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Research Article

MECHANICAL PROPERTIES & MICROSTRUCTURES OF DISSIMILAR MATERIALS BY FRICTION STIR WELDING

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ABSTRACT
The aim of present study was to analyze the influence of the microstructures and mechanical properties of friction stir welded joint of aluminium alloy and Pure Copper plates in 3mm thickness. With this aim, welds were produced using high molybdenum high speed steel, with a taper pin tool having diameter of 3mm pin and 14mm shoulder respectively. The objective of the friction stir welding process is to obtain a good welded joint with the desired strength and microstructure.

Keywords: *Friction Stir Welding, Aluminium Alloy, Pure Copper, Hardness, Tensile Testing*

INTRODUCTION
Friction stir welding (FSW) is a relatively new solid –state joining process (the metal is not melted). This joining technique is energy efficient environment friendly and versatile (Sidhu and Chatha, 2012). Aluminium is a rapidly growing material and has found many new applications as an engineering material.
Welding of dissimilar alloys is difficult due to variation in thermal and physical properties of parent metals. Friction stir welding is most suitable technique of joining dissimilar alloys among all techniques. Because fusion welding techniques are not suitable due to melting related defects such as porosity and formation of brittle intermetallics.
Diffusion welding is time consuming process while there is limitation on parent metal thickness in case of ultrasonic welding.

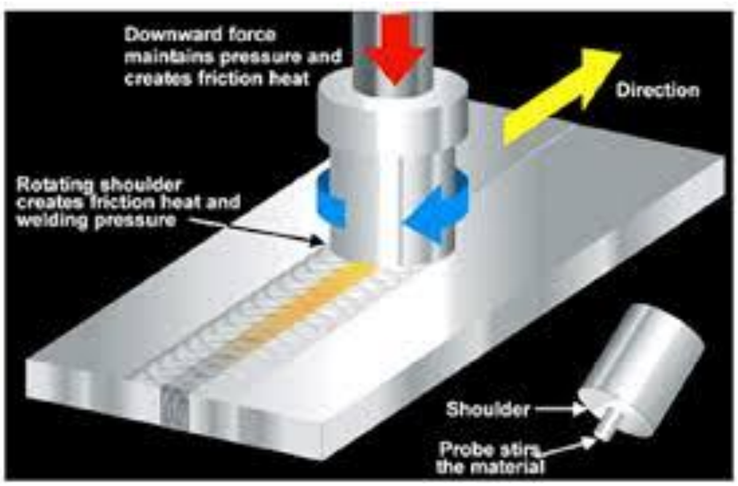

Figure 1: Schematic Diagram of the Friction Stir Welding Process (Sivashanmugam *et al.*, 2010)

In friction stir welding process a rotating pin emerging from a cylindrical shoulder is plunged between two edges of sheets to be joined and removed forward along the joint line.
The material is heated by friction between the rotating shoulder and the work piece surface and simultaneously stirred by the profiled pin leaving a solid phase bond between the two pieces to be joined. It was realised in the development of the FSW process that the tool design is critical in producing sound welds (Thomas *et al.*, 2001).

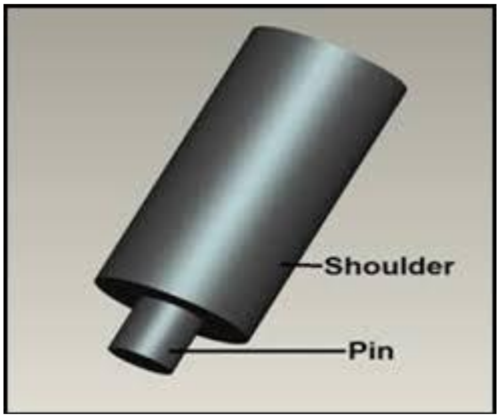

Figure 2: A Schematic View of FSW (Timothy, 2008)

During friction stir welding, Advancing and retreating side orientations require knowledge of the tool rotation and travel directions. The tool serves three primary functions.

1) Heating of the work piece
2) Movement of material to produce the joint and,
3) Containment of the hot metal beneath the tool shoulder.

Heat is generated within the work piece both by friction between the rotating tool pin and shoulder and by severe plastic deformation of the work piece. The localized heating softens material around the pin and combined with the tool rotation and translation, leads to movement of material from the front to the back of the pin, thus filling the hole in the tool wake as the tool moves forward.

The tool shoulder restricts metal flow to a level equivalent to the shoulder position, approximately to the initial work piece top surface. As a result of the tool action and influence on the work piece, a solid-state joint is produced.

Experimental Procedures and Studies

The plate size of Al6061 and pure copper are same and having 100mm length, 70mm width and 3mm thickness. The welding was carried out at constant rotation speed of 710 rpm, 900 rpm and 1120rpm with feed rates 16mm/min, 20mm/min and 25mm/min. In the present work HSS tool is used. The tool is having taper shoulder.

The tool shoulder diameter was kept 14mm with 2.7mm pin length and 3mm pin diameter. The tool pin taper. For micro structural evaluation samples prepared by RAGHAVENDRA SPECTRO METALLRGICAL LABORATORY, hyd and microstructure were measured on optical Metallurgical Microscope (MET SCOPE-1). The micrographs were taken at 200x magnification. The Vickers micro hardness was measured by using HARDWOOD HWMMT-X7 micro hardness tester.

RESULTS AND DISCUSSION

Welds Obtained

Welds were obtained according to the experimental design with using filler materials and without filler materials. All welds were defect free. The intermixing of metals was also found in the welded samples. During the FSW process, the materials were transported from the advancing side to retreating side behind the pin where the weld was formed.

Hardness of the copper was larger than the aluminium and due to the pin stirring action the aluminium gets displaced in the weld.

Microstructural Characteristics

Microstructure of weld taken at centre of weld with or without filler materials. At the centre of weld a line mix region of aluminium and copper were found. Microstructure consists of uniformly distributed fine intermetallic particles in a matrix of aluminium solid solution. Cracks and porosity are seen. Lack of fusion more a length of the root.

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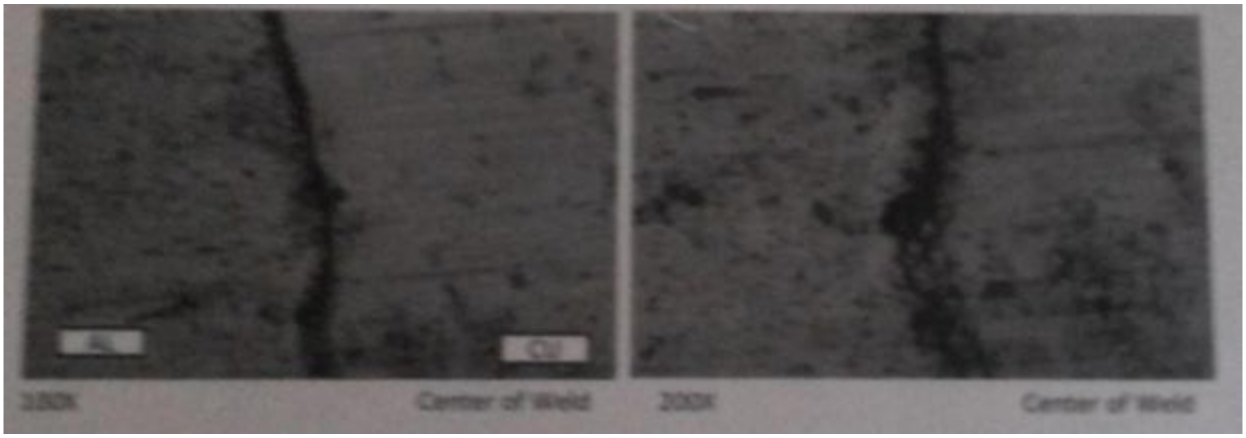

Figure 3: Microstructure of Aluminium and Copper at Centre of Weld at 200x for 710rpm


Figure 4: Microstructure of Aluminium and Copper at Centre of Weld at 200x for 1120rpm

Tensile Testing

A Stress Vs Strain graph, for 710 rpm, and 1120 rpm. Ultimate Tensile strength was 37.699 N/mm^2 and yield strength was 29.808N/mm^2 for 710rpm.

For 1120 rpm Ultimate Tensile strength was 76.800N/mm^2 and yield strength was 60.6N/mm^2 or Mpa.

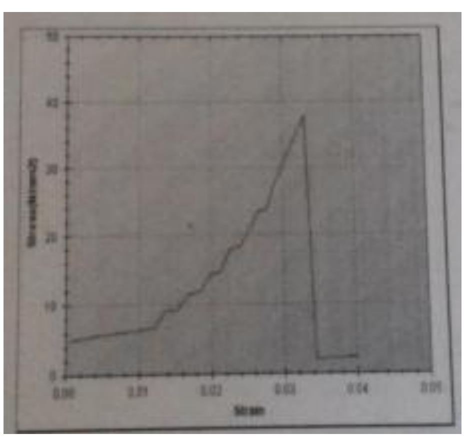
Figure 5: Stress Vs Strain Graph for 710rpm

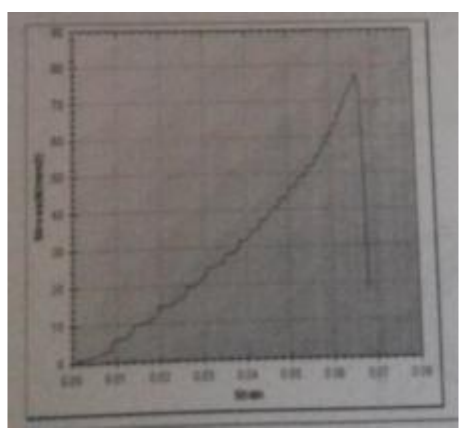
Figure 6: Stress Vs Strain Graph for 1120rpm

Microhardness

The Microhardness test is evaluated by Vickers were found to be 370HV for 710 rpm and for 1120 rpm 440HV.

Conclusion

All welds were defect free. Microstructure of weld and Microhardness were shown at centre of weld. Tensile strength was good.

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