EFFECTS OF FILLER WIRE AND CURRENT ON THE JOINING CHARACTERISTICS OF Al – Li – Cu ALLOY USING TIG WELDING

A. Chennakesava Reddy
Professor & Head
Department of Mechanical Engineering, JNTU College of Engineering
Kukatpally, Hyderabad –500 072
e-mail: dr_acreddy@yahoo.com

Abstract: Weld beads of 3 mm thick Al-Li-Cu alloy sheets were prepared from filler wires of parent metal, Al-Mg and Al-Si alloys using TIG welding process. The welding was carried with different currents while voltage, gas flow rate and weld speed keeping constant. The weld beads were given post weld heat treatment. The welding efficiency of 91% was reported with filler wires made of parent metal and Al-Mg alloy and 60 Amperes of welding current.

Keywords: Al-Li-Cu alloy, TIG welding, welding current, filler wire

1. INTRODUCTION

Aluminum-lithium-copper (Al-1.8Li-1.8Cu-1.0Mg-0.1Zr) alloy is a high strength lightweight alloy. It has 8.5% lower density, 10% higher stiffness and approximately equivalent mechanical properties to L73 (Al-4.3Cu-0.6Mg-0.8Mn-0.7Si) alloy. Al-Li-Cu alloy is expected to replace L73 alloy on combat aircraft [1]. Lot of research was carried out on Al-Li-Cu alloy to study the various aspects viz: fabrication [2], corrosion and structure-property correlation [3]. It is necessary to study this alloy with respect to welding process for its optimum utilization.

This investigation was carried out to study the welding characteristics of Al-Li-Cu alloy using Tungsten Inert Gas (TIG) welding process. The chemical composition of work pieces is given in Table 1. The objectives of the work are:

- To study the effects of filler materials and welding current.
- To study of penetration of weld beads.
- To study the tensile properties and the microstructural characteristics of weld beads.

Table-1: Chemical Composition of Work pieces

% Weight	Li	Cu	Mg	Zr	Mn	Al
	1.8	1.8	1.0	0.1	0.001	Balance

2. EXPERIMENTAL PROCEDURE

The TIG welding was carried out on 5 mm Al-Li-Cu alloy plates, which were produced by rolling process. The chemical compositions of filler wires are given in Table 2. Systematic pre-welding surface preparation was carried out by degreasing, picking in 5% NaOH solvent followed by dipping in HNO_3 and rinsing in distilled water to avoid weld pore formation during TIG welding process.

Table-2: The Chemical Composition of Filler Wires

Filler Wire	Li	Cu	Mg	Zr	Si	Mn
Wire-1	1.8	1.8	1.0	0.15	-	-
Wire-2	1.0	2.0	1.5	0.10	-	-
Wire-3	-	4.3	0.6	-	0.7	0.8

Butt welds were made transverse to rolling direction with a gap of 1.0 mm. The welding characteristics were studied by varying the current, the composition of filler wire (1 mm diameter), while the voltage (18V), Argon gas flow rate (10 Ltrs/hr) and welding speed (200 mm/min) were kept constant.

Flat tensile test specimens with gauge length of 25 mm and gauge width of 12 mm were prepared (Fig.1). The specimens were tested using universal testing machine at a strain rate of 0.001 /s at room temperature. The weld beads were evaluated for joint efficiency after subjecting them to post weld heat treatment (PWHT) (i.e. solution treatment at 525^0C and quenching in water and subsequently aging at 175^0C for 24 hrs). Small specimens for optical metallography were prepared using conventional mechanical polishing machine and etched using 2%HF solution and were revealed for microstructures using optical metallurgical microscope.

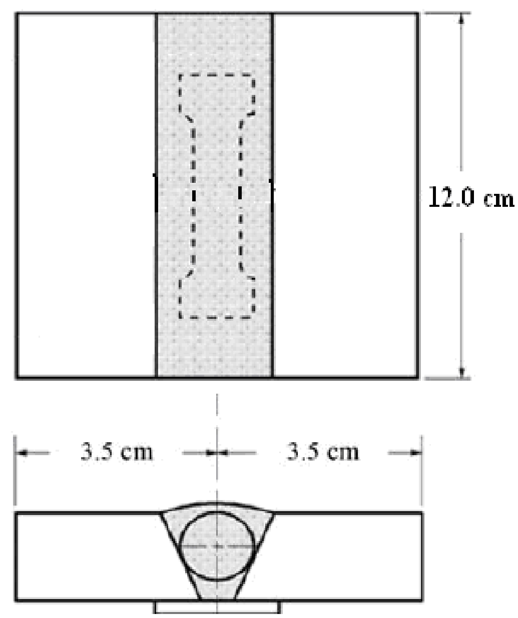

Fig.1: Preparation tensile specimens

3. RESULTS AND DISCUSSION

Each experiment was repeated twice and each characteristic value is an average of two readings. Results are of experimental, optical and, microstructural observations.

3.1 Effect of Filler Material and Welding Current on the Mechanical Properties

The variation of tensile properties with the composition of filler wire and welding current are shown in Fig.2 and 3. It is observed that the ultimate strength and ductility decrease with increasing welding current. This is owing to high heat input resulted from high currents, which subsequently promote rapid solidification of weld pool. Rapid solidification promotes fine grain structure which is responsible to the reduction of ductility. The tensile properties are maximum at welding current 60 amps. The chemical composition (which is near to that of plates) of wire-1 gives better tensile properties.

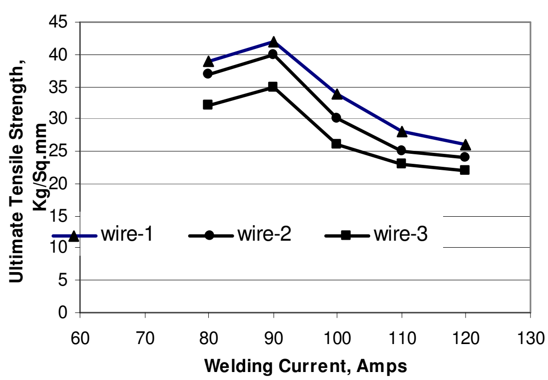

Fig.2: Effect of composition of filler wire and weld current on ultimate tensile strength

The low tensile properties in case of welds made of filler wire-2 and filler wire-3 might be due to the constitutional pollution of weld pools. The constitutional pollution is just because of the variation of filler wire composition with that of parent metal.

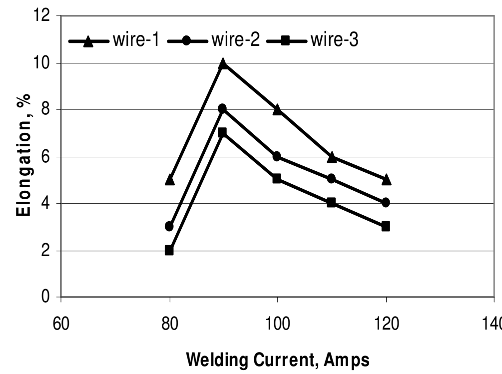

Fig.3: Variation of ductility with composition of filler wire and welding current

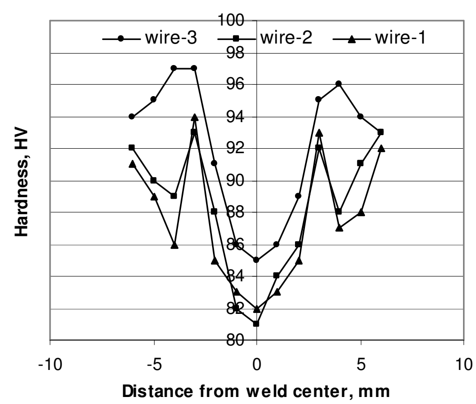

Fig.4: Effect of composition of filler wire on hardness

The variation of hardness from the center of weld is shown in Fig.4. The aluminum alloy sheets which are cold rolled tend to have stronger mechanical properties of the produced due to increasing in the dislocation density. As the grains undergo re-crystallization and coarsening in the weld area, the strain induced dislocations will destroy resulting in decrease in the hardness of the weld. The softened regions noted throughout the weld can also be attributed to coarsening and dissolution of strengthening precipitates during the thermal cycle of the welding. The heat affectes zone (HAZ) is nearly at 3 mm from the center of weld.

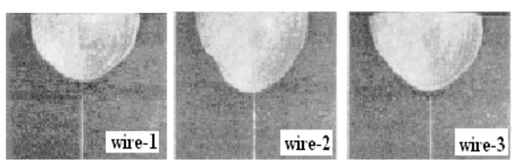

Fig.5: Weld bead profiles

Weld bead profiles are shown in Fig.5. There is no clear variation in the weld bead profiles obtained with different wires. For welds produced at a fixed arc energy using argon shielding gas, a significant increase in the depth of weld penetration was observed without reduction in the weld bead width at the top face. The depth of penetration in case of wire-2 and wire-3 is nearly same, whereas it is shallow U profile for wire-1 (Fig.6).

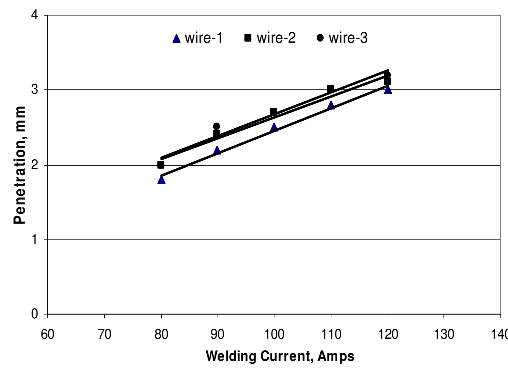

Fig.6: Effect of welding current on the depth of penetration

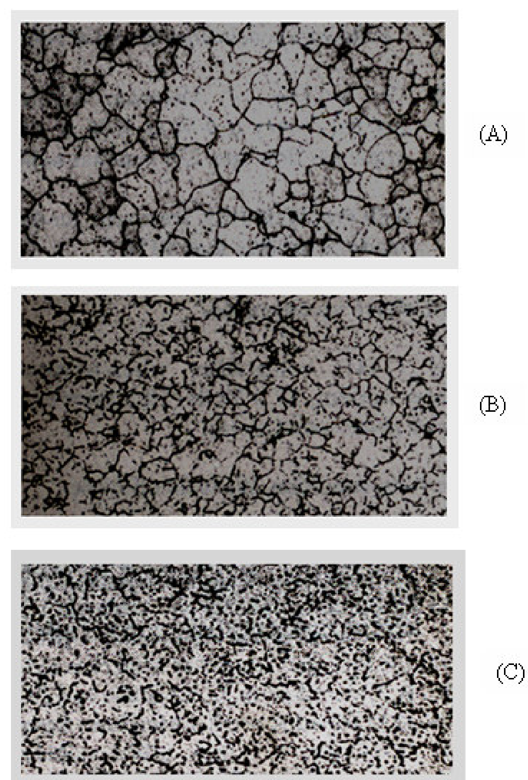

Fig.7: Microstrucutres of weld beads welded with different filler wires (10µM)

3.2 Microstructural Characteristics of Weld Beads

The microstructural characteristics of the weld beads are shown in Fig.7. The fusion zone of the weld bead prepared from the parent metal as filler wire as illustrated from the Fig.7(A) revealed the equiaxed grain structure. The microstructure of the fusion zone of the weld obtained by the filler wire-2 as shown in Fig.7(B) revealed the coarse cellular dendritic structure. Even though the filler wire-3 results fine grain structure as revealed from Fig.7(C), the tensile properties are contradictory. The reason could be the strengthening mechanisms induced on account of age hardening in the weld beads obtained by filler wire-1 and –2.

4. CONCLUSION

The ultimate strength and ductility decrease with increasing welding current. The welding current of 90 Amps gave maximum tensile properties of weld joints. The HAZ is neatly at 3 mm from the center of weld joint. The strengthening mechanisms induced on account of age hardening in the weld beads obtained by filler wire-1 and –2 increase the tensile properties.

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