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ORIGINAL ARTICLE

Effect of backing material and clamping system on the tensile strength of dissimilar AA7075-AA2024 friction stir welds

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Abstract Friction stir welding of dissimilar aluminum alloys has become an important application in the modern industries. Joint strength is a major consideration in this advanced technology. This paper presents an attempt made to improve the weld tensile strength by controlling the temperature distribution during the joining process. High-strength AA7075-T651 and AA2024-T351 aluminum alloys were friction stir welded using different backing and clamping materials. The tool rotation rate was preliminarily investigated to estimate the optimal spindle speed. Next, three composite backing plates and clamping systems were tested in conjunction with varying levels of traverse speeds and materials position. The transient temperatures were experimentally measured at different distances from the welding line. Asymmetric temperature distributions were observed with maximum records on the advancing side of the weld. Moreover, the influence of backing and cover materials on the joint strength was found to be varied with the applied level of the welding traverse speed. Based on these results, an idea to use asymmetric system of backing and cover materials was inspired. This system assisted to improve the temperature distribution and resulted in a sound weld with higher tensile strength. The detailed results of this work were discussed and the main outputs were outlined in the conclusions.

Keywords Aluminum alloys · Friction stir welding · Temperature distribution · Tensile strength

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1 Introduction

Friction stir welding (FSW) is a solid-phase continuous hot shear welding process. The fundamentals of this green joining method are plunging and stirring a non-consumable rotating tool with a specially designed shoulder and probe or pin into the abutting materials to be welded [1, 2]. The workpieces are joined together through heating, material movement, and forging dominated by the tool geometry in addition to the welding parameters. Heating is created both by the friction between the rotating tool (pin at the initial plunge stage and mainly shoulder during the run) and the workpiece and by severe plastic deformation of the workpieces. Materials around the probe are softened due to localized heating and move from front to back during tool rotation and stirring. Consequently, the hole in the tool wake is filled and the welding joint is produced. The shoulder restricts the plasticized materials from flowing out and applies forging pressure to consolidate the materials right behind the moving pin.

Reducing the heat input during the FSW process by decreasing the tool rotation rate and/or increasing the workpiece travel speed is one of the methods used for increasing the joint strength [3]. Since the temperature must be kept high enough to soften the materials around the welding pin tool to stir, this method requires inspection of the optimal welding speeds which are varied according to the joint configuration (butt or lap) and material types and dimensions [4]. For this reason, there is a limited range of tool rotation rate and travel speeds that could be controlled. Cooling of the welding tool and backing plate should offer another way of reducing the elevated temperature. Water or gas cooling and welding under water can be effectively used for joining high-temperature materials, such as steel and titanium [5]. For aluminum alloys, ambient air is found to be enough for cooling the welding tool and anvil, and the coolant-cooling is not required for such low-

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