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Friction Stir Welding and Single-Point Incremental Forming: *State-of-the-Art*

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2.1 Introduction

Solid-state joining and processing techniques are increasingly being employed by industries to link softer metals that are hard to join using regular fusion welding operations. Friction stir welding (FSW) is beneficial since it does not require filler, resulting in a large weight decrease. FSW has successfully connected high-strength aluminum alloys, as well as other metallic alloys, utilized in the automotive and aerospace sectors [1]. FSW's remarkable achievements have led to the refinement, enhancement, and modernization of the friction stir concept, resulting in several innovative techniques for joining and processing materials. These advances are gradually allowing the transfer of technological competence to higher strength and stiffness materials and cutting-edge applications [2].

This chapter's goal is to provide an introduction to FSW and the single-point incremental shaping procedure on friction stir welded blanks. The two fundamental processes in friction stir are joining and processing. While processing is intended to enhance material properties, welding is often used to combine different materials [3]. FSW involves the rotation of the tool in contact with the workpiece and uses a nonconsumable tool. This circular motion generates the required heat for the process through the frictional interaction between the tool and the workpiece.

A "third body region" is one that is physically separate from the workpiece and the tool. This region is formed either on the tool (in cases where the tool is expendable) or on the workpiece (in cases where the tool is nonexpendable). As shown in Figure 2.1, the third region of the material, despite its solidity, exhibits a fluidity that extends into three dimensions, enabling it to combine and merge with other materials at the interface. This zone, which is located between the material's melting point and crystallization temperature, develops as a result of frictional heat produced at the operating surfaces. It has a low flow stress and a high viscosity, and it resembles the deformed or plasticized material used in friction stir operations [4, 5].

Friction stir techniques often involve the appearance of a third body region that is not observed in fusion technologies, as frictional heat is not generated near the material's melting point. The third body region facilitates material intermixing and interatomic diffusion at elevated temperatures, creating a strong bond between similar or dissimilar materials. Yet, at greater pressures or lower temperatures, interatomic bonding may become the primary mechanism for material joining or processing.

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