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Friction Stir Lap Joining of AC4C Cast Aluminum Alloy and Zinc-coated Steel

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Abstract. AC4C cast aluminum alloy and zinc-coated steel were friction stir lap welded, and the microstructures and mechanical properties of the joints were examined and analyzed. Experimental results show that the welding speeds have a significant effect on the tensile properties and fracture locations of the joints at a rotational speed of 1500 rpm. When the welding speed is higher than 60 mm/min, the joints fracture in the zinc-coated steel base material and the tensile strength is equal to that of the zinc-coated steel; when the welding speed is lower than 60 mm/min, the joints fracture in the interface and the shear strength is about 50 MPa. The change of the fracture locations is attributed to the presence of large quantity intermetallic compounds adjacent to the interface of the joints. The composition and formation mechanism of the intermetallic compounds and its effect on the mechanical properties of the joints were discussed.

Introduction

The need of light weight in automotive body construction leads to the increasing use of the combination of steel and Al alloy in fabrication of vehicles [1]. At present, the following main welding technologies have been employed to join Al alloy and steel: ultrasonic welding, explosive bonding, electric discharge bonding and friction welding. On the other hand, as an emerging welding technology, friction stir welding (FSW) is one of the most popular bonding methods for joining dissimilar materials. Most studies mainly focus on the dissimilar metal joining of Al alloy and steel; while, little research have involved joining of Al alloy and zinc-coated steel [2-4]. Studies on this topic are important for revealing and comprehending the friction stir weldabilities of Al alloy and zinc-coated steel. In this study, AC4C cast aluminum alloy and low carbon zinc-coated steel are selected as the experimental materials for friction stir lap welding. The emphasis is placed on the tensile strength, fracture location of the joint and the interface microstructure evolution of the weld under different welding heat inputs.

Experimental

The base material was a 3 mm thick AC4C cast aluminum alloy plate and a 0.8 mm thick low carbon zinc-coated steel plate. The plate was cut and machined into rectangular welding samples, 300 mm long by 100 mm wide. They were longitudinally lap-welded with welding parameters of 1500 rpm rotational speed and 60-120 mm/min welding speed, using an FSW machine. The upsetting force of the welding tool (SKD61 tool steel) used in this experiment is 1 ton. The diameters of tool shoulder and tool pin are 15 mm and 5 mm, respectively. The length of the pin is 2.9 mm. The tilt angle of the tool is 3 degrees. After welding, the joint was cross-sectioned perpendicular to the welding direction for the metallographic analyses and tensile tests, using an electrical-discharge cutting machine. The cross-sections of the metallographic specimens were polished with diamond polishing agent, etched with Keller's reagent (1 ml hydrochloric acid, 1.5 ml nitric acid, 2.5 ml hydrofluoric acid and 95 ml water) and observed by optical microscopy. The

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