Magnesium for Automotive Lightweighting: Status and Challenges

Sarah Kleinbaum

Abstract

Cast and wrought magnesium have long been identified as a key pathway to automotive lightweighting and improved energy efficiency. However, adoption in the automotive market remains low. This talk will look at the application of magnesium components into various vehicle subsystems from 2012 through today and identify the technical challenges that currently limit full adoption.

Keywords

Magnesium • Lightweight • Automotive • Challenges

Motivation

Magnesium is widely recognized as one of the four high potential materials for achieving automotive lightweighting along with aluminum, advanced high strength steel, and polymer composites. With the lowest density of any structural metal, magnesium has twice the specific strength of mild steel. Magnesium also has great castability due to its fluidity that has led to the use of complex thin-walled magnesium die cast components, such as instrument panels, in vehicles. However, magnesium currently accounts for less than 1% of a vehicle's weight on average due to several technical challenges. To better understand the state of magnesium penetration into the automotive industry and the need for research to increase that penetration, we will conduct an analysis of automotive components made from magnesium from 2012 through today.

Methodology

To determine the extent of magnesium usage in automotive components and the change in usage over time, teardown data from 38 midsize vehicles sold in the USA and available in the A2MAC1 database will be examined. The vehicles selected represent all the available teardown data for this size class and location from 2012 through 2016 and span a wide range of sales price points and curb weights within the class. Material type and weight of each component were determined visually by A2MAC1. Required component functionality (strength, stiffness, energy absorption, aesthetics, etc.) will be assessed and technical gaps identified.

Known Challenges

Many automotive components are produced from flat sheet and stamped into their final shape. Magnesium has a strong basal texture that evolves during the rolling of ingot into sheet which limits its room temperature formability. Some alloys of magnesium can be stamped at higher temperatures, around 250 °C, due to the addition of rare earth elements but with limited draw depths and often at a higher cost. At this temperature, die lubrication also becomes a challenge as the lubricant often bakes onto the sheet and is difficult to remove prior to painting.

For both wrought and cast components, corrosion resistance of magnesium is a concern. Unlike steel and aluminum, which form stable oxide layers, magnesium forms oxides that are porous and ineffective at preventing further corrosion. Paints can be applied to improve corrosion resistance but require a unique pre-treatment that requires the magnesium components to be painted individually rather than as part of a larger sub-assembly. Galvanic corrosion is also an issue when magnesium is part of a multi-material assembly. Coatings or other isolation strategies are necessary to prevent accelerated corrosion.

S. Kleinbaum (✉)
Vehicle Technologies Office, Office of Energy Efficiency and Renewable Energy, Department of Energy, 1000 Independence Ave SW, Washington, DC, USA
e-mail: Sarah.kleinbaum@ee.doe.gov

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Welding and joining of magnesium to other materials in assemblies also present a challenge. Magnesium's low melting temperature and immiscibility with steel prevent fusion welding, which is the first choice of the automotive industry. Fasteners such as self-piercing rivets can cause cracking of the magnesium as well as galvanic corrosion. Solid state welding techniques show some promise, but these have not yet achieved widespread adoption by the automotive community.

Expected Results

The challenges outlined above are well-known and the subject of much academic and industrial research. The analysis to be undertaken should help highlight the progress made to overcome these challenges and where further research is needed to increase the use of magnesium to lightweight vehicles.