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

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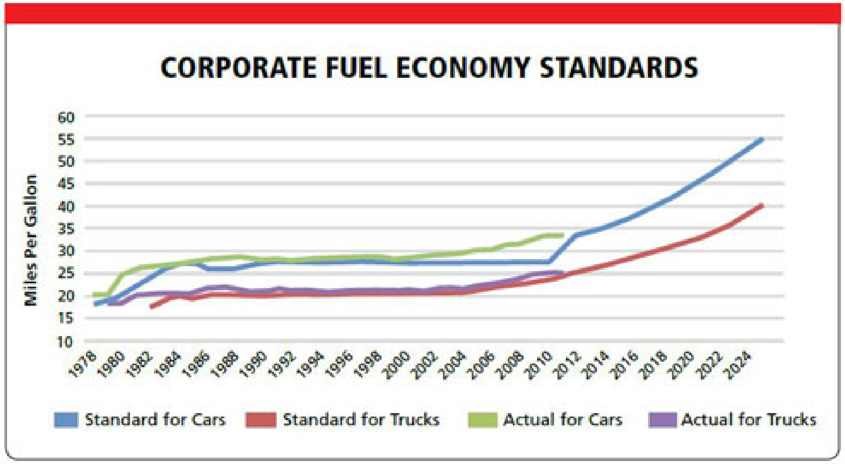
Project Objective



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.

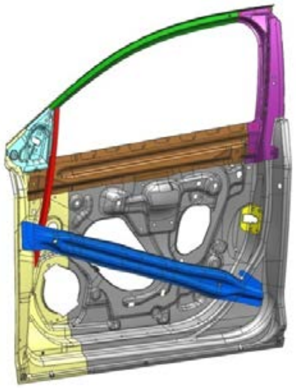
Solution: Design magnesium die cast automotive components and develop manufacturing process

- Density of Magnesium = 1.7 g/cm^3, 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

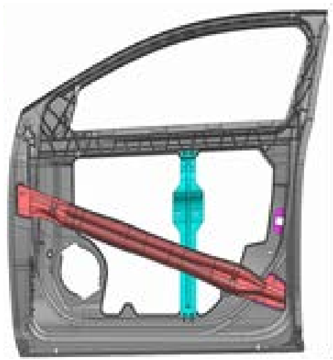


Today

- 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

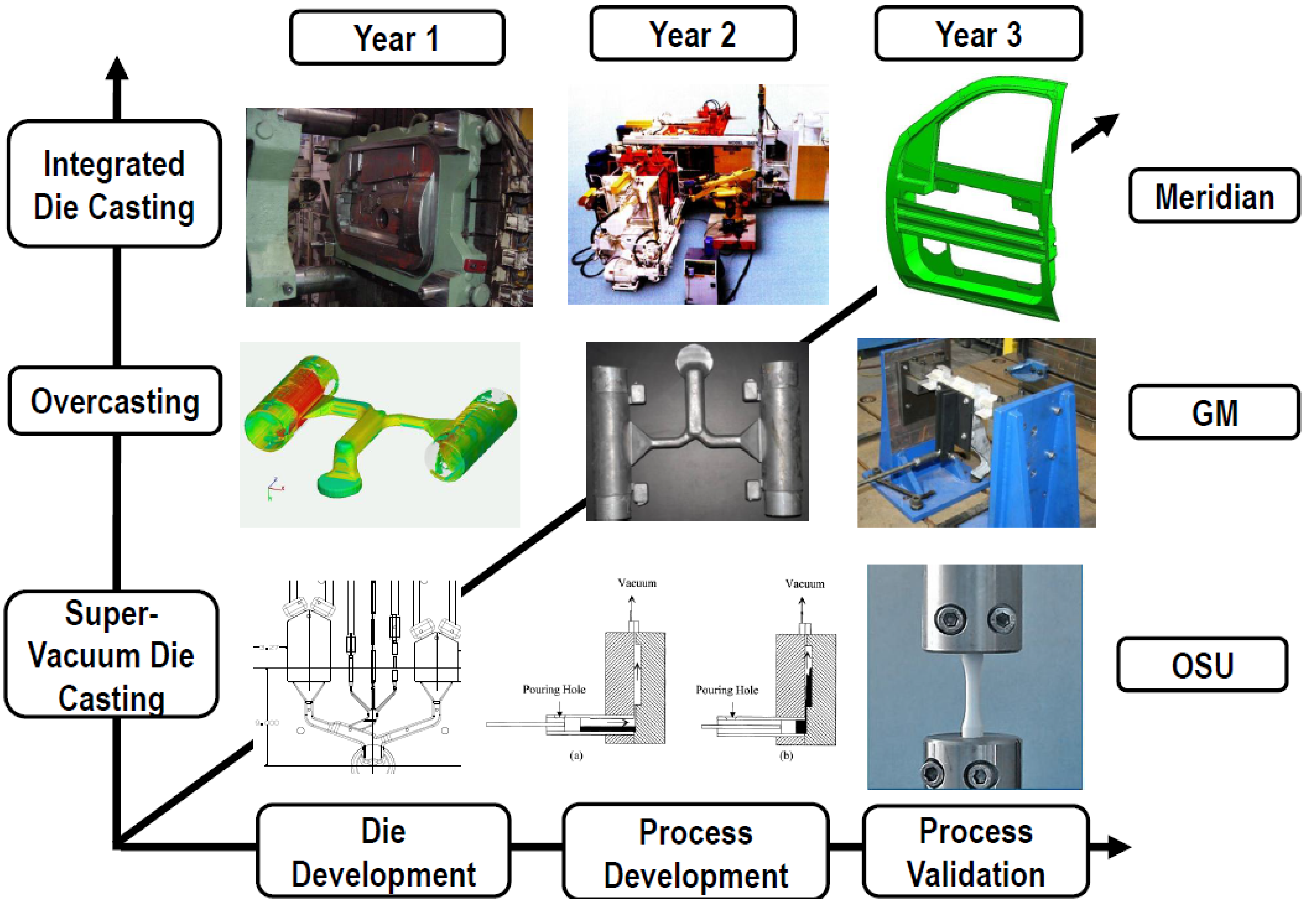
- Single Mg component + steel reinforcing bar
- Advanced Mg alloy for higher strength and ductility
- Super vacuum die casting for complete fill
- Improved ductility with less entrapped air
- Meridian, EDAG, and GM have experience with die cast Mg components
- OSU has die casting and alloy development expertise



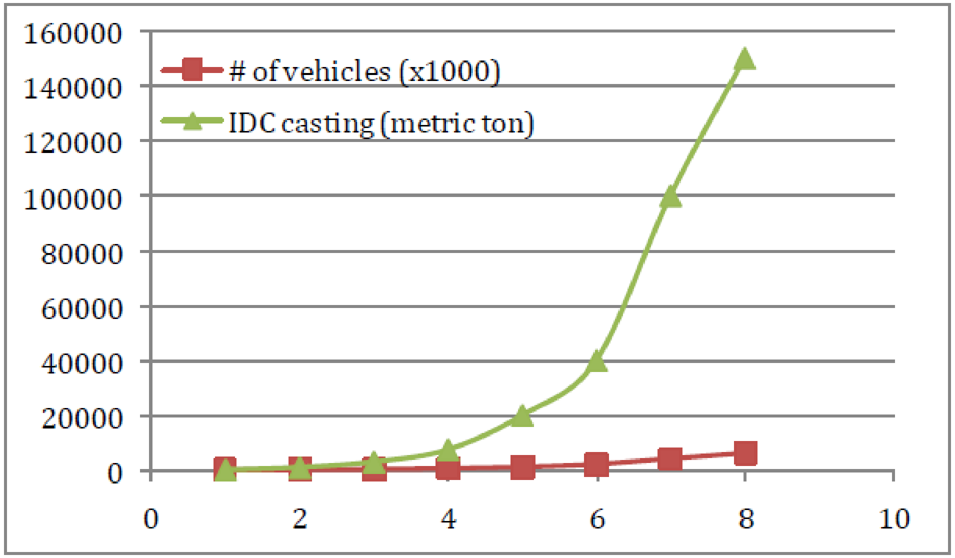
Why this is a difficult problem:

- 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)

Integrated Die Casting (IDC) Process Project Scope



Transition and Deployment



Projected commercialization ramp-up in years from project completion date

Market: automotive
Applications: side doors, cars and trucks

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

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 CO_2 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

	DIE DEVELOPMENT (Budget Period 1) 9/1/12 – 11/30/14
Task 1	Die design, simulation and manufacturing
Milestone 1	Delivery of test specimen die, vacuum capability, overcasting die, and door inner die design.
Gate 1	Die Review (Complete cavity fill and 1.5-2 mm thin-wall capability)
	PROCESS DEVELOPMENT (Budget Period 2) 12/1/14 - 11/30/15
Task 2	Casting process development
Milestone 2	Delivery of door inner die, SVDC, overcasting and IDC process parameters and test specimens/castings.
Gate 2	Process Review (less than 1% porosity and 1.5-2 mm thin-wall capability)
	TESTING AND VALIDATION (Budget Period 3) 12/1/15 – ~~8/31/16~~
Task 3	Testing and validation
Milestone 3	Delivery of specimen, component and door system test results
	PROJECT MANAGEMENT (All 4 years / entire project period)
Task 4	Project planning, coordination and reporting
Milestone 4	Delivery of energy efficiency of integrated die casting process
Gate 3	Final Review (50% energy efficiency improvement, economic benefits)

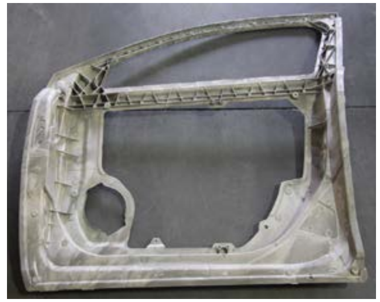
No-cost 9-month extension requested

DOE Investment	**2672**
Cost Share	**668**
Project Total, k$	**3340**

Results and Accomplishments

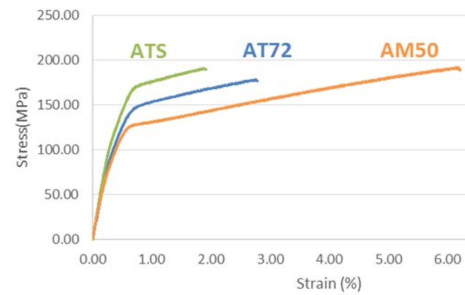
Status

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

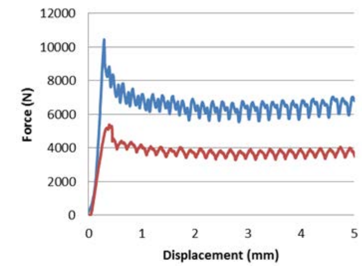


Milestones & Results

- 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.



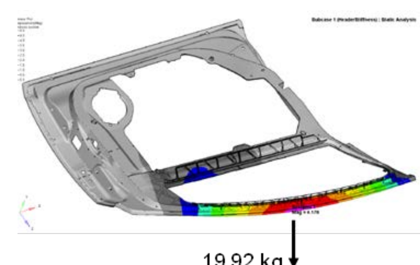
ATS alloy: ↑ strength, ↓ ductility rel. to AM50



< 10 MPa axial interface shear strength

Work to do

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



54 N/mm door header stiffness