

# Chapter 51

## Influence of Process Parameters on Microstructure of Friction Stir Processed Mg AZ31 Alloy

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### ABSTRACT

*Friction stir processing (FSP) has been developed on the principles of friction stir welding (FSW) as an effective and efficient new method for grain refinement and microstructural modification, providing intense plastic deformation as well as higher strain rates than other conventional severe plastic deformation methods. FSP produces an equiaxed homogeneous microstructure consisting of fine grains, resulting in the enhancement of the properties of the material at room temperature. The objective of the present paper is to examine the influence of friction stir processing (FSP) parameters namely tool rotational speed (RS), tool traverse speed (TS) and tool tilt angle (TA) on the microstructures of friction stir processed AZ31B-O magnesium alloy. This investigation has focused on the microstructural changes occurred in the dynamically recrystallised nugget zone/ stir zone and the thermo mechanically affected zone during FSP. The results presented in this work indicate that all the three FSP process parameters have a significant effect on the resulting microstructure and also found that the rotational speed has greatly influenced the homogenization of the material. The grain refinement is higher at intermediate rotational speed (1150 rpm), traverse speed (32 mm / min and tilt angle ( $1^\circ$ ). It is established that FSP can be a good grain refinement method for improving the properties of the material.*

### 1. INTRODUCTION

In recent years, magnesium alloys have been the subject of numerous research projects throughout the world because the use of magnesium alloys drastically increased in the automobile, aerospace, computer communication, and consumer electronic appliance industries due to their low density, high strength to weight ratio and good castability. (Mordike & Ebert, 2001). However, their application is limited

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due to the poor formability and low ductility at room temperature. In recent years, numerous measures have been taken to refine the grains. One such technique is the “severe plastic deformation technique (SPD)”, which results in the improvement in properties of the material, by grain refinement. Some of the well known severe plastic deformation techniques, namely thermo-mechanical treatment (TMT), equal-channel angular pressing (ECAP), high pressure torsion (HPT), accumulative roll bonding (ARB), etc. are complex and time consuming processes.

Recently, investigators have found that friction stir processing (FSP) can considerably increase the ductility of the magnesium alloys (Mishra & Ma, 2005; Chang, Du & Haung, 2007; Cavaliere & Demarco, 2007). During FSP, a specially designed rotating tool is forced into the work piece and traversed back and forth in the desired direction. The tool usually consists of a large cylindrical diameter shoulder with a smaller profiled pin. The tool serves two primary functions: (1) heating the work piece by way of friction between the shoulder and the work piece and (2) causing severe deformation of the material by the rotating pin (Mishra & Ma, 2005). Thus, during this process, the material undergoes severe plastic deformation and thermal exposure, which results in the formation of homogeneous and fine grain microstructure (Sato et al., 2005). Compared to other grain refinement methods, FSP is a very simple and cost effective technology. Friction stir processing has been successfully applied to many aluminium alloys. Karthikeyan et al (2011) studied the influence of friction stir processing process variables namely, rotational speed, traverse speed and axial force on the AA 6063-T6 aluminium alloy. They found maximum mechanical properties for certain combination of parameters through optimizing the process parameters. Kumar et al (2011) friction stir processed the twin-roll cast (TRC) Al-Mg-Sc alloy and obtained ultrafine grained (UFG) microstructure after processing. The grain size reduced from 19.02  $\mu\text{m}$  to 0.730.44  $\mu\text{m}$  after FSP and found that about 80% of the grains were smaller than 1  $\mu\text{m}$  with high angle grain boundary (HAGBs) character, but its application of magnesium is reported by only few researchers. Sato et al (2005) determined the effect of FSP on microstructure of AZ91 magnesium alloy and observed that more grain refinement and homogenization when compared to the cast properties. Darras et al (2007) have studied the effect of various friction stir processing parameters on the thermal histories and properties of commercial AZ31B-H24 magnesium alloy sheet. They concluded that the grain refinement and homogenisation of microstructure can be achieved in a single pass. The grain refinement can be controlled by varying heat input during processing (Feng & Ma, 2007; Freney & Mishra, 2010). At FSP, the tool rotational speed of the tool stirs and mixes the material around the rotating pin which results in an increase of the temperature of the metal (Jayaraman, Sivasubramanian & Balasubramanian, 2009). Tool tilt angle is also influencing the flow patterns of the stir zone that causes considerable grain refinement.

However, little or no work is done on the study of the influence of FSP process parameters on the microstructural changes on the Mg alloy. More studies are required to investigate the influence of FSP process variables on the resulting microstructure. The purpose of this work is to examine the influence of friction stir processing process parameters on the formation of fine grain and its distribution using optical microscope.

## **2. EXPERIMENTAL PART**

In this investigation, rolled sheet of magnesium AZ31B alloy, supplied by Xi'an Yuchen Metal Products Co., Ltd, China was used as the base material. The chemical composition and material properties of base

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