ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Friction Stir Welding of Dissimilar materials between AA6101 Aluminium and pure Copper

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Abstract

There are many applications where dissimilar Aluminium and Copper weldments are used**.** In present work Friction Stir Welding of AA6101 Aluminium and pure Copper plates of 5mm thickness in butt joint configuration is done. Friction stir welding is done at 700 rpm and at 11mm/min tool traverse speed with cylindrical H13 material tool. For this vertical machining center is used. Joint shows onion ring structure in stir zone. Cavity like defect are seen at the surface of joint. Tensile testing of joint is done using computerized UTM.

Keywords: Friction Stir Welding, Aluminium, Copper, Tensile Strength

Introduction

Friction stir welding has several advantages over other welding methods. Friction stir welding (FSW) was invented at The Welding Institute (TWI) of the United Kingdom in 1991 which is a solid-state joining technique. In FSW mechanically intermixing the two pieces of metal is done due to rotational and translational motion of tool and forging pressure exerted by tool shoulder on metal pieces. Aluminium and Copper are two common metals in the electric power industry, and the Al–Cu transition pieces are widely used to transmit the electricity. The dissimilar combination of Aluminium and Copper is generally difficult for fusion welding. AA6101 Aluminium alloy grade is used for electrical bus bar conductor where it requires minimum loss of electrical conductivity and good mechanical properties.

Jiahu Ouyang et al. [5] studied temperature distribution and microstructural evaluation of the friction stir welding of 6061 aluminium alloy to copper. They found that there are several intermetallic compounds such as CuAl2, CuAl, Cu9Al4 together with small amounts of α-Al and the saturated solid solution of Al in Cu. The peak temperature measured in the weld zone is up to 580oC.They carried experiments in range of 151-1400 rpm and 57-330 mm/min for rotational and tool traverse spped respectively.Concluded that direct FSW of 6061 aluminum alloy to copper has proved difficult due to the brittle nature of the intermetallic compounds formed in the weld nugget, also they proved Copper and Aluminium have a high affinity to each other at temperatures higher than l20ºC and produce brittle, intermetallics on the interface.

M Satya Narayana Gupta et al. [6] studied dissimilar friction stir welded joint of pure aluminium and pure copper. They have done thermo-mechanical finite element analysis of friction stir welded Al/Cu bimetallic lap joints. They performed Friction stir welding at a rotational speed of 1500 rpm and weld speed of 30 mm/min.They found the maximum temperature is in the range of the 300 °C to 400 °C and which is below the melting point of the base metal. The maximum thermal stress is 10 MPa and which is far less than the yield strength of the base metals.

Esther T. Akinlabi et al. [7] developed butt welds of aluminium alloy and copper alloy by Friction Stir Welding by varying the feed rate and keeping all other parameters constant. The welds were conducted at speed of 600 rpm and the feed rates were 50, 150 and 300 mm/min. They investigated microstructure and fracture surfaces of the joint interfaces. The strongest weld was produced at the highest feed rate employed at 300 mm/min. Concluded that good joints can be achieved at a high feed rate.

There is no work reported on dissimilar Friction Stir Welding of AA6101 Aluminium alloy and pure Copper is done at lower tool traverse speed 11mm/min. In this study experiment is conducted at

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11mm/min tool travers speed and 700mm tool rotational speed.

Materials and methods

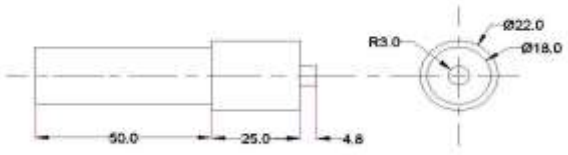
Experimental Details

1) Methodology

In this work frictional stir welded AA6101-T6 Aluminium and pure Copper specimens are compared for mechanical properties. In this study FSW specimens are prepared at 11mm/min feed rate and at 700 rpm spindle speed.

In this experiment plate size of aluminium and copper are same and having 100 mm length, 50 mm width and 5 mm thickness. H13 material is used to manufacture the tools. [9] Tool has pin diameter of 6 millimeter size. Tool dimensions: Shoulder Diameter- 18mm, Pin Diameter- 6mm

Figure:1



Straight Cylindrical Pin Tool

2) Experiment Design

Following are materials and parameters used for experiment
Material: AA6101-T6 Aluminum, Pure Copper
Sheet Thickness: 5mm
Tool: Cylindrical
Spindle Speed: 700 rpm
Welding Speed: 11mm/min

The FSW process was carried on vertical milling machining centre.
Machine Specification:
Make: HASS Technology (P) Ltd.
Spindle motor power : 30kW
Maximum Spindle speed : 12000 rpm
Maximum Cutting feed : 5000 mm/min
Table area : 500x300 mm
Travel (X, Y, Z) : 500x300x200 mm
Main electrical power supply : 40 Kva
Specimen of 100mm long and 50 mm wide were cut out of base metal by using a power hacksaw. The edges of the specimen were machined to obtain a perfect square butt joint configuration. The test pieces were clamped in machine bed by using specially designed fixture. At advancing side Cu and at retreating side AA6101 Aluminium worklpieces are clamped on milling machine table. Straight cylindrical pin tool is used. Tool was mounted in a vertical arbor with a suitable collate.
The joint is formed as shown in figure2

Figure:2

Photograph of Dissimilar joint Copper and Aluminium AA6101

Results and discussion

Testing of Specimen

1. Visual Inspection

From figure2 following are the observations:

a) Dissimilar joint of Copper and Aluminium AA6101 found satisfactory in visual inspection.
b) Cavity like defects are present at the surface of joint.

2. Tensile Test

Tensile test was performed in order to evaluate the static properties of the welded joints. These tests were executed at room temperature using an UTM.
Tensile testing specimen was made as per the drawing shown in figure3 Care was taken during this stage to align the centre of the weld with the centre of the tensile specimen. Tensile testing was carried out on an UTM.
UTM Specification- Tests carried on Computerized Universal Testing Machine.
UTM Specifications: Model No. TUE-C
Maximum Capacity (KN):- 400KN
Measuring Range (KN): 0-400

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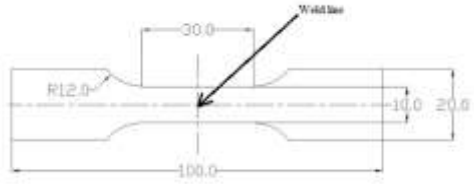
Figure:3

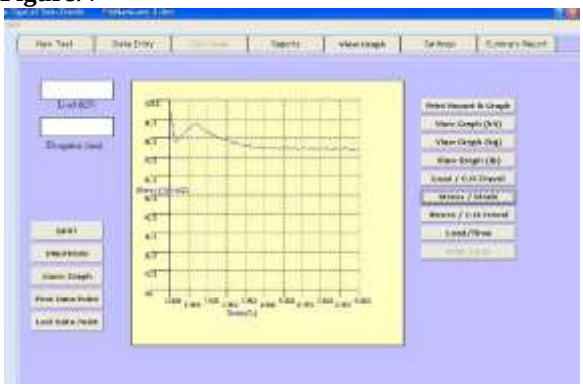


Tensile Test Specimen [8]

Tensile test results

Following graph shows result of tensile test of the joint.

Figure:4



Stress vs Strain graph of Dissimilar Joint

Table1: Comparison of Tensile Strength

Material	Tensile Strength N/mm^2
Dissimilar Joint	93.2
AA6101 –T6 Aluminum	284.4
Copper	220

Comparison of Tensile Strength of Disimilar joint and base Metal Copper and Aluminium alloy AA6101 is as shown in above table.

As seen from figure and table:

1. For dissimilar joint Copper and Aluminium AA6101 Tensile strength for FSW is less than that for both base metals.

Conclusion

1) Copper and Aluminum AA6101 dissimilar friction stir welded butt joint is formed and it is brittle in nature. This observation is similar to Jiahu Ouyang et al. [5]
2) For formation of strong butt joint it requires more downward force and higher welding speed, rotational speed combination.
3) Extensive experimentation is required to study effect of above parameters on properties of dissimilar Cu-Al friction stir welded specimen.

Acknowledgements

Authors of article express gratitude to Datta tools (P) Ltd. for their facility support in conducting experiments.

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ISSN: 2277-9655
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