Materials and Design 32 (2011) 976–983

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Short Communication

Microstructure and mechanical properties of friction stir welded Al/Mg_2Si metal matrix cast composite

H. Nami [a,*], H. Adgi [a], M. Sharifitabar [b], H. Shamabadi [a]

[a] School of Metallurgy and Materials Engineering, University of Tehran, Tehran, Iran
[b] School of Metallurgy and Materials Engineering, University of Sistan & Baluchestan, Zahedan, Iran

ARTICLE INFO

Article history:
Received 13 March 2010
Accepted 6 July 2010
Available online 4 August 2010

ABSTRACT

In this research, friction stir weldability of 15 wt.% Mg_2Si particulate aluminum matrix cast composite and effects of tool rotation speed and number of welding passes on microstructure and mechanical properties of the joints were investigated. Microstructural observations were carried out by employing optical and scanning electron microscopy of the cross sections perpendicular to the tool traverse direction. Mechanical properties including microhardness and tensile strength were evaluated in detail. The results showed fragmentation of Mg_2Si particles and Mg_2Si needles existing in eutectic structure in stir zone. Also, homogeneous distribution of Mg_2Si particles was observed in the stir zone as a result of stirring with high plastic strains. Tension test results indicated that tensile strength of the joint had an optimum at 1120 rpm tool rotation speed and decreased with increasing of the number of welding passes. Hardness of the joint increased due to modification of solidification microstructure of the base composite. This research indicates that friction stir welding is a good candidate for joining of 15 wt.% Mg_2Si aluminum matrix composite castings.

1. Introduction

Particulate reinforced aluminum metal matrix composites (MMCs) have recently become a major focus of attention in aerospace, motor parts and automotive industries due to their several attractive advantages over conventional alloys such as high specific stiffness, high strength to weight ratio at room or elevated temperatures, excellent fatigue properties, high formability and improved wear resistance [1,2]. However, one of the main limitations for the industrial applications of Al MMCs is the difficulty in using conventional welding methods to join them together [2]. The drawbacks associated with the fusion welding of these composites include: (a) incompatible mixing of the parent and filler materials, (b) presence of porosity in the fusion zone, (c) excess eutectic formation and (d) formation of undesirable deleterious phases [3].

Friction stir welding (FSW) is a promising candidate for joining of particulate reinforced aluminum matrix composites. FSW is a solid state welding process, where a rotating non-consumable tool with a pin extending from a larger shoulder is translated along the weld line/joint. During welding, the rotating tool produces frictional heating with temperature below the melting point of material, and plastic deformation due to stirring of material around the pin, which forms the weld. This solid state joining process avoids the formation of shrinkages, porosity and segregation of the ceramic reinforcements; moreover significantly reduces the thermal stresses [4].

Al–Si alloys with high Mg content are in fact in situ aluminum matrix composites containing a large amount of Mg_2Si hard particles and have a potential as automobile brake disc materials. This is because of high melting temperature, low density, high hardness, low thermal expansion coefficient and reasonably high elastic modulus of Mg_2Si particles [5,6].

No work has been reported on the friction stir welding of Al/Mg_2Si composites. However, some works have been carried out on the FSW of SiC particulate aluminum matrix composites [2,7], Al_2O_3 particulate aluminum matrix composites [4,8] and B_4C aluminum matrix composites [9]. The objectives of the present investigation are to study (a) the friction stir weldability of Al/Mg_2Si cast composite and (b) effect of rotational speed of pin and number of FSW passes on microstructure and mechanical properties of the joints.

2. Experimental procedure

The parent material was in situ Al/Mg_2Si composite made by gravity casting containing 15 wt.% Mg_2Si particles with an average diameter of 20 μm. Commercial pure metals (Al, Mg) and Si were used as starting materials to prepare Al/Mg_2Si composite ingot.

* Corresponding author. Address: North kargar Avenue, School of Metallurgy and Materials, Faculty of Engineering, University of Tehran, Tehran, Iran. Tel.: +98 2182095692; fax: +98 2188006076.
E-mail addresses: halednami@ut.ac.ir (H. Nami), hojjatadgi@ut.ac.ir (H. Adgi), Mahmood_Sharifitabar@yahoo.com (M. Sharifitabar), Hassan2535@gmail.com (H. Shamabadi).

0261-3069/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.matdes.2010.07.008