

# Friction Stir Processing of Aluminum Cast Alloys for High Performance Applications

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## INTRODUCTION

Friction Stir Processing (FSP) is a recent outgrowth of the Friction Stir Welding (FSW) process and relies on solid-state deformation to modify the surface of the working surface/materials. Our work to date has shown that we can locally eliminate casting defects and refine the microstructure to improve their mechanical properties and enhance corrosion resistance. Such improvements have important implications for manufactured components for a variety of automotive and other industrial applications.

The project, "*Microstructure Evolution during Friction Stir Processing of Aluminum Cast Alloys*", was completed in mid-2009. We verified and validated the potential of FSP to locally strengthen cast components, and to enhance mechanical properties – see project description under completed projects.

Based on our encouraging results, the consortium decided to continue this project to further investigate four (4) specific tasks; there are:

- Thermal processing response to FSP (T4, T7, as cast etc.)
- Mechanical property enhancement, particularly dynamic properties
- Establish a feasible process scheme and methodology for localized composite manufacture zones via FSP
- Develop a predictive model for the evolution of the FSP microstructure (incorporating thermal energy input and resultant structure)

## OBJECTIVES

1. Evaluate the response of aluminum cast alloys to post-FSP thermal processing.
2. Verify mechanical property enhancement of Aluminum cast alloys via FSP.
3. Investigate the potential of friction stir processing to form a localized particle-reinforced zone in standard Al cast components.

4. Develop a predictive model for the evolution of the FSP microstructure.

## METHODOLOGY

The principal goals of this work are to fully understand the mechanism that governs the microstructure evolution of aluminum cast alloys during FSP, to explore the behavior of the alloys in the thermal treatment afterwards, and to investigate the feasibility of FSP to manufacture a particle-reinforced zone in standard aluminum cast alloys. In order to achieve these goals, the following methodologies and strategies will be pursued:

1. Design experimental apparatus and conduct experiments to apply FSP and post-FSP heat treatment on aluminum cast alloys.



Figure 1: Main facility for FSP – HAAS VM3 mold machine.

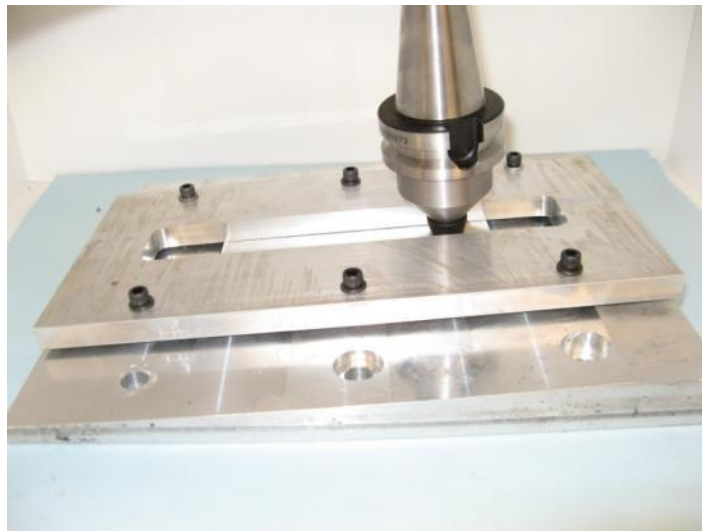


Figure 2: FSP tool and fixture.

2. Perform systematic experiments to fully characterize the effects of various variables (rotation speed, traverse speed and download force) in FSP on the performance of aluminum cast alloys. Establish optimum parameters for microstructure evolution.

Table 1: List of FSP parameters

	<b>Rotation speed (RPM)</b>	<b>Traverse speed (IPM)</b>	<b>Depth (MM)</b>
<b><i>Microstructure Manipulation (FSP only and FSP + heat treatment)</i></b>	1000	1	3.5
	1000	2	3.5
	500	1	3.5
<b><i>Composite fabrication</i></b>	1000	2	3.5

3. Based on the experimental results, a predictive model that takes into account thermal and force/loading factors will be established and validated.
4. Develop/standardize a methodology that can be utilized to manufacture localized zones of composite material that is made by the emplacement of a second phase into the Al alloy matrix during FSP. The particle-reinforced zone will be created via:
  - i) Emplacing discontinuous reinforced aluminum (DRA)
  - ii) Mixing-in nano-sized encapsulated Ta powders
  - iii) Mixing-in nano-sized encapsulated SiC powders
  - iv) Mixing-in micro-sized ecapsulated Cu powders