# J. High Integrity Magnesium Automotive Castings (HI-MAC, AMD 601[i])

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## Objective

Develop and validate casting process technologies needed to manufacture squeeze-cast and low-pressure-cast magnesium (Mg) automotive suspension components. Address critical technology barriers inhibiting Mg application and component affordability. Deliver components for static and/or vehicle testing. Evaluate potential of emerging casting technologies.

## Approach

**Casting Process Development:** Broaden the range for potential cast Mg-component applications by developing casting technologies for production of automotive suspension and powertrain components with a greater range of geometries and properties than are available today. Evaluate "Ablation" and other new casting processes for the casting of Mg automotive components.

**Development of Enabling Technologies and Material Science:**
Address key technology barriers that currently limit the casting of Mg automobile suspension and chassis applications and affect the cost of cast Mg components. Specific technologies include: computer modeling to enable prediction of casting quality and microstructure; thermal treatment including research into stepped heat treatment and fluidized beds; microstructure control during casting including grain refining; fatigue performance testing.

## Accomplishments

This project was approved on April 1, 2006, and since that time the project team has:

- Held two quarterly review meetings for the 46 project participants including: (Universities (6); National Laboratory (1); manufacturing and industrial companies (39).
- Established eight steering committees to work on each of the major project tasks.
- Retrofitted and "ready to dry-run test" one squeeze-cast machine in support of Task #1 (Figure 1).

**Figure 1.** Squeeze-cast machine retrofitted and ready to dry-run test.

- Met all projected guidelines for the issuance of purchase orders and the collection of project in-kind.
- Preliminary results from the Mg core gas studies at the University of Alabama at Birmingham (UAB) have been received. The studies demonstrated significantly higher core gas evolution when cores are in contact with molten Mg than when in contact with aluminum (Al). Additional work is continuing including the analyses of gas by-products generated.
- A work team has been organized to coordinate Low-pressure Permanent Mold (LPPM) Task 2 and Metal Filling Task 6. Several group meetings were held to transfer technology within group and define technical goals. The team has completed the design and engineering of major components including: Mg LPPM Equipment; one furnace system; metal-transfer system from the melting furnace to casting furnace; cover-gas management and recirculation system; mold hot-oil-heating system; the proposed Casting Component (control arm) has been designed for Mg and initial modeling completed; combined team meeting with LPPM group to discuss strategies to combine metal pump with LPPM equipment in future casting trails; conducted a literature review to determine history of liquid Mg pumping and capabilities of various pumps designs (see Figure 2).
- Completed eight project presentations at CANMET's technical meeting in October, 2006. No publications have been presented at this time in support of the HI-MAC project.

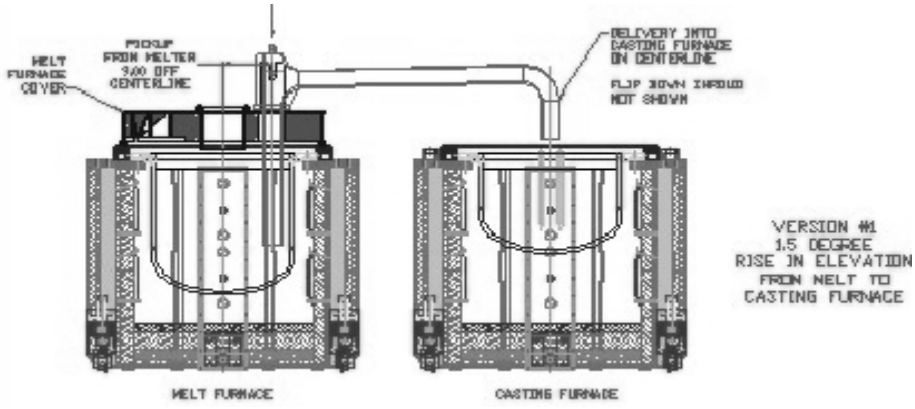


**Figure 2.** The dual furnace system for the LPPM casting equipment includes a casting furnace (that will sit under the LPPM machine), and a separate melting furnace to provide easy access for melt control and protection. A pressurized pump will transfer metal from the melting furnace into the casting furnace. (Proposed engineering drawings may be modified prior to final build).

### Future Direction

- The project team will follow the Statement of Work and the respective time line for each of the eight tasks.
- With in the next year, it is expected that the following items will be completed:
  - The design and completion of the Low Pressure Mg Casting machine and the squeeze-cast machine will be completed and test samples run.
  - The metal transfer pump design will be completed, and a new pump will be built. Initially, molten Zn will be tested prior to the testing of Mg.
  - Computer modeling companies have been defined in support of the project deliverables, and their progress will be tracked in accordance with the project's SOW.

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## Introduction

The use of Mg automotive components in new-vehicle applications can be utilized to reduce vehicle weight and improve performance. Mg sheet and wrought technologies hold potential for vehicle application, but application is long-term. Perhaps the quickest near-term path to increased Mg content in automobiles is through increased use of metal castings.

Wider vehicle application of cast Mg components offers a potential weight reduction of nearly 100 kg per vehicle. The Structural Cast Magnesium Development (SCMD) project (see 2.G) has successfully demonstrated the re-design, conversion, and production of a production cast aluminum (Al) engine cradle to cast Mg, providing weight reduction of approximately 35%. Similar applications of Mg castings for suspension and chassis components can be achieved. To produce affordable, high-strength Mg castings, it will be necessary to develop and optimize Mg-casting procedures (existing and/or new) and to develop tools that support the casting process and reduce the cost of Mg components.

The USAMP *Magnesium Vision 2020* document (see 2.G) identifies the cost and quality of Mg components, the need for engineering and manufacturing process development and the lack of enabling infrastructure as key inhibitors to cast-Mg applications on vehicles. Specifically, the document vision identifies three key technology barriers that must be overcome to increase the application of Mg cast components in vehicles by 2020:

- Lower manufacturing costs
- Improved casting quality requiring lower porosity and new casting methods
- Infrastructure development

The High Integrity Magnesium Automotive Casting (HI-MAC) project addresses the near- and mid-term

metal-casting development needs identified in the *Magnesium Vision 2020* document. Eliminating these technical barriers that currently inhibit Mg-casting production will move the automotive industry into a better position to realize emerging automotive Mg-component needs, build needed Mg-industry infrastructure and develop tools that will be needed to reduce the cost of Mg components and enable sustainable production requirements. The HI-MAC project will address these three key issues:

- **Development of Casting Tools:** Develop technologies and tools that will be required for sustainable long-term procurement of cast-Mg automotive components (Tasks 3, 4, 5 and 6). These tasks will address the science and technological barriers that currently inhibit production and affect the affordability of cast-Mg components.
- **Casting Process Development:** Develop casting processes to facilitate production of cast-Mg automotive chassis components that cannot be manufactured using current process limits (Tasks 1, 2 and 7).
- **Infrastructure Development:** Development of casting processes and tools will include industry participation by automotive suppliers currently producing Al components (Tasks 1, 2, 7), the development of equipment uniquely suitable for the production of Mg components (Task 2, 6) and development of a broader research and science base (Tasks 3, 4, 5, 8).

Research teams associated with the HI-MAC project will broaden the range for potential cast-Mg component applications by developing and optimizing manufacturing technologies that can produce a greater range of geometries and properties than are available today and encourage potential supplier-base infrastructure through project partnerships. Additionally, HI-MAC will investigate and evaluate new and emerging technologies and develop tools that address critical technology barriers currently inhibiting Mg application and component affordability. Technical challenges are identified for each task.

Casting process and tool development will be demonstrated by production of a Mg control arm by low-pressure-cast, squeeze-cast and a new emerging casting process. Control arms will be delivered for static and/or vehicle testing.

The project is divided into seven tasks to address key technology barriers that limit cast-Mg automobile suspension and chassis applications and affect the manufacturing costs of these components.

**Task 1:** Squeeze-casting process development
**Task 2:** Low-pressure casting process development
**Task 3:** Thermal treatment of castings including research into stepped heat treatment and fluidized beds
**Task 4:** Microstructure control during casting including grain refining and property improvement
**Task 5:** Computer modeling and properties to enable prediction of casting quality and microstructure
**Task 6:** Controlled Molten Metal Transfer and Filling
**Task 7:** Emerging Casting Technologies
**Task 8:** Technology Transfer

## Conclusions

The development of squeeze- and low- pressure casting processes for Mg automotive components will enable production of Mg suspension castings with property requirements and geometries not currently feasible with high-pressure die casting. Enabling technologies will reduce processing costs of Mg components.

[i] Denotes project 601 of the Automotive Metals Division (AMD) of the United States Automotive Materials Partnership, one of the formal consortia of the United States Council for Automotive Research (USCAR), set up by the "Big Three" traditionally USA-based automakers to conduct joint pre-competitive research and development.