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Review

Friction stir processing – State of the art

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ABSTRACT

Increasing demands for operating properties of fabricated elements on one hand, and a necessity of reducing mass of a structure on the other, triggers materials engineering research into producing surface layers representing required functional properties. Methods commonly used in the production of surface layers, such as surfacing, spraying or re-melting with a laser beam have been known for years. A new method is the friction stir processing (FSP) of surface layers. The FSP process is primarily used for the modification of microstructure in near-surface layers of processed metallic components. In particular, the process may produce: fine grained structure, surface composite, microstructural modification of cast alloys, alloying with specific elements, improvement of welded joints quality. The chapter is composed of a few main parts. In the first part, based on literature review the main application and achievements of FSP processes are presented. In the second part: analysis of the process. The third part is focused on microstructure refinement and the last part provide information about friction stir alloying as well as friction stir processing with ultrasonic vibration.

1. Introduction

Friction stir processing (FSP) utilizes the same process principles as FSW (friction stir welding) [1]; however, instead of joining samples together the process modifies the local microstructure of monolithic specimens to achieve specific and desired properties by surface modifying the microstructure (Fig. 1). As in FSW, the tool induces plastic flow during the process, but depending on the selection of process parameters, i.e. applied force, travelling speed and rotational speed, the material flow can yield a modified microstructure that is beneficial to the performance/requirement of the material. Developed by Mishra in 2000, the modified process is a relatively new and exciting technique for microstructural development and modification as well as property enhancement [2].

During the FSP process, a pin is plunged into the modified material with the shoulder of the rotating tool abutting the base metals. As the tool (Fig. 1) transverses the modified direction, the rotation of the shoulder under the influence of an applied load heats the metal surrounding the modified area and with the rotating action of the pin induces metal from each section to flow and form the modified area. The microstructure that evolves during FSP results from the influence of material flow, plastic deformation and elevated temperature and is characterized by a central stir zone surrounded by a thermomechanically affected zone (TMAZ) and heat affected zone (HAZ). The deformed material is transferred from the retreating side (RS) of the tool pin to the advancing side (AS) and is forged by the tool shoulder, resulting in a solid state modification of the material. In the FSP process the most important area is between stir zone and

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