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Low Height Ultra-Thin Fin on A5083 Aluminum Plate Fabricated by Friction-Stir Forming

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Abstract

Recent demands on miniaturization of an electronic apparatus have caused board-space constraints, and thermal management is getting increasingly difficult. Thermal management employing heat sinks is often compromised by the space constraints for a product design. Lower profile passive heat sinks having thin fins are among necessary solutions to these space limitations. Most such products have been generated by conventional or back pressure applied forging. However, thinness of its fin is limited, though a higher density of fins is more effective. This paper describes a new forming technology, friction-stir forming (FSF), to generate a low profile, ultra-thin fin. The suggested process is as follows. The authors put a material plate on a die and conducted friction stirring on its back surface. The material deformed and precisely filled narrow grooves of the die due to high pressure and heat caused by friction stirring. This study investigates the forming conditions and the corresponding results including the height limit of the fin. Consequently, we successfully generated low-profile, ultra-thin fins with 0.5mm thickness and less on 3mm-thick JIS A5083P-O aluminum plate.

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Keywords: friction stir forming; fin; heat sink; aluminum alloy.

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1. Introduction

Recent demands for miniaturization of electronic apparatuses cause board-space constraints, and thermal management is getting increasingly difficult. Thermal management employing heat sinks is often compromised by the space constraints for a product design. Lower profile passive heat sinks having thin fins are a possible solution to these space limitations. Most of such products have been generated by conventional or back-pressure applied forging; however, fin thinness is limited, though higher fin density is more effective. This paper reports a new forming technology, friction-stir forming (FSF), to generate a low profile ultra-thin fin.

Recently, friction stir processing has begun to be applied for material forming, i.e., for incremental forming, by Otsu et al. (2014) and Matsumoto et al. (2015) and for boss generation on a plate (Yukutake et al. (2012)). FSF is the one of such the friction-stir processes, which is invented by Nishihara et al. (2002, 2003). Figure 1 presents a schematic drawing of FSF. A material plate is put on a die, and friction stirring is conducted on its back surface. The material deforms and precisely fills narrow grooves of the die due to high pressure and heat caused by friction stirring.

This study investigates the forming conditions and the corresponding results including height limit of the fins with the FSF approach for fabricating less than 0.5mm thick low-profile fins.

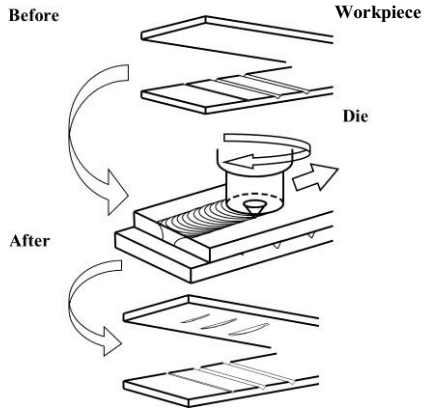

Fig. 1. Schematic drawing of FSF (Nishihara, 2003).

Nomenclature

D_s	shoulder diameter of FSF tool [mm]
D_p	probe diameter of FSF tool [mm]
h_p	height of probe [mm]
h	Maximum fin height [mm]
n	tool spindle speed [rpm]
s	groove width [mm]
V_t	tool feed rate [mm/min]