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Experimental Characterization of Metal Matrix Composite with Aluminium Matrix and Molybdenum Powders as Reinforcement

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Abstract

This paper is on the successful fabrication of Metal Matrix Composite (MMC) using an Aluminium plate and Molybdenum powder by Friction Stir Process (FSP). The aim was to produce a superficial MMC layer on the Al plate in order to increase the mechanical properties of the as received Al plate. A uniform dispersion of Mo particles in the Al matrix was observed from SEM observations and EDX analyses and a significant improvement in the Vickers microhardness was also detected.

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Keywords: Metal Matrix Composite; Aluminum; Molybdenum; Friction Stir Pprocessing; Mechanical Properties

1. Introduction

Aluminium and its alloys are widely used in different engineering fields such as aerospace, automobile, and marine industries, due to their low density, high specific mechanical properties and good workability. It is known that in some of these applications the surface properties are crucial and dictate the performance and the life of a component. Therefore, material having a surface with high hardness and wear resistance together with a ductile core having high toughness may be required [1]. In this scenario the surface Metal Matrix Composites (MMCs) turn out to be one of the best examples of modern engineered materials that have clearly demonstrated their potential for different structural applications.

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The interest in the technologies concerning the production of surface engineered material has grown more and more in the past years [2]. There are different methods to produce surface MMCs modifying only the top surface without affecting the inner core of the material such as plasma spaying, diffusion bonding, laser assisted processes and centrifugal casting [2;3]. All of these methods involve matrix material transformation from solid to liquid or vapor during the process. On the other hand, by using the solid state processes for the production of a surface MMC, the material state transformation does not occur, offering many advantages over the conventional processes. In this context, the friction stir process (FSP) is the one of the best example for such solid state process used to modify the surfaces and to develop the surface composites [4;5]. The FSP, based on the basic principles of friction stir welding, consists of a rotating tool with a shoulder and a pin inserted and moved along the material. The friction developed between the tool and the work piece provides localized heating and plastic deformation [1;6]. As Mo has low solubility and diffusivity in aluminium [7;8] and a high melting point, it could be interesting to use this material as reinforcement in an aluminium matrix. On the basis of these considerations, this study has shown that the FSP can be effectively used to produce an Al-Mo surface layer on Al base plate.
Microstructural observations and microhardness measurements have been carried out both on the top surface and cross section surface of the MMC samples to study the dispersion of the molybdenum particles within aluminium matrix and in order to detect whether use of Mo as alloying element increase the microhardness value.

2. Experimental section

The materials used in this experiment were commercial Al as base plate and Mo powder (99.9% pure, Sigma Aldrich) as reinforcement element. The as-received molybdenum powder was measured using a Particle Size Analyzer and the average size of Mo particles was found to be 30.46 μm. The aluminium plate with a thickness of 6 mm was cut in a rectangular shape of dimension 150 x 100 mm and exactly in its centre a groove with 2 mm width and 0.5 mm depth was cut throughout the top surface of the aluminium plate. Molybdenum powder used as alloying element was filled inside the groove cut on the plate surface and then the FSP is carried out on these aluminium plates with Mo powder filled grooves. The Friction stir processing of Al-Mo system was carried out using a Friction Stir Welding machine (Fig.1). The used machine has 12 HP spindle motor having clockwise as well as anti-clockwise spindle rotation with a maximum of 3500 rpm rotational speed and 50 kN plunge load capacity. High speed steel (HSS) tool was used for the Friction stir processing to generate sufficient frictional heat required for the process as well as successful incorporation of Mo particles into the alloy system. The tool with shoulder diameter of 20 mm and tool pin length of 1mm with a diameter of 6 mm was used for processing. The experiments were performed with a tool rotational speed of 840 rpm, a traverse speeds of 40mm/min and a plunge speed of 3 mm/min.

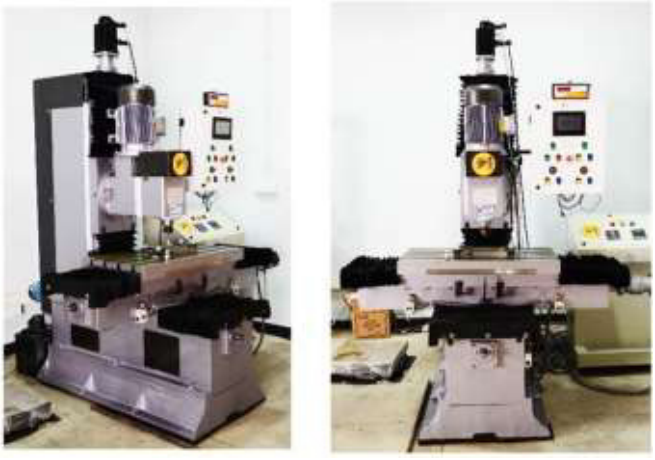

Fig. 1. Friction stir welding machine used for processing of aluminum plates.