Non-Rare Earth Magnesium Bumper Beams

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2Magna International, Corporate R&D

Project ID#: MAT-149

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Overview

- Project start date: Jan. 2019
- Project end date: Dec. 2020
- Percent complete: 13%

Timeline

Budget

- Total project funding: $1,000K ($500K/yr)
- $500K - DOE share
- $500K - Industry share

Barriers

- Material technology roadmap for magnesium
  - Low cost feedstock
  - Improved alloys for energy absorption
  - Manufacturing of extrusions
  - 250 MPa yield strength and 15% elongation by 2025

Partners

- Magna International
- Pacific Northwest National Laboratory (PNNL)
Relevance

• **Challenge**
  - Improved energy absorption in magnesium alloys
  - Lower cost materials and manufacturing pathways

• **Objective**
  - Develop Shear Assisted Processing and Extrusion (ShAPE) to fabricate *magnesium extrusions with rectangular profile*
  - Eliminate costly rare-earth (RE) elements
  - Equivalent energy absorption relative to Al extrusion
  - Progress toward multi-zone extrusions

• **Benefit**
  - >30% weight reduction possible by replacing of aluminum bumper beams with magnesium alloy
What is ShAPE?
- Scalable method of extruding materials with microstructures and bulk properties that cannot be achieved by conventional extrusion
- Linear and rotational shear are combined to plasticize material without melting

This project will adapt ShAPE for rectangular hollow profiles
- Move from round tubes to non-circular profiles of interest in bumper beam applications
- Adapt ShAPE for portal bridge die approach

Benefits of ShAPE for Mg
- Grain refinement and texture alignment
  - Eliminates asymmetry in tensile/compressive strength
  - Energy absorption of non-RE ZK60 equivalent to AA6061
  - >20% room temperature elongation
- 10-20X reduction in ram force
- Potential for industrial scale
ShAPE extrusion enables non-RE Mg alloy ZK60 to attain energy absorption similar to AA6061.
• Project scope finalized on Jan. 3rd, 2019
• Project kick-off with PNNL and Magna in Richland, WA on Mar. 12th, 2019
• Task 1: Initiated die design process

**Patent-Pending PNNL Technology

Work has begun on design of portal bridge dies for ShAPE extrusion of non-circular cross sections
Demonstrated that ZK60 can be re-combined in weld chamber after flowing through portals

- Die design variations underway to investigate the effect of die design features on material flow in weld chamber and around mandrel
- Magna will be conducting modeling and simulation efforts of material flow within the portal bridge die to aid in die design

Material re-combination shown for portal bridge die integrated into ShAPE process
Collaboration

• Pacific Northwest National Laboratory
  ▪ Scott Whalen (PI)
  ▪ Md. Reza-E-Rabby (Die design)
  ▪ Jens Darsell (Process development)
  ▪ Dalong Zhang (Characterization)

• Magna International
  ▪ Tim Skszek (PI)
  ▪ Massimo DiCiano (Flow Modeling)
  ▪ Mechanical testing of ShAPE extrusions
  ▪ Design of extrusion profile geometry
  ▪ Modeling of material flow in ShAPE extrusion dies
  ▪ Extrusion Die Fabrication
### Proposed Future Research

Proposed future work is subject to change based on funding levels.

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<th>Task Number &amp; Brief Description</th>
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<th>FY2020</th>
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- **Extruded non-RE Mg with rectangular hollow profile**
- **Perform microstructural characterization and mechanical property testing**
- **Complete mechanical testing of ShAPE extrusions**
• **Relevance**
  - Improved energy absorption in Mg alloys
  - Lower cost materials and manufacturing
  - >30% weight reduction possible by replacing of aluminum bumper beams with magnesium alloy

• **Approach**
  - Develop Shear Assisted Processing and Extrusion (ShAPE) to fabricate non-RE magnesium extrusions with rectangular profile
  - Equivalent energy absorption relative to Al extrusion
  - Progress toward multi-zone extrusions

• **Accomplishments**
  - Project kick-off between PNNL and Magna on 3/12/19
  - Portal bridge die design underway – Joint effort between PNNL and Magna
  - Initial trials performed to demonstrate re-combination of flow streams in portal die