Available online at www.sciencedirect.com

ScienceDirect

Procedia Materials Science 11 (2015) 12 – 16

Procedia Materials Science

www.elsevier.com/locate/procedia

5th International Biennial Conference on Ultrafine Grained and Nanostructured Materials, UFGNSM15

Effect of Pin Profile on Defects of Friction Stir Welded 7075 Aluminum Alloy

S. M. Bayazid[a,*], H. Farhangi[a], A. Ghahramani[a]

[a] *School of Metallurgy and Materials Engineering, College of Engineering, University of Tehran, Tehran, P.O. 11155-4563, Iran*

Abstract

In this work, effect of the pin profile on defects of FSWed 7075 alloy was investigated. Three pins with cylindrical, square and triangle geometry were used for welding. Microstructure of the welding zone showed that the tunnel hole produced by triangle pin has smaller dimensions compared to cylindrical pin. On the other hand, results of optical microscope indicated that the size of grains resulted from square pin is smaller than the other kinds of tools. Also, the results showed that when the pin is cylindrical, tunnel, kissing bond, and zigzag line defects are formed. On the other hand, when the pin is triangle, original joint line with severe plastic deformation and crack defects are created.

Peer-review under responsibility of the organizing committee of UFGNSM15

Keywords: 7075 Al alloy; Friction stir welding; Pin profiles; Defects

1. Introduction

Over the years FSW has increased significance for joining such as aluminum alloys as the heat produced during the process is not severe enough to produce the defects which are generally observed in these materials during fusion welding, Thomas et al. (1999). Rotational speed of the tool, tool traverse speed, and vertical pressure on the plates during welding are the main process parameters of FSW, Rajakumar et al. (2010). However the tool geometry which includes the geometry of the FSW tool shoulder and tool pin probe profile is also a significant characteristic which affects the weld strength. Therefore, study of the FSW process also includes the investigation and study of tool

* Corresponding author. Tel.: +98-914-148-5543; fax: +98-218-208-4076.
E-mail address: mahmoud.bayazid@ut.ac.ir

Peer-review under responsibility of the organizing committee of UFGNSM15
doi:10.1016/j.mspro.2015.11.013

characteristics, Su et al. (2003). The effectiveness of an FSW joint is strongly affected by several tool parameters; in particular, geometrical parameters such as the height and the shape of the pin (cylindrical, trapezoidal, screwed, etc.) has a related influence on the metal flow and on the heat generation due to friction forces, Leal et al. (2008), Querin et al. (2009), Rai et al. (2011), Zhang et al. (2012). The FSW tool is a critical part of this welding process. Dawes and Thomas (1999) defined in detail the tool development approach taken at The Welding Institute and outlined the tool design aspects of the scroll shoulder concept. While there have been several studies focused on the variation of rotation and welding speeds to optimize the welding parameters and study their microstructures for aluminum alloys, limited research has been carried out on the effects of tool structure, Leal et al. (2008), Barcellona and Buffa (2004), Boz and Kurt (2004). A large majority of research conducted on the FSW process has focused specifically on visualizing the material flow around the FSW tool, Guerra et al. (2002). It is well understood that plastically deforming material is forced to flow in the direction of tool rotation from front to the rear of the FSW tool. Even though some work has been done in contemporary literature on the study of the tool shoulder and probe profile, a comparative detailed study of different basic tool features for a given material is rarely found. There is, therefore, a need to systematically investigate the effect of tool pin profile geometries on the FSW weld. In this study, the effects of various tool geometries on mechanical properties, microstructural characteristics and defects of the welded joint made from 7075 aluminum alloy were studied.

2. Experimental

5 mm thickness 7075-T6 Al alloy plate with chemical composition of Al-5.7 Zn-2.4 Mg-1.55 Cu-0.19 Cr-0.18 Fe (in wt.%) was used as base material. The tools are shown in Fig. 1. The welding and rotation speeds were 63 mm min-1 and 1600 rpm, respectively. The microstructure of the specimens was studied by using optical (OM) and electron microscopes (SEM). An Olympus BX60M optical microscope and a VEGE/TESCAN-XMU field emission scanning electron microscope (FESEM) were used to examine the microstructure of the joints. Fracture surfaces of the FSWed specimens after tensile test were examined with FESEM.

3. Results

In fusion welding of aluminum alloys, the defects like porosity, hot crack etc. depreciates the weld quality and joint properties. Usually, friction stir welded joints are free from these defects since there is no melting takes place during welding and the metals are joined in the solid state itself due to the heat created by the friction and flow of metal by the stirring action. However, FSW joints are disposed to other defects like tunnel defect, cracks, pinhole, piping defect, kissing bond, etc. due to unsuitable flow of metal and inadequate consolidation of metal in the FSW region, Elangovan and Balasubramanian (2007). As revealed in Fig. 2, five types of defects can be observed from the overall cross-sectioned samples. First, tunnel defects can be found in all of the samples that created with cylindrical and triangle tools. Second, kissing bond and zigzag defects can be found in joints that created with cylindrical tool. Third, crack and OJLwSPD defects can be found in the advancing side of joints that created with triangle tool. But, for joints that created with square tool all of the as welded specimens were sound. Also, fracture surfaces of the tensile samples were investigated by scanning electron microscope (SEM). It should be noted that different failure patterns could be caused by different defects distributions. Therefore, representative tensile fracture surfaces of the samples are shown in Fig. 3. From the fractured surface analysis, it can be inferred that the defect free welds are showing uniform deformation across the weld before failure.