL-SiC composite materials based on input parameters Viz., Welding current, voltage and Gas Flow Rate (GFR). While making joints where additionally weld metal is needed, a filler rod is fed into the weld puddle.

Table 1: Composition of the work

Samples	6061Al (%)	SiC (%)
1	100	0
2	94	6
3	92	8
4	90	1

For present work, 600 edge preparations are made and tack welding will be carried out after edge preparation the welding trials. Single pass butt welding joint are made using welding process. NDT will be carried out to know the leakages and defects in the welded joints. Destructive testing will be carried out from Universal Testing Machine (UTM) to know weld bead joint strength. As response parameters Yield strength (YS), Ultimate Tensile Strength (UTS), Percentage of elongation will be recorded for each composition of material. Comparison will be made based on the results among different composition of materials. Conclusion will be made for optimized and non optimized values.

IV. WELDING PROCESS

Welding process, consist of non-consumable tungsten electrode which is used to provide the arc for welding. A separate filler metal with an inert shielding gas is used. Gas tungsten arc welding process welding set utilized suitable power source, a cylinder of argon gas, welding torch having connection of cable for current supply, tube for shielding gas supply and tube water for cooling torch. In all welding, the best weld is one that has the properties closet to those of base metal; therefore, the molten puddle must be protected from the atmosphere. The atmosphere oxygen and nitrogen combine readily with molten metal which yields weak welds beads. The major inert gases that are used are argon and helium. Electrode is used only to create the arc in Tungsten inert gas welding and it is not consumed in the weld. For joining similar metal, where additional weld metal is needed, a filler metal or rod is fed into the puddle.

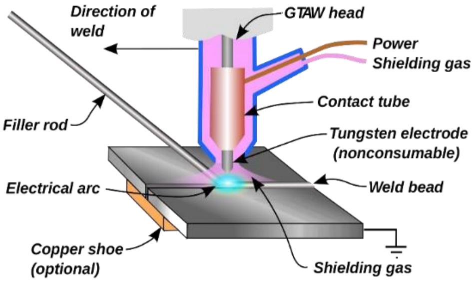

Fig 1: TIG welding process

V. RESULT AND DISCUSSION

`A. Hardness Testing

The results of the various hardness tests are displayed in Table 2

Table 2: Hardness Values

Particulars	RHN	VHN	BHN
Sample 1	79	39.28	74.85
Sample 2	81	47.25	76.94
Sample 3	84	49.25	80.75
Sample 4	87	56.82	86.35

Sample 4 has a harder surface than the other samples because it contains a lot of silicon and after performing different tests, the following conclusions are drawn:

Due to the presence of a high quantity of carbides as reinforcement, sample 4 (90 % 6061Al and 10 % SIC has harder than the other samples.

B. Microstructure Examination

Using a Scanning Electron Microscope, morphological examination was done on the specimens to identify internal surface flaws such blow holes, cracks, and the accumulation of reinforcement. In SEM, an image is created from the bombardment of electrons that reflect. The microstructure of a composite 6061 aluminium alloy made by stir casting with various weights fractions of silicon carbide is examined using scanning electron microscopy.

In table 3 and 4 welding input parameters and the response parameters were recorded for different compositions of the work materials.

Table 3: Welding input parameters

Sl No	Composition	Current(A)	Voltage(V)	GFR (litrs/min)
1	0-0	164	164	40
2	0-6	160	160	35
3	0-8	156	156	30
4	0-10	140	140	25
5	6-6	140	140	25
6	6-8	170	170	20
7	6-10	180	180	15
8	8-8	170	170	20
9	8-10	150	150	30
10	10-10	160	160	35

Table 4: Response parameters

Sl no	Composition	UTS Mpa	YS Mpa	Elongation
1	0-0	178	35	7
2	6-6	230	65	6
3	8-8	270	105	4
4	10-10	345	137	2

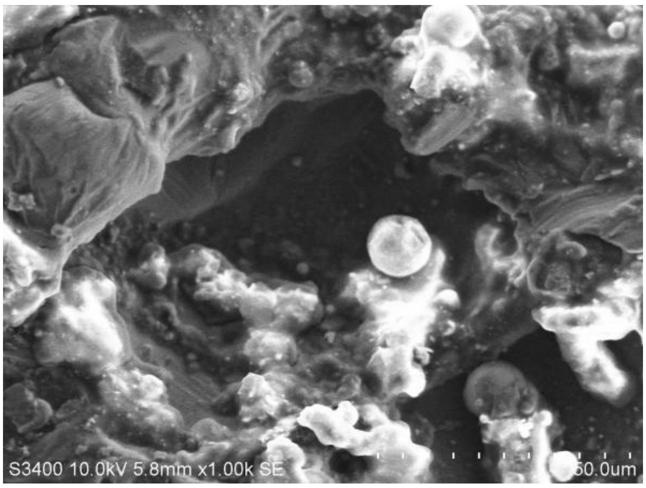

Fig 2: Sample 1

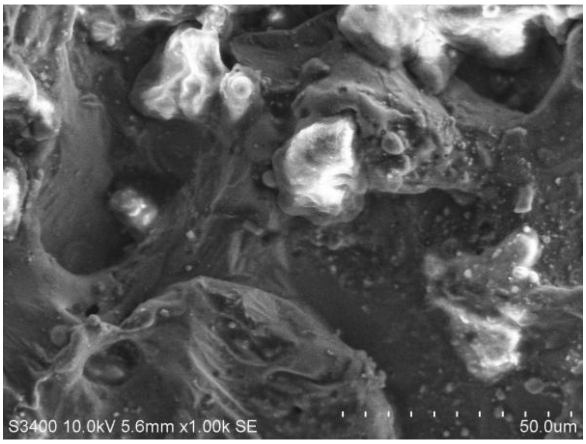

Fig 3: Sample 2

Fig 4: Sample 3

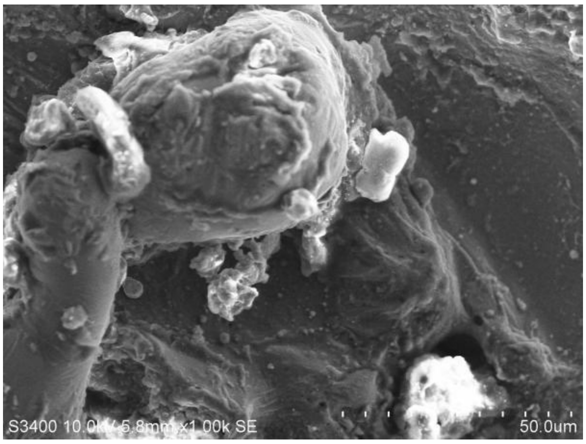

Fig 5: Sample 4

Using a SEM, the microstructure of MMCs as depicted in Figures 2, 3, 4, and 5 was investigated. It is seen from the SEM images that the SiC contains particles of various sizes and shapes. The results of the SEM pictures reveal that the SiC particles are distributed quite uniformly, and that the matrix occasionally has cracks, blowholes, porosity, and other casting flaws. While the ceramic phase is represented by a dark phase, the metal phase is represented by a white phase.

VI. CONCLUSION

In this paper, welding on Al-SiC was successfully carried out and their properties Viz., hardness, microstructure and tensile strength values are tabulated. The following were the conclusions obtained. The hardness and tensile strength increased at the different rates with an increase in SiC content. The sample welded at 160A was found to have the maximum tensile strength. This is due to the minimum amount of internal stresses developed. The fine, equiaxed grain are uniformly distributed, in the welding region is the reason for better tensile properties. The hardness was found to be highest for the sample welded at 160A. In all the samples hardness variations were observed between the parent metal, Heat Affected Zone and Weld Zone. The sample welded with 160A had more fine grains and is better suited for the higher tensile properties.

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