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Influence of SiC particles on microstructural characteristics of TIG weld joints of Al 6061-20%SiCp

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Abstract

Al 6061-20% SiCp metal matrix composites are new candidates for a variety of applications in automobile, aerospace and defense industries in view of their excellent mechanical properties particularly wear resistance. The present study is focussed on the influence of TIG welding parameters on micro-structural characteristics Al 6061- 20% SiCp weldments. TIG welding trials with currents ranging from 90 – 150 A at a constant voltage of 19V were carried out and the microstructures of the weld joints were thoroughly examined using light optical microscope. Broadly, the study indicated that low currents lead to defective welds and improper filling of the joint. The role of the SiCp is to generate more porosities. On the other hand, at currents beyond 140A, excessive heat input results in large amount of metal being melted which can lead to cracking in the weld zone. Again the role of SiCp is to enhance the cracking tendency. The trials with 120A current and 19V, showed consistent improvement and better weld quality as it is evident from the micro and macro examination. From the mechanical tests it was found that with embedment of 20% SiCp, yield strength and hardness have increased significantly compared to the base metal. The increase in tensile strength is as a result of the presence of SiC particles in the composite which contributed for effective dislocation barriers.

Key words: Al 6061-SiC Composite, Tungsten Inert gas Welding and Microstructure.

1 Introduction:

Aluminum is non-ferromagnetic, a property of importance in the electrical, electronics & aero-space industries. It is non–pyrophoric, which is important in application involving handling or exposure of inflammable or explosive materials. Aluminum is non-toxic and is routinely used in containers [1] for food and beverages. Metal Matrix Composite (MMCs) have been used commercially in the automotive market for nearly 20 years. Properties of interest to automotive engineer include increased specific stiffness, wear resistance and improved high-cycle fatigue resistance [2]. Parts as simple as a pipe with a welded seam to as complex as a structure like hull of a sea-going vessel are within the capabilities of the process. However, complex and large assemblies are more typical because the advantages of arc welding are enhanced as the finished product becomes more complex and unwieldy [3].

Arc welding is one of several fusion processes for joining metal. By the generation of intense heat, the juncture of two metal pieces is melted and mixed directly or, more often, with an intermediate molten filler metal [4]. Filler metal composition is generally different from that of the weld metal, which is composed of the solidified mix of both filler and base metals. Shielding and Fluxing high-temperature molten metal in the weld pool will react with oxygen and nitrogen in ambient air [5]. Luo et al [3] have reported that among all liquid state processes, stir cast technology is considered to be the most cost effective method. Z M Xu [4] has studied in detail the production techniques and the properties of SiCp reinforced aluminum alloy composites. Lloyd [5] explains the basic aspects of the preparation of MMC based on Al alloys. A. Urena et al [6] have indicated that Al 6082-T6 welded with TIG, the yield strength of 145 MPa and tensile strength 219 MPa for the weld joints. Further, SiC particles, in all the specimens tested, failure was located in the weld metal.

Hashim and Dawes et al [7] have described the reasons for lowering of tensile properties of the weld joints. Davis [8] has opined that cracking is a major concern in the welding of aluminum alloys. Preston [9] has studied the welding characteristics of aluminum alloy welded with TIG and Pulsed MIG. Rajesh Manti [10] studied the effects of pulsed TIG welding process parameters (pulse duration, peak current, and pulse frequency) on the microstructure and micro-hardness of Al-0.8%Mg-0.5%Si (6061) alloys. Chen D [11] has studied the microstructures, tensile properties and fatigue properties of a 2195-T8 Al-

Li alloy subjected to a weld heat-affected zone (HAZ) simulation and gas-tungsten-arc (GTA) welding using a 4043 filler metal, with and without a post-weld heat treatment. John A Wert [12] has explained the effect of welding speed on micro-hardness. The micro-hardness of the joints, can reflect the mechanical behavior of the joints. In the present work, TIG welding have been successfully carried out with Al 6061+20%SiC plates of 6 mm thickness using 4043 filler wire of 2.4 mm diameter. The micro-structure of the base metal is indicated in Figure 1 wherein the SiCp are dispersed uniformly. Optimum welding parameters like current, voltage and welding speed have been identified.

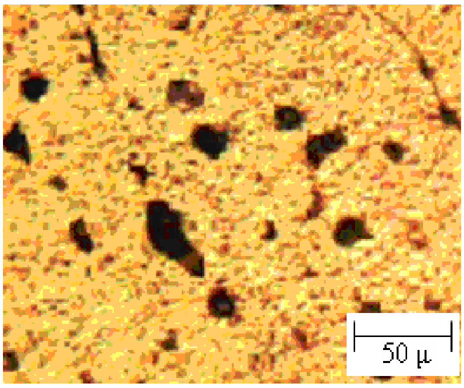

Figure 1 : Micro-structure of Al 6061-SiCp

2. Experimental work

Al 6061 alloy plates of 120 x 8 x 8 mm were butt welded with suitable V groove preparation (Figure 2). Fusion welding has been carried out at various current rating ranging from 90A to 140 A, at a constant voltage of 19 V, and also maintaining a argon flow rate of 10-12 lit / min. Arc distance of 5mm has been kept for all the trials. Filler wire of type 4043 with a 2.4 mm diameter was used for all the trials.

Figure 2 : Plates with edge preparation

Macro section of Al 6061 SiCp the weld and heat affected zone is shown in Figure 3. The weld was found to be free from defects for the optimum current of 120A. Base metal and HAZ of Al 6061 composite weld joint is indicated in Figure 4.

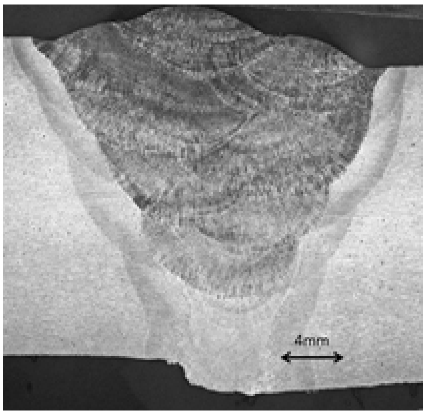

Figure 3 : Macro-section of the weld joint

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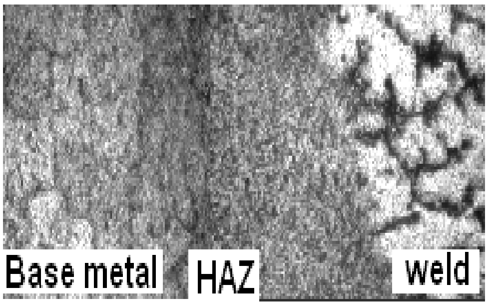

Figure 3 : Micro-structure of the composite Joint showing HAZ & weld

However, welding at high currents resulted in crack development as shown in Figure 4.

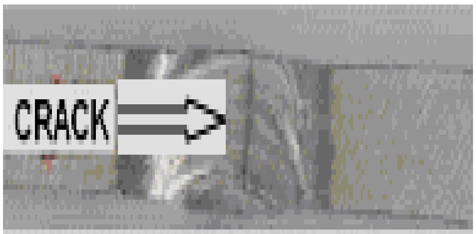

Figure 4 : Micro-structure of the composite Joint showing HAZ & weld

3.0 Results and Discussions:

Table 1 indicates the heat inputs used during the trials and the mechanical properties of the joint. Table 2 failure location of the joint. It is evident that at the optimum parameter, the weld is sound.

Table 1 compares the mechanical properties of TIG weldment with various heat inputs. The results show that the Al 6061+20SiC welds, at heat input of 0.51KJ/m has higher tensile strength (157kJ/m) and yield strength (108kJ/m). Weld consists of fine grains [20-30 microns] with uniformly distributed SiC. Base metal shows a fairly coarse grained structure with a grain size of [150-200 microns].

The SiC particles have in fact contributed to higher strength of the weld joint as compared to base metal. This could be due to grain refining effect due to heat of welding. Figure 6 shows the microstructure of Al 606-20%SiCp and the distribution of SiCp in base metal, HAZ and a crack when welded with high heat input.

Table 1 (Mechanical properties)		
Al 6061 alloy		
Heat Input (kJ/mm)	**Yield strength (MPa)**	**Tensile strength (MPa)**
0.34	70	85
0.46	70	86
0.51	81	108
Al 6061 + 20%SiC		
0.34	101	129
0.46	108	140
0.51	116	157

Table 2 (Failure location)		
Al 6061 alloy		
Heat Input (kJ/mm)	**Failure location**	**Distance from centre**
0.34	Weld zone	6.9 mm

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0.46	Weld zone	7.2 mm
0.51	Weld zone	7.0mm
Al 6061 + 20%SiC		
0.34	Fusion line	9.4 mm
0.46	Fusion line	9.2 mm
0.51	Fusion line	8.6 mm

It is also observed that the hard particles of SiC can be deleterious when heat inputs are high.

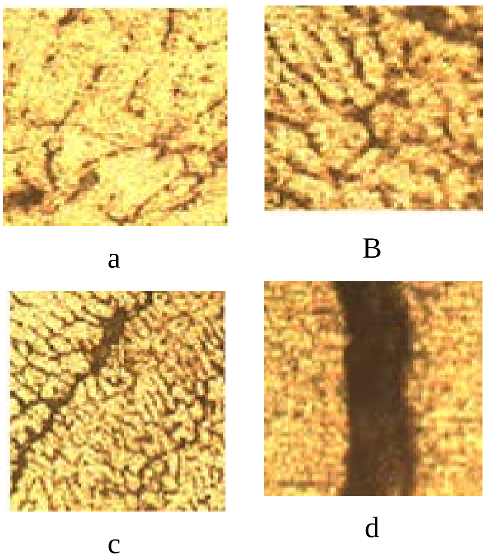

Figure 6 : Micro-structure of the weldment
a) Base metal b) HAZ
c) Weld d) crack at higher heat input

There is significant refinement of the grain structure of the weld. This could be due to the presence of SiCp.

4 Conclusion :

Optimum welding parameters like current, voltage and welding speed have been identified. Following are the major conclusions of the study :

- Heat input ranges from 0.34 KJ /m to 0.51 KJ/m have shown excellent welding characteristics of Al 6061 + 20% SiCp.
- Higher heat input above 0.51 KJ/m have shown proneness to cracking.
- SiCp have clearly indicated the uniform distribution of SiCp which reveals excellent wettability of SiC particles with the matrix.

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