Available online at www.sciencedirect.com

ScienceDirect

Journal of Magnesium and Alloys 4 (2016) 52–61
www.elsevier.com/journals/journal-of-magnesium-and-alloys/2213-9567

Review

Magnesium based surface metal matrix composites by friction stir processing

B. Ratna Sunil [a,*], G. Pradeep Kumar Reddy [b], Hemendra Patle [c], Ravikumar Dumpala [c]

[a] *Department of Mechanical Engineering, Rajiv Gandhi University of Knowledge Technologies (AP-IIIT), Nuzvid 520202, India*
[b] *Department of Mechanical Engineering, Vignana Bharathi Institute of Technology, Hyderabad 501301, India*
[c] *Department of Mechanical Engineering, Visvesvaraya National Institute of Technology, Nagpur 440010, India*

Received 2 November 2015; accepted 2 February 2016

Available online 2 March 2016

Abstract

Surface metal matrix composites (MMCs) are a group of modern engineered materials where the surface of the material is modified by dispersing secondary phase in the form of particles or fibers and the core of the material experience no change in chemical composition and structure. The potential applications of the surface MMCs can be found in automotive, aerospace, biomedical and power industries. Recently, friction stir processing (FSP) technique has been gaining wide popularity in producing surface composites in solid state itself. Magnesium and its alloys being difficult to process metals also have been successfully processed by FSP to fabricate surface MMCs. The aim of the present paper is to provide a comprehensive summary of state-of-the-art in fabricating magnesium based composites by FSP. Influence of the secondary phase particles and grain refinement resulted from FSP on the properties of these composites is also discussed
© 2016 Production and hosting by Elsevier B.V. on behalf of Chongqing University.

Keywords: Surface composites; Friction stir processing; Hardness; Light weight; Magnesium alloys; Biomedical implants

1. Introduction

Metal matrix composites (MMCs) are a significant group of modern engineered materials that have clearly demonstrated their potential as promising candidates for various structural applications [1]. By adding an appropriate amount of secondary phase particles, the specific strength of pure metals or alloys can be improved. In addition, higher fatigue and wear resistance also can be achieved [2]. Aluminum, copper, magnesium and titanium are a few examples for matrix materials and SiC, SiO_2, Al_2O_3, TiB_2, WC are a few examples for secondary phase materials. The potential applications of metal matrix composites (MMCs) can be found in automobile, aerospace, marine and power generation industries [3,4]. Stir casting [5], squeeze casting [6–8], spray deposition [9], *in situ* fabrication [10], powder metallurgy [11–13], diffusion bonding [12] and vapor deposition methods are a few examples for manufacturing techniques commonly used to fabricate bulk MMCs [14–16]. Recently, magnesium and its alloys have proven as excellent candidates for constructing structures in automobile, aerospace, marine and electronic industries because of their low density, high specific strength (158 kN-m/kg), good castability, weldability and machinability [17–19]. The density of magnesium (1.738 g/cm^3) is substantially less than aluminum (2.7 g/cm^3) [17]. But magnesium is brittle in nature compared with aluminum. Magnesium based MMCs are an upcoming new class of materials in non-ferrous metals that address the problems associated with brittleness of magnesium.

There are some important applications in which the surface properties affect the functioning and the life of the component. Surface MMCs are the best example for such materials, which contain dispersed secondary phase particles at the surface alone and the material at the core is unaffected. Therefore, the surface exhibits higher hardness and wear resistance and the material in bulk experience negligible loss to its toughness [20]. Laser assisted processes, centrifugal casting and plasma spraying are a few examples of such methods developed to fabricate surface MMCs [21–26]. All of these techniques involve the material transformation from solid to liquid or vapor state during the process. On the other hand, solid state processing techniques that do not result in the transformation of the material to liquid phase during the process offer relatively many advantages over

* Corresponding author. Department of Mechanical Engineering, Rajiv Gandhi University of Knowledge Technologies (AP-IIIT), Nuzvid 520201, India. Tel.: +91 9677119819; fax: +91 08656 235150.

E-mail address: bratnasunil@gmail.com, bratnasunil@rgukt.in (B.R. Sunil).

http://dx.doi.org/10.1016/j.jma.2016.02.001
2213-9567/© 2016 Production and hosting by Elsevier B.V. on behalf of Chongqing University.

conventional liquid phase processing techniques. Friction surfacing and friction stir processing are the best examples for such solid state processing techniques used to modify the surfaces and to develop the surface composites [27–32]. Recently, Sharma et al. [33] summarized the overall developments that happened in fabrication of composites using FSP. The present paper aims to give a comprehensive review of the work reported in the literature exclusively in developing magnesium based surface MMCs by FSP with an emphasis given to describe the influence of fine grain structure and the presence of different phase particles on the properties of the composites.

2. Friction stir processing (FSP)

Friction stir processing (FSP) has evolved from the basic principles of friction stir welding (FSW) and emerged as a promising tool to alter the surface microstructure of metallic sheets and plates [29]. During FSP, the material surface is modified by inserting a cylindrical rotating tool that contains a small pin at the end and plunged along a desired length in traverse direction by applying a suitable load. Therefore, the material at the stir zone undergoes intense plastic deformation and dynamic recrystallization is initiated [34], which lead to refinement of the microstructure.

3. Fabrication of surface composites using FSP

Secondary phase particles can be incorporated and distributed in a metal during FSP to fabricate surface MMCs. Along with incorporating the secondary phase particles, grain size reduction at the surface can be achieved, which is another advantage with FSP. For the first time, Mishra et al. [35] successfully developed 5083Al-SiC MMCs using FSP and demonstrated the potential of FSP in developing surface composites.

Usually a narrow groove or holes are produced on the surface of the sheet and the secondary phase particles are filled before FSP is carried out as schematically shown in Fig. 1. However, for the past decade, a few methods were developed to introduce the secondary phase particles into the matrix material during FSP as given below.

i) Groove filling method in which a groove is produced on the surface of the work piece and filled with the secondary phase and FSP is carried out over the groove
ii) Groove filling and closing method involves closing the groove with a pin less FSP tool after filling the groove with secondary phase to avoid the escape of the secondary phase during FSP.
iii) Holes filling is another method in which tiny blind holes are drilled on the surface of the work piece and filled with secondary phase and FSP is carried out
iv) The holes filling and closing method involves closing of the holes after they are filled with secondary phase similar to the groove filling with the help of pin less FSP tool.
v) The sandwich method is another way of dispersing secondary phase into the matrix material in which the secondary phase is placed in the form of a laminate or layer between work pieces and a sandwich kind arrangement is made. When FSP is carried out, the secondary phase layer is dispersed though out the stir zone.

In situ supply of secondary phase through a hole provided within the FSP tool itself during the process is another development reported in the literature to produce surface composites

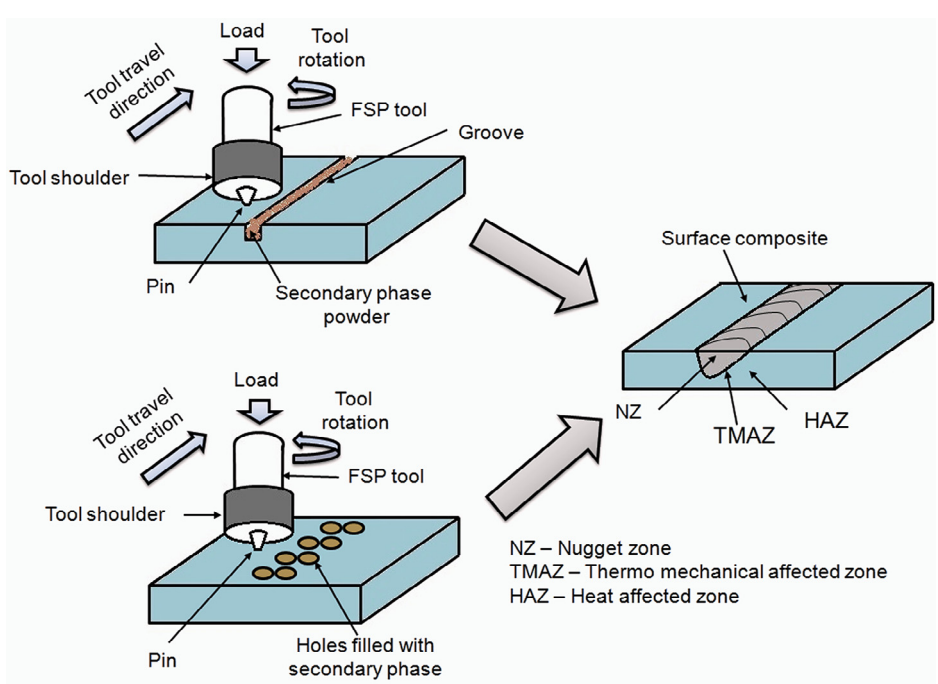

Fig. 1. Schematic representation of surface MMCs fabrication by FSP.

Download English Version:

https://daneshyari.com/en/article/1630155

Download Persian Version:

https://daneshyari.com/article/1630155

Daneshyari.com