Finite volume modeling of laser assisted friction stir welding of 2017A-T451 aluminum alloy for enhanced sustainability of welded joints

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Abstract

This study focuses on a new welding modification friction stir welding, using a preheating during the welding phase. This method utilizes laser energy to pre-heat the workpiece to a localized area at the front of the FSW tool, thereby reducing the temperature gradient over a localized area in advance of the tool. The amount of heat generated during welding determines the quality of the weld. Therefore the understanding of the temperature distribution is required to determine the optimal method of welding parameters. In this study, a two-dimensional model of an aluminum alloy plate coupled to a circular laser source is developed, using FLUENT software that is based on the finite volume method, also the geometry of the pin of the FSW tool was modified in several configurations to highlight the effect of the geometry of the tool on the temperature distribution in the welded plate. The model developed can be used to better understand the process, predict process performance and to determine the optimal parameters of the process.

Key words: FVM, numerical modeling, hybrid laser friction stir welding, tool geometries;

1 Introduction

Friction stir welding (FSW) is a solid state joining process that utilizes a rapidly-rotating, high strength steel tool in the form of a pin inserted along the weld stem to join metals. Known problems associated with friction stir welding (FSW) may be alleviated by the proper selection of process parameters leading to more sustainable processing and to enhanced welded joints. Such parameters include tool feed, spindle speed, tool geometry, tool tilt angle, and in-process cooling or heating. The proper selection of such factors is a key for achieving defect-free welds by avoiding defects such as warm holes and voids. Furthermore, achieving desirable grain size at the weld as well as the final phases also results from the combination of the process parameters which must be carefully defined in order to achieve target results. FSW is considered a hot-working process in which massive plastic deformation occurs through the rotating pin without subjecting the workpiece to any form of induced heating or melting. Such deformation gives rise to a thermomechanically-affected zone (TMAZ) and a heat-affected zone (HAZ) [1]. Friction stir welding is heavily used in the aerospace industry to join, for example, high strength aluminum alloys that are hard to weld using traditional welding techniques. For steel and other high-temperature materials, the application of FSW is limited to the presence of suitable tools that can operate in the temperature range of 1000 to 1200 °C [5]. This is due to the fact that the heat produced by stirring and friction may not be sufficient to soften the material around the rotating tool. Therefore, it is important to