

Computational methods for Prediction of tool fatigue life in friction stir welding

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Abstract

As a solid state joining technique, FSW shows advantages in joining thin plates of hard-to-weld materials. FSW has been quickly applied for the joining of aluminum alloys, magnesium alloys, titanium alloys, coppers, steels and even dissimilar metals. During friction stir welding, the tool pin inserts into the work piece and moves along the welding seam with a specified rotation speed. The material flow [Zhang and Zhang (2008)] can cause a severe interaction between the tool and the work piece. Forces acting on the tool are studied based on an adaptive remeshing model [Zhang and Wan (2012)] of FSW. The bending moment caused by the transverse force on the pin is an important reason of tool pin fatigue. So a computational fluid dynamic model of FSW is established to study the fatigue stresses on the tool pin. The detail of the CFD model is described in [Zhang and Wu (2015)].

Due to the ratio of radius and length of the pin, Timoshenko beam theory is implemented in the calculation of fatigue stresses. The pressure on the pin is simplified as uniform distributed body forces. 10% of the total heat input is assumed to be flow into the tool according to [Zhang et. al. (2011)]. The change of properties of the pin materials caused by temperature rise is considered. Kandil, Brown and Miller (KBM) multiaxial fatigue criteria and accumulative damage rules are used to predict the fatigue life of the tool pin. The results indicate that, tools are undamaged when the welding speed is small. When the transverse speed is increased, the fatigue life of the tool becomes shorter. The frequency of fatigue stresses are increased in higher rotating speeds. Increase in pin length can lead to increase in fatigue stresses and decrease the fatigue life.

Keywords: Friction stir welding, Computational fluid dynamics, Tool pin, Fatigue life

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