Development of Integrated Die Casting Process for Large Thin-Wall Magnesium Applications
Award # DE-EE0005753

Partners: The Ohio State University, Meridian Lightweight Technologies
September 2012 – August 2016

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U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
June 14-15, 2016

This presentation does not contain any proprietary, confidential, or otherwise restricted information.
Project Objective

Problem: CAFE standards “require” significant vehicle weight reductions by 2025.
- Solution must include a manufacturing process scalable to annual production of millions of vehicles.
- Vehicles must be competitive in cost, size, quality, and performance.
- Must meet safety standards.

Solution: Design magnesium die cast automotive components and develop manufacturing process
- Density of Magnesium = 1.7 g/cm³, vs. Aluminum (2.7) and Steel (7.8)
- Die casting → metal only where you need it; minimal yield loss
- Die casting → no rolling or welding
- Die casting → scalable to mass production
- Compatible with complex geometric features

Objective: Design, cast, fabricate, test
- Buick LaCrosse door
- Head-to-head comparison—Magnesium vs. Steel
## Technical Approach

### Why this is a difficult problem:
- Low modulus of Mg → need design innovations to compensate
- Cannot cast closed sections → need design innovations to compensate
- Pushing the state-of-the-art for production wall thicknesses: 3mm → 1.5mm
- Complete filling of die cavity: difficult in large thin-wall casting
- Galvanic corrosion if Mg touches steel in wet areas
- Sharp fracture edges must be managed (ductility lower than steel or aluminum)

### Today
- Sheet steel pieces with different thicknesses
- Welded and hemmed together
- Stamped into shape
- Excess discarded
- Some headerless have Mg panels, but typ. >3mm

### New Approach
- Single Mg component + steel reinforcing bar
- Advanced Mg alloy for higher strength and ductility
- Super vacuum die casting for complete fill
- Improved ductility with less entrapped air
- Meridian, EDAG, and GM have experience with die cast Mg components
- OSU has die casting and alloy development expertise
Integrated Die Casting (IDC) Process Project Scope

Year 1
- Integrated Die Casting
- Overcasting
- Super-Vacuum Die Casting
- Die Development

Year 2
- Process Development

Year 3
- Process Validation

Meridian
GM
OSU
Benefits

- Reduced part count
- Fewer manufacturing steps
- 50% less embodied energy
- 50% less weight
- Improved fuel economy, performance, economical route to meet CAFE standards

Transition and Deployment

Projected commercialization ramp-up in years from project completion date

Market: automotive
Applications: side doors, cars and trucks
Commercialization approach

1. Implement at GM:
   - Estimate the cost penalty and door mass reduction likely with this technology
   - compare with the $/kg-reduced for other technologies
   - implement on an appropriate car model.

2. After GM success, Meridian will aggressively market the technology to other automotive OEMs and other manufacturers

Technology sustainment model: Pursue continuous improvement to cut the cost penalty per unit mass reduction, and thereby allow for more widespread implementation.
Measure of Success

Success

- A low-energy, lightweight, door technology option for car makers.

Energy impact (from prelim. technical energy models)

- 50% (0.1 Million Btu per door) less embodied energy than current sheet steel door.
- 7.4 kg/yr/vehicle CO2 reduction through improved vehicle fuel economy due to 60% door mass.

Economic impact (from prelim. technical cost models)

- Goal: $1,500,000 cost saving per 100,000 doors vs. steel.
**Project Management & Budget**

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>DIE DEVELOPMENT (Budget Period 1) 9/1/12 – 11/30/14</strong></td>
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<tr>
<td>Task 1</td>
<td>Die design, simulation and manufacturing</td>
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<td>Milestone 1</td>
<td>Delivery of test specimen die, vacuum capability, overcasting die, and door inner die design.</td>
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<td>Gate 1</td>
<td>Die Review (Complete cavity fill and 1.5-2 mm thin-wall capability)</td>
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<td><strong>PROCESS DEVELOPMENT (Budget Period 2) 12/1/14 - 11/30/15</strong></td>
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<td>Task 2</td>
<td>Casting process development</td>
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<td>Milestone 2</td>
<td>Delivery of door inner die, SVDC, overcasting and IDC process parameters and test specimens/castings.</td>
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<td>Gate 2</td>
<td>Process Review (less than 1% porosity and 1.5-2 mm thin-wall capability)</td>
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<tr>
<td><strong>TESTING AND VALIDATION (Budget Period 3) 12/1/15 – 8/31/16</strong></td>
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<tr>
<td>Task 3</td>
<td>Testing and validation</td>
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<tr>
<td>Milestone 3</td>
<td>Delivery of specimen, component and door system test results</td>
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<td><strong>PROJECT MANAGEMENT (All 4 years / entire project period)</strong></td>
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<tr>
<td>Task 4</td>
<td>Project planning, coordination and reporting</td>
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<td>Milestone 4</td>
<td>Delivery of energy efficiency of integrated die casting process</td>
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<tr>
<td>Gate 3</td>
<td>Final Review (50% energy efficiency improvement, economic benefits)</td>
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<th>DOE Investment</th>
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<td>Cost Share</td>
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<tr>
<td>Project Total, k$</td>
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No-cost 9-month extension requested.
Results and Accomplishments

Status
Task 1: Done
Task 2: Nearly done
Task 3: Underway

Milestones & Results
• 3 casting trials run in door die
• 2 modifications made to door die
• Mg-7Al-2Sn-xSi ("ATS") alloys cast, heat treated, and tensile tested.
• AM50 overcast onto steel and aluminum tubes, and tested.
• Aluminum sheet stampings made.

Work to do
• Build and test doors and door castings.
• Cast doors using Ca-bearing AM60 alloy.
• Assess embedded energy of manufacture.

ATS alloy: ↑ strength, ↓ ductility rel. to AM50
< 10 MPa axial interface shear strength

54 N/mm door header stiffness