FRICTION STIR WELDING OF DISSIMILAR AL6061-T6 AND PURE COPPER

M. Velu, Ajay Tidole, Paras Mehra and Devdatt Kulkarni
School of Mechanical Engineering,
Vellore Institute of Technology University,
Vellore, Tamilnadu, India

ABSTRACT

This paper presents the results of joining dissimilar aluminium alloy Al6061 T6 and pure copper sheets by friction stir welding. The butt-joint configuration was used. The joint appeared good with the bare eye. The macro and micro structures of the interface revealed intermixing of the base metals without material discontinuities. The microhardness across the interface did not show jump near the interface. This confirms the homogeneity of the microstructure across the interface.

Key words: Friction Stir welding, Dissimilar, Microstructure, Microhardness.

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1. INTRODUCTION

Bi-metallic components are being used in the structural applications, where a component made of a monolithic material is not sufficient to meet the functional requirement [1]. Thus bi-metallic or multi-materials use the benefits of the very different materials by joining them by a suitable joining process. Joining dissimilar materials are not easy due to mismatch in physical and thermal properties. However, the development in the field of welding technologies enables one to join dissimilar materials without defects [2]. Among various welding methods, the solid-state joining process viz. friction stir welding (FSW) has been used off late. The probability of formation of brittle intermetallic compounds is very much reduced in FSW process [3]. This is attributed to the low operation temperature involved in the process.

The bi-metallic components of Al and Cu are widely applied in industries such as aerospace, automobile and power. Thus welding of these metals in butt configuration is a challenging task because they are not metallurgically compatible. Attempts to fusion join them would involve difficulties due to different melting temperatures, thermal expansion coefficients and tendency to form brittle intermetallic compounds such as Al5Cu and Al4Cu9. Hence attempts to join them by solid-state process such as FSW are found in the literature. However, much work was not done. In this paper, aluminium Al6061-T6 alloy and pure Cu sheets were butt welded by FSW process. The characterisation of the joint is reported.
2. MATERIALS AND METHODS

The sheets of aluminium alloy Al6061-T6 and pure copper of thickness 3 mm were selected as base metals for butt joint by FSW. The Al6061-T6 has good toughness, light weight, high resistance to corrosion and high electrical and thermal conductivity. On the other hand, pure copper possess high electrical conductivity and corrosion resistance. The sheets were cut into pieces of 120×50×3mm thick. The butting edges were thoroughly cleaned and finished. The suitable fixture was designed to fix the plates firmly. The tool as shown in Fig. 1 was machined from the rods of H13 tool steel. The tool pin was tapered [1, 2]. The sheets were fixed firmly in the fixture in butt configuration. The copper was on the advancing side and the Al6061 was on the retreading side. The tool was fixed to the head of the milling machine. The rotational speed of the tool was set at 1400 rpm and the feed rate of the milling table was set at 14 mm/min[5]. The butt joint by FSW was obtained as shown in Fig. 2. The microstructures at different locations near the joint area were obtained using Carl Zeiss Optical Microscope at 500X magnification. The standard methods of specimen preparation and metallography were followed. The etchants are used to get the microstructures i.e. Nital for Al6061-T6 and (Conc.HNO₃ + H₂O) for Cu. The microhardness at various points across the weld-interface were measured using hardness tester (make: Matsuzawa, model: MMT-X7B). A load of 200g and a dwell time of 10 s were set in the tester.

![Figure 1 Tool used in friction stir welding (a) Geometry (b) Photo.](image1)

![Figure 2 Friction stir welded butt joint of Al6061-Cu](image2)
3. RESULTS AND DISCUSSIONS

3.1. Macrostructures
Macrostructure at 4x magnification is shown in Fig. 3. It shows the proper distribution between the particles into each other. Also there were no defects found.

![Figure 3 Macrostructure of the joint](image)

3.2. Microstructures
Microstructures at different locations on the joint are shown in Fig. 4. As seen in Figure 4 (a) and (b) the base metals have very homogeneous structure indicating their purity. The weld-interface at Figure 4(c) shows a thin interlayer formed between the base metals[6, 7]. The grain size of Cu (HAZ) is more than that of Cu (BM) [8, 7] There are no defects found at the interface [9].

![Figure 4 Microstructures (500X) of friction stir welded butt joint of Al6061-Cu at (a) Al(BM) (b) Cu (BM) (c) Weld-interface](image)
3.3. Microhardness
The distribution of microhardness across the weld-interface is plotted in Fig. 5. It can be seen that near the weld-interface, there is no jump in the microhardness values. This is attributed to the absence of intermetallic compounds and hence brittle zones. The microhardness of the copper near the HAZ has reduced [7] in comparison with that of the BM. This indicates that the copper was softened due to the heat generated by friction. This phenomenon was also noticed in the aluminium side [10].

![Figure 5 Microhardness values of friction stir welded butt joint of Al6061-Cu](image)

4. CONCLUSIONS
The FSW of Al6061-T6 and pure copper was carried out using milling machine. The following conclusions are drawn from the work.

- The defect-free weld between the base metals was obtained.
- The microstructure near the weld-interface did not show any brittle phases, confirming the absence of intermetallic compounds.
- The microhardness distribution reveals no jump in the values at the weld-interface.

REFERENCES


