Pacific Northwest
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PNNL-35288

Non-Rare Earth Magnesium Bumper Beams - CRADA 418 (Abstract)

CRADA 418 (PNNL 72457)

February 2024

Scott A Whalen

Magna Services of America Inc.

U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Richland, Washington 99354

Abstract

Magna will team with the Pacific Northwest National Laboratory (PNNL) to develop Shear Assisted Processing and Extrusion (ShAPE™) of rectangular and multi-zoned extrusion profiles using non-RE Mg. It is envisioned that the ShAPE™ process, developed during this project for non-circular profiles, will serve as the foundation for fabrication of full-scale bumper beams of the future where near net-shapes are extruded directly from castings in a single step, without the need for costly rare earth additives. In this project, the ShAPE™ process will be developed for a rectangular profile measuring 1” x 2” with a 0.06” wall thickness. Successful extrusion of rectangular cross sections is a critical step along the path toward profiles with multiple zones. With the process established for a rectangular profile, the project will then make advancements toward multi-zoned cross sections.

A magnesium alloy bumper beam offers a 35% weight savings compared to aluminum alloys and 60% compared to high strength steels. The bumper beam was chosen as the first component to target because the geometry can have a fairly simple 0.6-0.12 inch wall/web thickness, generally compatible with PNNL’s knowledge base and equipment capability surrounding ShAPE™. The bumper component offers commercial value by providing mass reduction in the front of the vehicle along with ride and handling benefit. PNNL has demonstrated the ability to ShAPE™ process non-RE Mg tubing with high strength, ductility and energy absorption. It has been shown that ShAPE™ extruded ZK60 and Mg_2Si tubing with 0.30 inch diameter and 0.03 inch wall thickness have similar energy absorption to AA6061-T6. This is due to significant grain refinement, breakdown and dispersion of second phases, and the ability to eliminate anisotropy in compressive/tensile strength by aligning texture 45 degrees to the extrusion axis. Scalability of the ShAPE™ process has been demonstrated in ZK60 by fabricating 2.0 inch diameter tubing with 0.06 and 0.12 inch wall thicknesses having concentricity as tight as 1.3%. These tubes exhibit an ultimate tensile strength of 260-300 MPa and room temperature ductility of >20% parallel, perpendicular and 45 degrees to the extrusion axis.

Aluminum bumpers represent approximately 54% of the NA light vehicle market. If the research effort is successful, providing a 30% mass reduction at equal cost relative to aluminum bumpers, it is anticipated that 25% market penetration would be realized over the next 5 year and 50% market share by 2030. 100% of the aluminum automotive bumpers are sourced from the tier network, providing resourcing opportunity based on equal performance, reduced mass and cost equivalent lower than aluminum bumpers. Due to the relatively low vehicle content, magnesium components are currently shredded and 100% recycled with aluminum content in the US, presenting a positive life cycle impact.

Pacific Northwest National Laboratory

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99354
1-888-375-PNNL (7665)

www.pnnl.gov