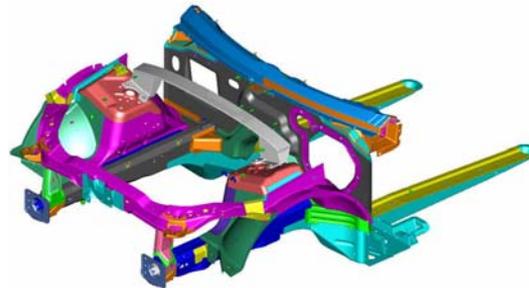


Magnesium Front End Research and Development **Project ID Im_20_quinn**

AMD 604

2009 DOE Merit Review Presentation

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Unibody Architecture - Steel

Acknowledgement

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Overview

Timeline

- Start: Oct. 1, 2006
- End: Sept. 30, 2009
- 65% complete

Budget

- Total project funding
 - DOE: \$1.5 M
 - USAMP: \$3.5 M
 - + Canada: \$3M (U.S. Equiv.)
 - + China: \$3M (U.S. Equiv.)
- Funding received in FY08: \$347.7 K
- Funding for FY09: \$934.0 K
- Funding for FY10: \$0
(Project ends FY09)

Barriers/targets

- Improved high volume manufacturing techniques for shaping for Mg- Low-cost extrusion, casting and sheet forming technologies.
- Improved high volume manufacturing techniques for joining of Mg - Large-scale joining and corrosion protection of magnesium structures.
- Corrosion: Durability of Mg-intensive structures (fatigue and corrosion).

Partners

- **OEMs:** Chrysler, Ford, GM
- U.S. Supplier list (next slide)
- International Partners from China and Canada. (slide 4)



USAMP AMD 604 – Magnesium Front End Research and Development



U.S. Partner Organizations

Cosma Engineering

University of Dayton – Research Institute

IAC Corporation

Westmoreland Testing

Henkel U.S.

PPG Industries

Chemetall Oakite

MetoKote

Atotech

MacDermid

Luke Engineering

University of Michigan – Dearborn

Ohio State University

Eastern Michigan University

Contech U.S., LLC

Scientific Forming Technologies Corp.

Lehigh University

North Dakota State University

Mississippi State University

Magni Industries

Keronite

International Hardcoat Corp.

Dow Automotive

Visteon Inc.

MNP Corp.

ATF Inc.

Kamax LP

REMINC

Hitachi America

North American Die Casting Assn.

Gibbs Die Casting

EKK Inc.

Timminco Corp.

U.S. Magnesium Corp.

International Partner Organizations

Canada

CANMET
(Natural Resources Canada)
University of Waterloo
University of Western Ontario
Ryerson University
University of Sherbrooke
GM – Canada
University of Windsor
Centerline Corp.
University of Toronto
NRC – Aerospace Divn.
MAGNA
Meridian Corp. - Canada

China

China Magnesium Center
(Ministry of Science and Technology)
Tsinghua University (Beijing)
Meridian Corp. - China
Louyang Copper
Zhejiang University
Shanghai Jiao Tong University
Xi'an University of Technology
Chongqing University
Northeastern University
Inst. of Metals Research – Shenyang
Dalian University
Shanxi Yingguang Magnesium

Overall Objectives

Organize and deploy an international research and development project aimed at the advancement of magnesium technology by a dedicated collective of researchers toward the goal of having sufficient engineering and manufacturing capabilities to exploit the full weight-reduction potential of magnesium alloys as engineering materials for entire automotive sub-structures, thereby leading to concomitant fuel economy realizations at affordable cost, excellent vehicle performance and with due consideration for the environment.

General Targets:

- Mass reduction up to 60% less than steel comparator; 35% less than aluminum comparator structure.
- Neutral or negative cost penalty compared to steel baseline.
- Vehicle performance attributes comparable to baseline structures.

FY2008 Targets

- Support conduct of international review meeting in China, April 2008.
- Demonstrate technology readiness required to pass USAMP AMD Board “Gate 2” Review, July 2008.
- Develop pertinent technologies to meet U.S. task goals
- Assure conduct of individual task area research and achievement of international task area goals.
- Provide performance and manufacturing data to companion AMD603 design project for incorporation in “Phase 2” adaptations.

FY2008 Milestones

- Participated in 2nd International Review Meeting, Hangzhou, PRC, April 1-4, 2008.
- Contributed to 1st published review document of the international project released at China meeting.
- Passed USAMP AMD Board Gate 2 Review in July, 2008.
- Individual Task Area achievements detailed by list in this report.

APPROACH

1. Knowledge-based attributes by Task team:

Task 1.1 – Crashworthiness

Task 1.2 - Noise, Vibration, Harshness (NVH)

Task 1.3 - Durability (fatigue, fracture, environmentally-assisted fracture)

Task 1.4 - Corrosion and surface treatment

2. Enabling Materials and Manufacturing Technologies

Task 1.5 – Low-cost extrusion and forming.

Task 1.6 – Low-cost sheet and forming.

Task 1.7 - High-integrity casting.

Task 1.8 - Joining

3. Integrated Computational Materials Engineering (ICME) – conducted as separate projects: AMD702 and AMD703.

4. Phased long-term project with decision gate in 5/09 to build prototype structure or surrogate structure in Phase 2 continuation if agreed.

FY2008 Accomplishments

Task

- 1.1 Crashworthiness** – Fabricated and conducted static and dynamic evaluation of tubular crush structures in 2 of 3 materials of consideration: AZ31 sheet and AM30 extrusion.
- 1.2 NVH** – Developed noise transmission models and evaluation of acoustic materials. Provided CAD models and materials to partner countries for analysis.
- 1.3 Durability** – Organized and conducted 3-country round robin fatigue tests of AM30 extrusion material. Developed geometry for welded joint fatigue studies.
- 1.4 Corrosion** – Conducted 1st round evaluation of candidate surface pretreatments and developed approach for evaluating coatings to steel fasteners in galvanic couples.
- 1.5 Extrusion** – Conducted validation of DEFORM model for extrusion process and designed and produced extruded AM30 box sections for crashworthiness testing.
- 1.6 Sheet** – Conducted companion project AMD602 for warm-forming of AZ31 sheet material. Obtained novel twin-roll sheet materials from China for evaluation.
- 1.7 Casting** – Obtained first “super vacuum die cast” components and provided materials for testing and analysis by other task teams. Developed tooling and analysis for Task 1.1 crush tube components to be manufactured by the SVDC process.
- 1.8 Joining** – Conducted assessment of pretreatment effect on adhesive bonding and loss of adhesive strength in corrosion undercutting. Developed programs for threaded fasteners and friction-stir welding.

FY2008 Accomplishments - Highlights

- New understanding and limitations in crashworthiness and NVH
- New processes such as super-vacuum die casting and continuous cast sheet
- Promising results in corrosion (coating protection), fatigue and joining technologies
- Limitation of the current AZ and AM alloys: low properties and strong anisotropy

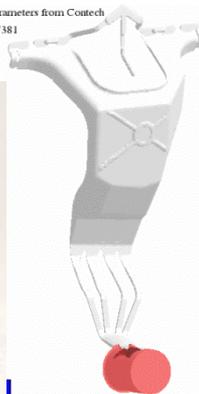


AM30 Extrusion
Crush Test

Super-Vacuum Die Casting Development
50-60% Improvement in Ductility



AZ91D Process Parameters from Contech
Elapsed Time = 0.7381
Fluid fraction



Alloy	UTS, MPa	YS, MPa	Elongation, %
AZ91D-SVDC	230	160	4
AZ91D-HPDC	200	150	2.5
AM60B-SVDC	230	125	9
AM60B-HPDC	210	120	6

Future Work

1. Conduct decision gate process with international partners in May, 2009 to determine parameters for either continuation of research or termination of efforts in September '09.
2. Conclude all Phase 1 task objectives by end of Sept. '09, or seek extensions to continue specific research in the following task areas requiring additional time and effort:
 - a.) Fatigue and Durability (1.3)
 - b.) Corrosion and Surface Treatment (1.4)
 - c.) Joining (1.8)
 - d.) Novel crashworthiness options including mixed material designs.
3. Provide ongoing details of design and manufacturing to companion project AMD603 (Design and Development) for incorporation into determination of design performance by CAE (e.g. durability and crashworthiness) and manufacturing 'Bill of Process' which forms the basis for technical cost models.

Summary

- The AMD604 Project has clearly demonstrated the capability for an international cooperative research effort with multiple and complex technical disciplines and targets, and the associated organizational structure required to effectively conduct the research work and make the results known to participants.
- Indications from the companion design project (AMD603) suggest that design targets for weight reduction relative to steel baseline may approach a 50% capability for the unibody structure based upon known forming technologies (e.g. die casting, sheet forming and extrusion), and presumptions regarding joining and surface finishing technologies.
- Crashworthiness and durability (e.g. fatigue, corrosion, stress corrosion) remain among the top “knowledge-based” concerns and areas for improved information and consideration.
- Surface treatment for corrosion protection and selection of appropriate joining technologies are among the critical manufacturing issues to be determined.
- Capability to form all constituent magnesium components via die casting, extrusion or sheet forming by “warm” processes appears feasible.