Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 173 (2017) 679 – 685

Procedia Engineering

www.elsevier.com/locate/procedia

11th International Symposium on Plasticity and Impact Mechanics, Implast 2016

Impact and Tensile testing of Al2024 alloy processed by Friction Stir Processing

Atul Suri[a*], Ankit Sahai[a], K. Hans Raj[a], N. K. Gupta[b]

[a]*Faculty of Engineering, Dayalbagh Educational Institute, Dayalbagh, Agra, 282005, INDIA*
[b]*Department of Applied Mechanics, IIT Delhi, New Delhi, 110016, INDIA*

Abstract

Friction stir processing (FSP) is a prominent technique of severe plastic deformation (SPD) that can provide modification and control of microstructure to enhance the mechanical properties of Al alloys, which can be used in aerospace and aircraft applications. The present work focuses on the evaluation of mechanical and impact behavior of Al 2024 alloy processed with FSP using a non- consumable round pin tool. The length of tool pin is considered to be 4.5 mm for performing FSP on Al 2024 plates having 6 mm thickness. The tool feed rate is maintained at 25 mm/min and tool rotational speed is considered as 1200 and 1800 rpm. Mechanical evaluations were conducted by determining microhardness, tensile tests and Izod impact test for different specimens. The maximum hardness is observed to be 155 HB in the nugget zone at the rotational speed of 1200 rpm, which is about 1.5 times of unprocessed specimen. The ultimate tensile strength also exhibits an increase of 20% for specimen processed at 1800 rpm. Fracture morphologies indicate that the dimple size and distribution on fractured surface is affected by the variation of rotational speeds. The impact test indicate that the impact strength increases by 2.5 times of unprocessed specimen at 1800 rpm.

Peer-review under responsibility of the organizing committee of Implast 2016

Keywords: Friction Stir Processing; Impact Testing; Microhardness; Fractography

* Corresponding author. Tel.:+91-9412894687; fax:+91-0562-2801226.
E-mail address: atulsuridei@gmail.com

Peer-review under responsibility of the organizing committee of Implast 2016
doi:10.1016/j.proeng.2016.12.145

1. Introduction

These days, materials with ultrafine grained (UFG) structure are becoming more and more attractive for naval and aerospace applications for the improved mechanical strength at ambient temperature due to increased amount of grain boundaries acting as obstacles for moving dislocations [1]. The extraordinary mechanical strength of UFG metals stimulated the development of their production methods. Today, UFG metals can be efficiently produced by different variants of the severe plastic deformation (SPD) method namely FSP [2-7], ECAP [8-9], Twist Extrusion [10], etc.

Friction stir processing is a severe plastic deformation (SPD) technique, introduced by Mishra et al.[11] for producing ultra-fine grained (UFG) materials with improved properties. In context of common SPD methods such as high pressure torsion, equal channel angular extrusion and accumulative roll bonding, FSP can produce bulk UFG materials in a single pass. In FSP, Fig.1, a non-consumable rotating tool with a shoulder and pin is traversed along the specific region on a workpiece. Friction between the tool shoulder and the workpiece results in localized heating that softens and plasticizes the processed zone. The stirring action of the rotating pin causes intense plastic deformation of the locally heated material. The combination of plastic deformation, mixing and thermal exposure results in a modified microstructure in the stir zone (SZ), which is commonly characterized by fine and equiaxed grain structure with predominant high-angle boundaries.

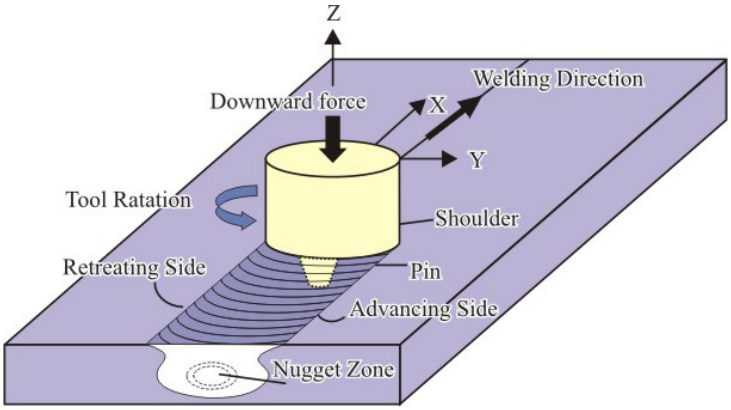

Fig.1: Friction Stir Processing

FSP creates a region called ‘‘nugget zone,’’ where the microstructural refinement takes place producing equiaxed ultrafine grains with high-angle grain boundaries [11-12]. Johannes and Mishra [13] investigated the effect of multipass FSP on the superplasticity of 7075 Al rolled plate by using mini tensile specimens cut from the center of each stir zone on the staggered pass samples. The result show good superplastic ductility in each stir zone of the multipass FSP 7075 Al samples. Friction stir processing has been used with aluminium-based alloys for improving mechanical properties [14-17] and inducing superplasticity [18-19] through grain refinement.

The present work focuses on evaluating the tensile and impact properties of Al2024 alloy after friction stir processing for multiple rotational speeds using round pin tool.

2. Experimental Procedure

The experiments were conducted using Al 2024 alloy. The alloy was supplied in the form of rectangular plates of 6 mm thickness. The tool used for conducting Friction Stir Processing on the specimen is made of eutectoid alloy steel. The length of the tool pin was taken as 4.5mm. The experiment was performed at two rotational speeds of the tool, which were 1200 rpm and 1800 rpm and the feed rate was maintained constant as 15 mm/min. The rounded pin tool,