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Fatigue Behavior of Dissimilar 5754/7075 and 7075/5754 Spot Friction Welds in Lap-Shear Specimens

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ABSTRACT

Fatigue behavior of spot friction welds or friction stir spot welds in lap-shear specimens of dissimilar aluminum 5754-O and 7075-T6 sheets is investigated based on experimental observations and two fatigue life estimation models. Optical micrographs of the 5754/7075 and 7075/5754 welds after failure under cyclic loading conditions are examined to understand the failure mechanisms of the welds. The micrographs show that the 5754/7075 welds mainly fail from the kinked fatigue crack through the lower sheet thickness. Also, the micrographs show that the 7075/5754 welds mainly fail from the kinked fatigue crack through the lower sheet thickness and from the fracture surface through the upper sheet thickness. A kinked fatigue crack growth model based on the stress intensity factor solutions for finite kinked cracks and a structural stress model based on the closed-form structural stress solutions are adopted to estimate the fatigue lives of the 5754/7075 and 7075/5754 welds in lap-shear specimens. The fatigue life estimations based on the kinked fatigue crack growth model and the structural stress model agree well with the experimental results.

INTRODUCTION

Resistance spot welding is the most commonly used joining method for vehicle body members made of steel sheets. However, resistance spot welding of aluminum sheets is likely to produce poor welds as reported by Thornton et al. [1] and Gean et al. [2]. Recently, a friction stir spot welding or spot friction welding technology for joining aluminum sheets was developed [3,4]. A comprehensive literature review of spot friction welding process can be found in Pan [5]. Spot friction welds between dissimilar aluminum sheets [6,7,8,9], between similar magnesium sheets [10,11,12,13], between dissimilar magnesium and aluminum sheets [13], and between dissimilar aluminum and steel sheets [14,15,16] were investigated. Fatigue behavior of spot friction welds between similar and dissimilar sheet materials was investigated by experiments [17,18,19,20,21,22,23,24]. For fatigue life estimations, Lin et al. [20,21], Tran et al. [22] and Wang and Chen [23] adopted a kinked fatigue crack growth model and a structural stress model to predict the fatigue lives of aluminum spot friction welds.

It should be noted that different types of aluminum alloys are currently used to make different components of vehicle in the automotive industry. Note that spot friction welds between dissimilar aluminum sheets were tested under quasi-static loading conditions in [6,7,8,9]. However, fatigue behavior of spot friction welds between dissimilar aluminum sheets has not been investigated. In this paper, fatigue behavior of spot friction welds in lap-shear specimens of dissimilar aluminum 5754-O and 7075-T6 sheets is investigated based on experimental observations and two fatigue life estimation models. As in Tran et al. [9], the dissimilar spot friction welds are denoted as 5754/7075 when aluminum alloys 5754-O and 7075-T6 were used as the upper and lower sheets, respectively. The dissimilar spot friction welds are denoted as 7075/5754 when aluminum alloys 7075-T6 and 5754-O were used as the upper and lower sheets, respectively. The 5754/7075 and 7075/5754 welds in lap-shear specimens were first tested under quasi-static and then cyclic loading conditions. Optical micrographs of the welds after failure under cyclic loading conditions are examined to understand