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Characterisation of Aluminium and Copper Weld Joints during Friction Stir Welding

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Abstract: The present study evaluates the mechanical properties of weld Joint of alloys of aluminium and copper joined by Friction Stir Welding (FSW)". In this study, different alloys of aluminium by varying amounts of copper by stir casting process were prepared. The prepare alloys were welded by Friction Stir Welding under fixed parameters. Mechanical properties of alloys of welded joints are determined. The mechanical properties and microstructures of different alloys of welded joints are analysed. The study revealed that the alloy which has four percent of copper exhibited good results in all respects.

Keywords: Friction Stir arc welding.

1. INTRODUCTION AND LITERATURE REVIEW

Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) that uses a third body tool to join two facing surfaces. Heat is generated between the tool and material which leads to a very soft region near the FSW tool. It then mechanically intermixes the two pieces of metal at the place of the joint, then the softened metal (due to the elevated temperature) can be joined using mechanical pressure (which is applied by the tool), much like joining clay, or dough. It is primarily used on aluminium, and most often on extruded aluminium (non-heat treatable alloys), and on structures which need superior weld strength without a post weld heat treatment [1]. The working principle of Friction-stir welding (FSW) is as shown Fig.1.

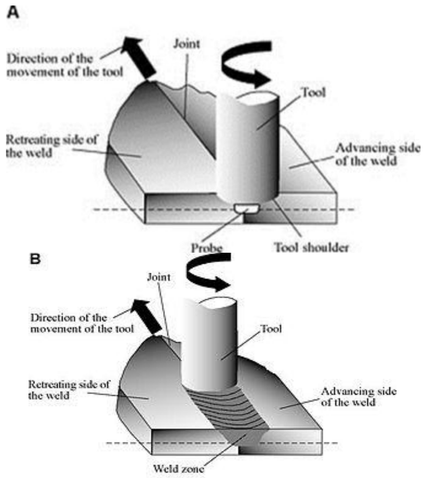

Fig.1. Working Principle of FSW [1].

The investigators have revealed different theories in the field of Friction Stir Welding. The Welding Institute (TWI) for the first time used FSW for butt-welding of ferrous and non–ferrous metals and plastics. Liu et al observed while welding copper to AA5A06 (Commercial aluminium) (AA is Russian designation) that the distribution between the Copper (Cu) and Aluminium (Al) has an evident boundary and the material in the stir zone shows obvious plastic combination of both materials [2]. Ericsson and Sandstrom investigated that the fatigue strength of friction stir (FS) welds is influenced by the welding speed, and also compare the fatigue results with results for conventional arc-welding methods: MIG-pulse and TIG [3]. Huseyin Uzun et al. investigated that the joining of dissimilar Al 6013-T4 alloy and X5CrNi18-10 stainless steel was carried out using friction stir welding (FSR) technique [4]. Santella M.L. et al. performed experiments to produce surfaces of A319 and A356 castings, treated by friction stir [5]. Cavaliere p. et.al. analyze the effect of process parameters on mechanical and macrostructural properties of AA6056 joints produced by friction stir welding [6]. Elangovan k. and Balasubramanian V., studied the influences of rotational speed and pin profile of the tool on friction stir processed zone formation in AA2219 aluminium alloy [7].

Cavaliere P. and Panella F. demonstrated the Friction stir welding for enhancement of fatigue resistance of aluminium and magnesium alloys, with respect to traditional fusion techniques [8]. Jayaraman M. et al. optimized the process parameters of FSW on tensile strength of cast aluminium alloy 319 by using Taguchi method [9]. Patil H. S and Soman S. N. investigated the effects of different welding speeds tool pin profiles on the weld quality of AA6082-O aluminium [10]. S. Rajakumar et al. observed that AA6061 aluminium alloy has gathered wide acceptance in the fabrication of light weight structures requiring high strength-to-weight ratio and good corrosion resistance [11]. Elangovan et al. The researchers in this paper focuses on the development of an effective methodology to determine the optimum welding

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conditions that maximize the strength of joints produced by ultrasonic welding using response surface methodology (RSM) coupled with genetic algorithm (GA) [12]. Guo Studied that the Dissimilar AA6061 and AA7075 alloy have been friction stir welded with a variety of different process parameters [13]. Ni (2014) observed that the Thin sheets of aluminium alloy 6061-T6 and one type of Advanced high strength steel, transformation induced plasticity (TRIP) steel have been successfully butt joined using friction stir welding (FSW) technique [14]. V. Buchibabu et al examine the impact of plate thickness, alloy strength and processing conditions on the susceptibility of tool failure in friction stir welding of AA7075 and AA7039 [15]. M. M. Z. Ahmed at al. joined Aluminium alloys AA7075 and AA5083-H111 by friction stir welding at constant rotation rate of 300 rpm and different traverse speed of 50, 100, 150 and 200 mm/min in similar and dissimilar joints [16].

2. EXPERIMENTAL SETUP

Alloys of aluminium (2014 series) and copper were prepared by sand casting method by varying percentage of copper. Four different alloys are prepared, 2% of copper and rest aluminium (2014 series), 4% of copper and rest aluminium (2014 series), 6% of copper and rest aluminium (2014 series) and 8% of copper and rest aluminium (2014 series) are shown in the Fig.2.

Fig.2 Aluminium Alloys.

The above alloys were joined by friction stir welding on different welding parameters namely Rotating speed of tool -1486 rpm, Angle of tilt- 0 degree and Tool used- HSS tool octagonal cylindrical type. These parameters were fixed for the entire welding process. The friction welding setup is shown in the Fig. 3.

3. RESULTS AND DISCUSSION

The specimens were prepared from the weld joint to test tensile strength, impact strength, hardness and microstructures. The test results are shown in the below graphs are depicted from Figs.4-6.


Fig.3. Friction Stir Welding Setup

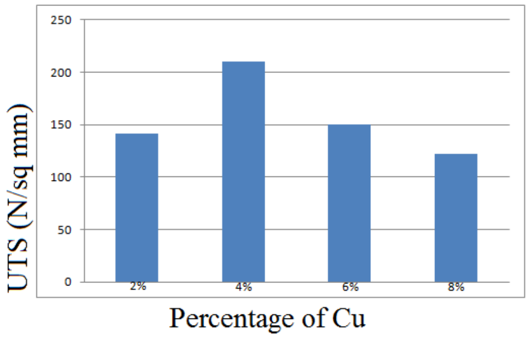

Fig.4. Comparison of Tensile Test Results

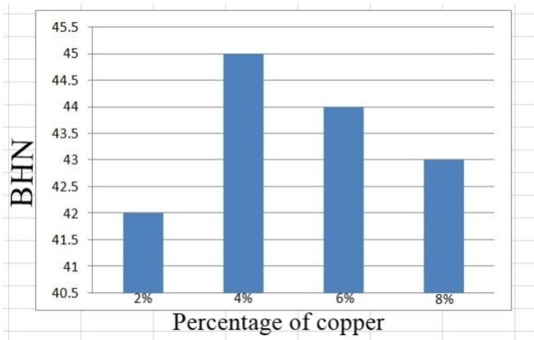

Fig.5. Comparison of Hardness Test Results.

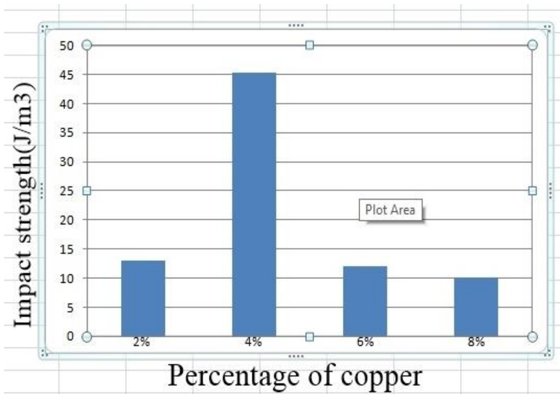

Fig.6. Comparison of Impact Test Results.

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In the microstructure tests as shown in the Figs. 7 & 8, the Cu atoms of welded specimen (2% Cu and rest is 2014 series Al) are precipitated near the weld line in the shape of some kind of slabs, which results in lower strength and high hardness, which were evenly distributed in unwelded specimen.

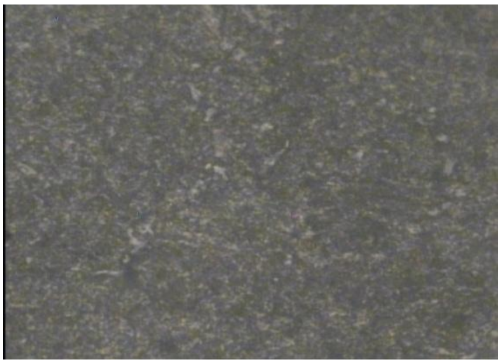

Fig.7. Microstructure of Unwelded Specimen (2% Cu and rest is 2014 Series Al).

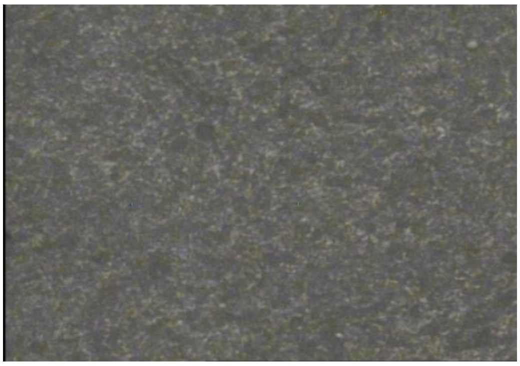

Fig.8. Microstructure of Welded Specimen (2% Cu and rest is 2014 series Al).

The microstructures as shown of all specimens are observed. The weld and base metal are distinctly visible. The Figs 9 & 10 are shown below of weld and base metal. In our observation, grains grow in all directions equally. In specimen with 4% Cu, the ratio of crystal bulk to inter-granular boundary is high. This indicates high ductility but correspondingly, lower strength.

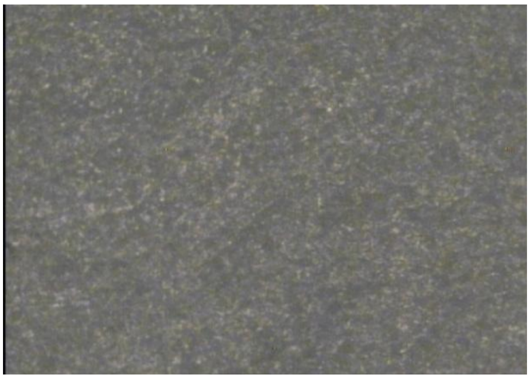

Fig.9. Microstructure of Unwelded Specimen (4% Cu and rest is 2014 series Al).

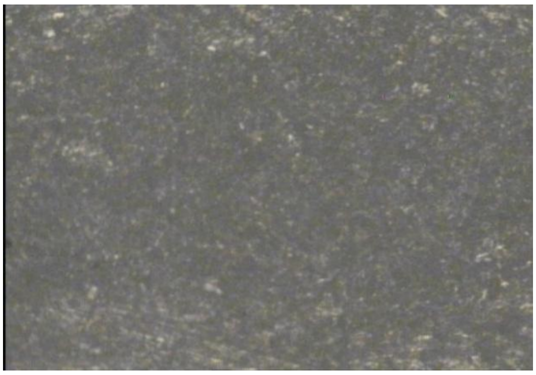

Fig.10. Microstructure of Welded Specimen(4% Cu and rest is 2014 series Al).

In the microstructure tests as shown in Figs. 11 & 12 the atoms of welded specimen (6% Cu and rest is 2014 series Al) a more uniform distribution of Cu atoms is observed which was uneven in unwelded specimen, But the impact strength is reduced as compared to unwelded specimen.

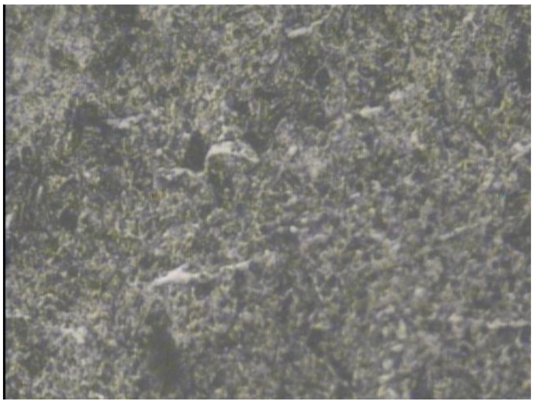

Fig.11. Microstructure of Unwelded Specimen (6% Cu and rest is 2014 Series Al).

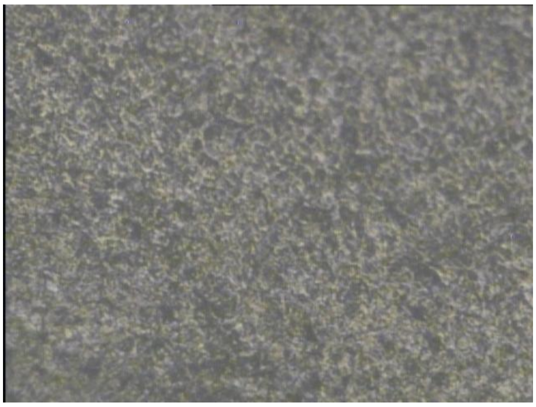

Fig.12. Microstructure of Welded Specimen (6% Cu and rest is 2014 Series Al).

In the microstructure tests as shown in Figs. 13 & 14, the Cu atoms of welded specimen (8% Cu and rest is 2014 series Al) are precipitated in the weld zone in the shape of some kind of slabs, which results in greater hardness and lower tensile strength & impact strength.

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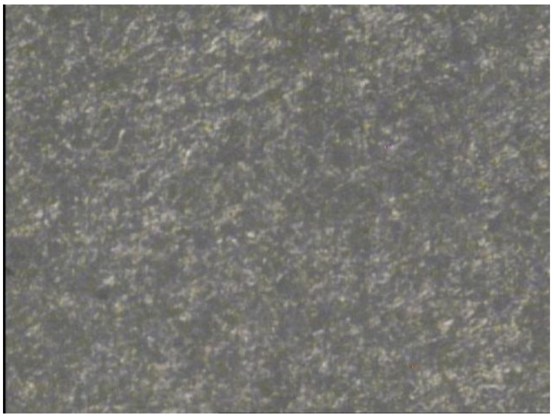

Fig.13.Microstructure of Unwelded Specimen (8% Cu and rest is 2014 Series Al).

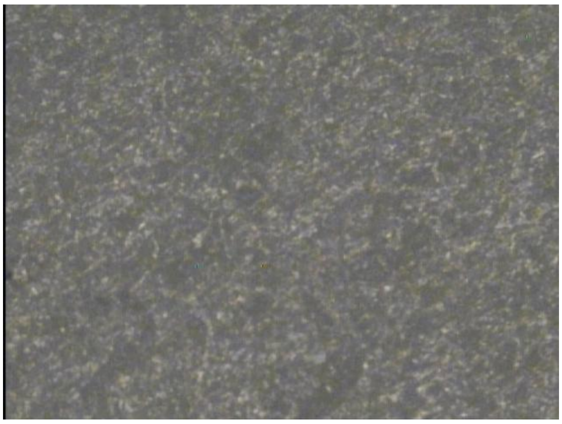

Fig.14. Microstructure of Welded Specimen (8% Cu and rest is 2014 Series Al).

4. CONCLUSIONS

The mechanical properties and microstructures of different alloys of welded joints are analysed. According to experimental results, it is concluded that best results are obtained of alloy with four percent of copper 2014 series aluminium alloy in all aspects. By analysing this, it is recommended that the four percent copper- aluminum alloy can be used in such type of industry where we require higher tensile strength, hardness and toughness and that composition can be used directly for any Industry where such type of mechanical properties are required.

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