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Microstructural and mechanical properties of friction stir welded Cu–30Zn brass alloy at various feed speeds: Influence of stir bands

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ABSTRACT

In this study, the effect of various feed speeds on microstructure and mechanical properties of friction stir welded Cu–30Zn brass alloy is investigated. Rotation speed was fixed at 950 rpm and feed speed varied in the range of 190–375 mm/min. Examination of the microstructure showed very fine grains with some deformed grains in the stirred zone and some coarser grains in the thermo-mechanically affected zone and base metal. A unique deformation pattern, namely "stir band" in the stirred zone region was identified and its density increased by increase in feed speed. Results showed that the grain size profile was independent of feed speed and the hardness values decreased by increase in feed speed. Increase in feed speed led to a slight improvement of yield strength and ultimate tensile strength, associated to continuous spring-like morphology of stir bands acting as a strengthening structure. However, ductility reduces considerably from 57 to 27%. Moreover, it is observed that during tensile test, fracture cracks originate exactly adjacent to the stir bands.

1. Introduction

Friction stir welding (FSW) has been successfully used to weld similar and dissimilar cast and wrought aluminum alloys, steels, as well as titanium, copper and magnesium alloys, dissimilar metal group alloys and metal matrix composites. The technique can be used to produce butt, corner, lap, T, spot and fillet joints as well as to weld hollow objects, such as tanks and tube/pipe, and parts with 3-dimensional contours [1–2]. Welding of copper is usually difficult by conventional fusion welding techniques due to the deteriorative influence of oxygen, impurities and also because of its high thermal diffusivity which is about 10–100 times higher than that of steels and nickel alloys [3–6]. In other words, the greater dissipation of heat through copper work-piece requires higher heat input for welding in comparison with other materials, resulting in quite low welding speeds [7]. Few researches have been already conducted on the FSW of copper and copper alloys [8–10]. Recently, several attempts have been made to join successfully pure copper and Cu–Zn alloys by FSW process [6–13]. Similar to other materials, four microstructural regions could be identified in FSW of copper alloys: nugget or stirred zone (SZ), thermo-mechanically affected zone (TMAZ), heat affected zone (HAZ) and base metal [6–12]. The SZ microstructure contains equiaxed and small recrystallized grains. Depending on the grain size of the base metal, its hardness may be higher or lower than base material [7]. It has been reported that, in 4 mm thick friction stir welded copper plates, nugget had lower hardness compared to base metal. Although grain size has been decreased, hardness reduction has been occurred slightly due to a reduction in dislocation density relative to the base metal [10]. On the other side, in FSW of 2 mm thick copper plates, nugget was harder than the base metal due to reduction in average grain size [11]. Microstructural evolutions during FSW process could certainly affect the mechanical properties. However, Shen et al. [13], reported that in pure copper, when welding speed increases, the size of nugget decreases and TMAZ become narrower, but the welding speed almost has no significant effect on the tensile properties of the joints when the welding speed varies in the range of 25–150 mm/min. Investigations on FSW of Cu–Zn brass alloys, particularly the influence of feed speed on microstructure and mechanical properties, are scarcely available [6,8–10,12]. It should be noticed that from economical point of view, using higher feed speeds is a favorable industrial demand [14].

The aim of this project is devoted to determine the effect of high feed speed on microstructure and mechanical properties of Cu–30Zn alloy. Macro- and micro-structures of weldment regions were characterized and compared by using optical microscopy (OM), scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS). In addition, hardness profile was measured through the weld zones. Elongation percentage (El%), yield

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