Materials and Design 32 (2011) 4502–4508

Contents lists available at ScienceDirect

Materials and Design

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

Comparison of corrosion behaviour of friction stir processed and laser melted AA 2219 aluminium alloy

K. Surekha, B.S. Murty *, K. Prasad Rao

Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, Chennai 600 036, India

ARTICLE INFO

Article history:
Received 16 December 2010
Accepted 15 March 2011
Available online 21 March 2011

Keywords:
A. Nonferrous alloy
C. Surface treatments
E. Corrosion

ABSTRACT

Dissolution of second phase particles ($CuAl_2$) present in AA 2219 aluminium improves the corrosion resistance of the alloy. Two surface treatment techniques, viz., solid state friction stir processing and fusion based laser melting lead to the reduction in $CuAl_2$ content and the effect of these processes on the corrosion behaviour of the alloy is compared in this study. Potentiodynamic polarization and electrochemical impedance spectroscopy tests were carried out to compare corrosion behaviour. The corrosion resistance achieved by friction stir processing is comparable to that obtained by the laser melting technique.

1. Introduction

Good weldability and high strength-to weight ratio of AA 2219 aluminium alloy makes it an ideal candidate for strategic applications. However, its corrosion resistance is poor owing to the formation of galvanic cells between the $CuAl_2$ intermetallic and the Al matrix. Surface treatments can improve the corrosion resistance of the alloy by homogenization/refinement of microstructure, dissolution/redistribution of precipitates. In the present study, the samples of AA 2219 were subjected to fusion based approach, laser melting (LM), and a relatively new solid state approach, friction stir processing (FSP), to improve the corrosion resistance.

Surface treatments are generally carried out to tailor the surface properties without affecting the bulk properties to improve strength, toughness, corrosion and wear resistance. In LM, an intense laser beam locally heats the surface and produces a rapidly solidified surface layer to a depth of a few hundred microns and the remainder of the material acts as an effective heat sink and hence the surface material solidifies under a relatively high rate of cooling. This alters the microstructure and the distribution of second phase particles and hence affects the surface properties. In FSP, a non-consumable tool rotating at a constant speed is inserted into the plates to be processed and the tool is responsible for heating of work piece and deformation of the material [1]. FSP being a solid state process is free from many solidification defects like cracks, porosity, etc.

Li et al. [2] studied the localized corrosion behaviour of LM AA 2024-T351 alloy and found that the pits were uniformly distributed, while in the base metal the pits were more in the rolling direction. This difference in corrosion behaviour was attributed to changes in the distribution and composition of the second phase particles present in the alloy. Liu et al. [3] studied the corrosion mechanisms of LM AA 2014 and AA 2024 alloys and noticed an improvement in pitting corrosion resistance of AA 2014 due to the cathodic nature of $CuAl_2$ phase relative to the α-Al matrix and the corrosion resistance of AA 2024 alloy decreased due to the anodic nature of Al_2CuMg phase relative to the α-Al solution. Liu et al. [4] found that corrosion behaviour after laser treatment depends on the electrochemical nature of various intermetallics with respect to the solid solution matrix. Watkins et al. [5] reviewed the literature on the corrosion properties of various aluminium alloys after laser surface melting and laser surface alloying and found promising improvement in the critical pitting potential compared to the conventional alloys.

Surekha et al. [6,7] studied the effect of FSP parameters namely, rotation speed and number of passes on the corrosion behaviour of AA 2219 alloy and found an improvement in the corrosion resistance that was attributed to the fracture and dissolution of the second phase particles. Jariyaboon et al. [8] reported the effect of welding parameters during friction stir welding (FSW), especially rotation speed and traverse speed, on corrosion behaviour and reported that rotation speed has a significant influence on the rate of corrosion. Fonda et al. [9] studied the microstructure, mechanical properties, and corrosion behaviour of friction stir welded AA 5456 and found that the anodic reactivity was highest in the weld nugget, particularly towards the lower advancing side, since nanoscale β precipitates were dispersed throughout the matrix of the susceptible regions. Hatemleh et al. [10] studied the effect of laser and shot peening on stress corrosion cracking susceptibility of friction stir welded AA 7075 aluminium found that surface treatment decreased

* Corresponding author. Tel.: +91 44 2257 4754; fax: +91 44 2257 4752.
E-mail address: murty@iitm.ac.in (B.S. Murty).

0261-3069/$ - see front matter
doi:10.1016/j.matdes.2011.03.033