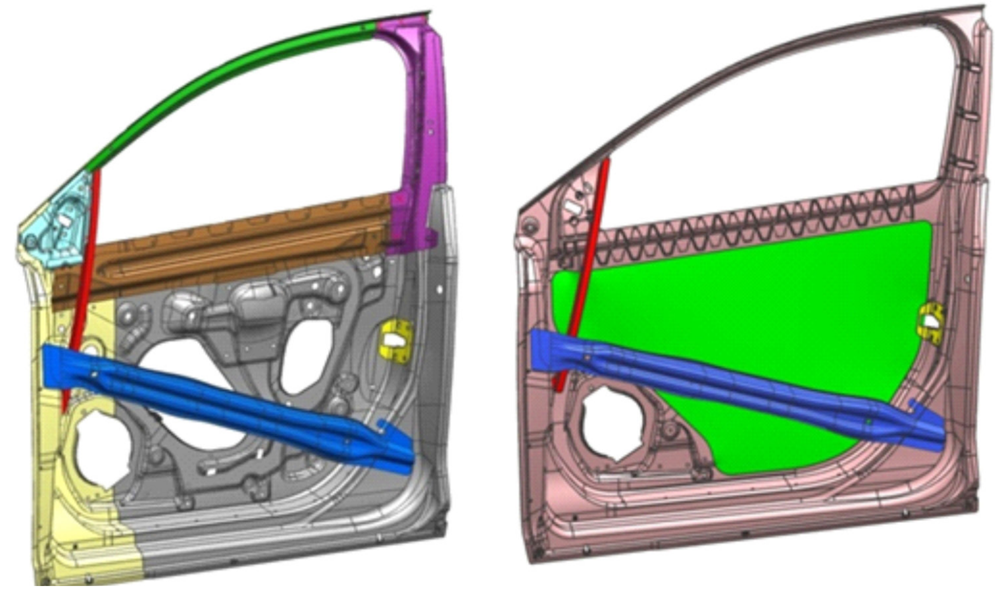
Development of Integrated Die Casting Process for Large Thin-Wall Magnesium Applications

Enabling Production of Lightweight Magnesium Parts for Near-Term Automotive Applications.



The magnesium door inner produced during this project (right) will be cast to shape, compared to an equivalent steel stamped door inner (left), which is made of multiple pieces that must be welded, thus requiring additional manufacturing steps. *Graphic image courtesy of General Motors.*

Most large automobile parts, such as door panels, are made from multi-piece, multi-step steel stamping and joining processes. However, automakers must meet challenging standards and improve fuel economy through the use of lightweight materials and innovative manufacturing methods. Magnesium, the lightest structural metal available, presents the greatest opportunity for vehicle light weighting, but is not pervasively used due to higher costs and other barriers.

Die casting, an alternative to steel stamping and joining, is considered the lowest cost and most productive casting process for producing large and complex automotive parts. Although magnesium has many desirable properties for casting, current applications of magnesium die castings are limited to non-structural or semi-structural components (such as brackets, covers, instrument panels, and steering systems). Increased application of magnesium die casting is limited due to non-ideal mechanical properties, the high cost of materials, and an increased susceptibility to galvanic corrosion.

This project aims to develop an integrated die casting (IDC) process that will overcome these limitations. IDC can achieve thin-wall, exact thickness capability in magnesium casting and consolidate multi-piece industrial structures into large, single-piece castings. The production of large, thin-walled magnesium alloy structural and closure panels will reduce process steps, materials usage, and parts count thereby reducing the embedded energy in the manufacturing value chain.

Benefits for Our Industry and Our Nation

The IDC process technology developed during this project is expected to improve energy productivity by at least 50% and result in lower CO_2 emissions when compared to conventional multi-piece, multi-step steel stamping and joining processes. In addition, the technology will also contribute to improvements in automobile fuel economy, helping meet consumer demand and industry fuel economy standards. An IDC magnesium door panel would provide a 50% mass savings when compared to a typical steel panel. Die casting also enables recycling of engineered scrap, which preserves metal value.

Applications in Our Nation's Industry

This project will utilize an automotive door inner as the example casting, but IDC technology has a wide variety of applications and could produce large, thin-wall castings for all automotive closure inner panels and other automotive structures. Application of lightweight materials is a cornerstone to all major automakers' strategies for addressing challenging fuel economy targets recently set for the industry. The IDC technology developed during this project will strengthen the domestic die casting industry and supply base of large, thin-wall magnesium panels and open up a potentially large market for applications in the automotive, heavy truck, rail, aerospace, defense, and consumer products industries.

Project Description

The project objective is to explore the ability of both the automotive component design process and the magnesium die casting process to significantly reduce weight and provide a production-ready commercial product. The magnesium door will satisfy all commercial specifications and successfully complete qualification testing. The project also targets next generation die-casting requirements through the development of an advanced magnesium alloy for improved performance, and by exploring methods to cast magnesium over steel structural supports for reduced manufacturing costs.

Barriers

- Current magnesium castings are produced through conventional high-pressure die casting (HPDC), are not considered weldable or heat treatable, and the two major magnesium alloy systems have limited strength and ductility.
- Magnesium is more expensive than steel and there are currently no high- strength magnesium alloys for HPDC applications. Some magnesium alloys that contain rare earth elements are being developed for HPDC applications, but they face serious roadblocks because of their cost and rare earth supply issues.
- Galvanic corrosion remains a concern for high-purity magnesium die castings when joined with steel components In order to mitigate corrosion issues, aluminum isolators are required when joining magnesium castings to steel, adding one step in the assembly process and additional cost.

Pathways

The project involves several critical steps:

- Initial structural design of the door to take advantage of the fact that the wall thickness can be varied to remove material where it isn't needed and to add thickness where required.
- Collaboration between the structural design team (EDAG) and the die caster (Meridian) to reconcile structural requirements with nuances related to the die design and metal flow during casting. Simulation of the casting process to optimize the die design for good metal consolidation, and to optimize the process parameters.
- Construction of the die.
- Process optimization through experiments, and fabrication of magnesium doors. Perform head-to-head crash testing vs. the steel door, plus mechanical and corrosion testing.

Additionally, advanced methods are being explored to cast magnesium over the top of steel and aluminum components. This will improve manufacturability for future applications. The energy consumption to produce doors with the die casting process will be compared to that of conventional processes.

Milestones

This project began in 2012.

- Finalize door design (Completed).
- Design the die, including simulations to validate the design. (Completed).
- Evaluate mechanical and corrosion properties of advanced alloys and overcasting for next generation castings (2015).
- Deliver structural and corrosion test results of specimens, door inner cast-ings, and assembled doors (2015).
- Perform crash testing on the magnesium doors and evaluate with respect to their steel equivalent (2016).
- Deliver results on the energy efficiency of the IDC process (2016).

Commercialization

The team will target application of IDC for near-term mass production of lightweight inner closure panels and other structural applications. After successful deployment in GM applications, the technology would be marketed by Meridian to other manufacturers in order to maximize benefits to U.S. industry. Implementing the IDC process in current U.S. manufacturing would require minimal changes to existing plants and equipment and will require only small investments. With rapid adoption, IDC could be applied to all five inner closure panels for about half of the vehicles produced annually in the United States within 10 years.

Project Partners

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