

Development of High-Volume Warm Forming of Low-Cost Magnesium Sheet

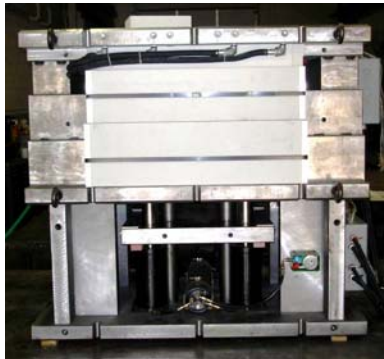
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AMD 602

2009 DOE Merit Review Presentation

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Overview

Timeline

- Start: Nov. 1, 2006
- End: Sept. 30, 2009

Budget

- Total project funding
 - DOE share: \$675k
 - USAMP share: \$675k
- Funding received in FY08 : \$206 K
- Funding in FY09: \$245 K
- Funding plan for FY 10: \$0
(project ends FY09)

Barriers/targets

- Development of a high volume manufacturing technique for forming magnesium sheet.
- Determination of process parameters for warm forming of magnesium sheet.
- Development of a supply base for low-cost magnesium sheet.

Partners

- OEMs: Chrysler, Ford, GM
- Supplier list (next slide)

AMD 602 Project Team

- OEM's
 - **Chrysler, Ford , GM**
- Contracts
 - **Troy Tooling Technologies**
 - **Materials Suppliers**
 - Magnesium Elektron
 - POSCO
 - Thyssen
 - CSIRO
 - Luoyang CU
 - **U. of Virginia**
 - **CANMET**
 - **PNNL**
 - **Fuchs Lubricants**
 - **Jay and Kay Manufacturing**
 - **Ricardo Meda**

Overall Objectives

Develop the technology and material supply base for cost-effective lightweight body panels fabricated from sheet magnesium. A warm forming system will be designed and built to develop a suitable process for forming magnesium sheet as well as a test bed to evaluate potential low cost magnesium sheet from various global producers. Specific deliverables from this project will include the following:

- Design and build a warm forming die and demonstrate a deep draw capability on conventional direct chill (DC) material.
- Evaluate materials and compare the formability of continuous cast (CC) and direct chill (DC) materials.
- Demonstrate high volume cycle times with CC material on an integrated forming cell.

FY2008 Targets

- Complete the material characterization work through microscopy, elevated temperature tensile testing and formability experiments on alloys from four suppliers.
- Develop forming limit curves for all test alloys at two different temperatures.
- Complete first full-scale forming trial and determine a forming window for Mg sheet with respect to temperature, binder pressure, lubricant and blank size.
- Develop a strategic approach to automating the warm forming system.

FY2008 Milestones

- Completed material evaluation and demonstrated comparable formability between CC and DC materials.
- Defined a forming window for magnesium sheet in terms of key process parameters.
- Initiated design and development of an integrated warm forming cell.

APPROACH

Continuous casting (CC) is a key technology for enabling the development of low cost Mg sheet. This project will drive material development in the supply base by giving them a mechanism for evaluating materials. The project will receive material from major global magnesium suppliers including Magnesium Elektron, CSIRO, ThyssenKrupp, LY Copper, and POSCO. These materials will be characterized via tensile testing at the University of Virginia, biaxial forming at CANMET, and through stamping trials at Troy Tooling Technologies.

Novel die systems will be designed and constructed that enable the use of warm forming in a conventional single-action presses. The die will be used to determine critical forming parameters for magnesium sheet including lubricant thickness, preheat temperature, die temperature, forming speed, etc. The forming windows for the different materials will be determined to see the effect of processing via different methods, e.g. continuous casting vs. ingot (DC) casting.

Full automation including loading of pre-heated sheet and part extraction will be developed to achieve acceptable cycle times (5-10 jpm) demonstrating the high volume feasibility of warm forming.



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Forming of Low-Cost Magnesium Sheet*



APPROACH

TASK 1: Acquire Low-Cost Magnesium Sheet

TASK 2: Design and Build Warm Forming Tool

TASK 3: Material Characterization

TASK 4: Lubrication

TASK 5: Die Tryout and First Phase Trials

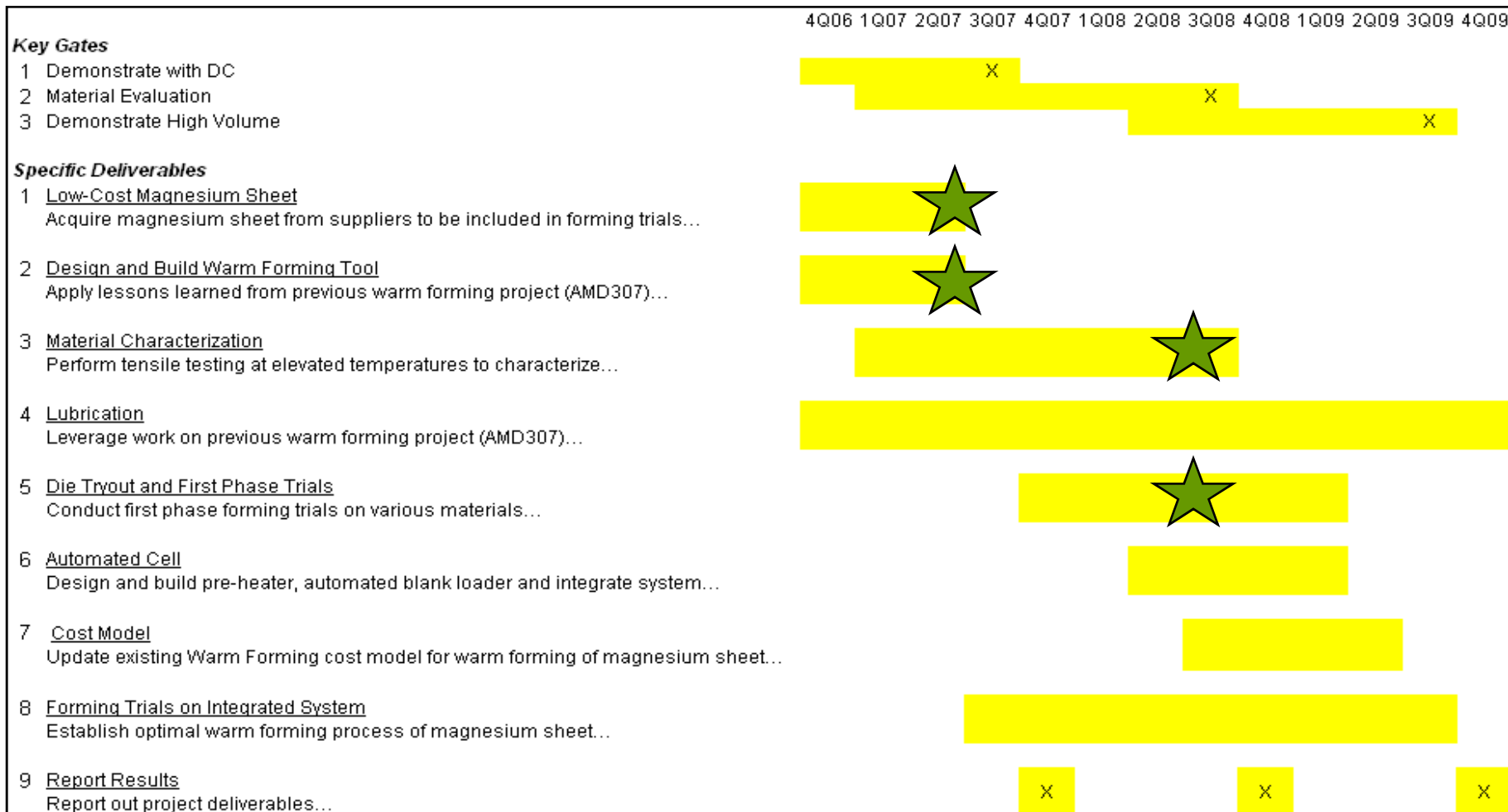
TASK 6: Automated Cell

TASK 7: Cost Model

TASK 8: Forming Trials on Integrated System

TASK 9: Report Results

Project Timing



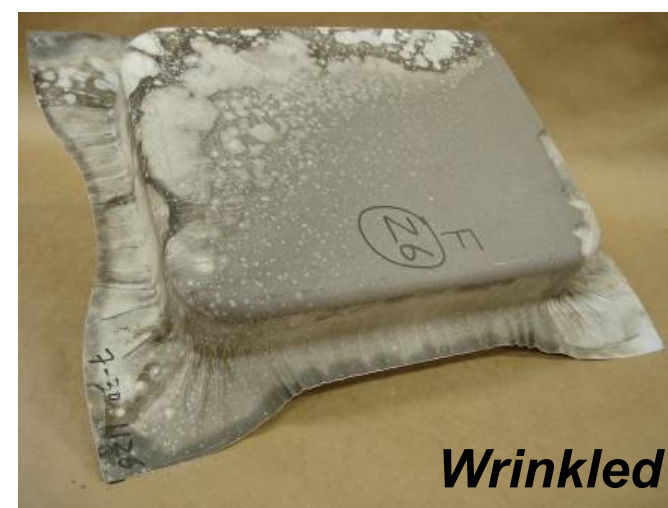
Indicates task completed

FY2008 Accomplishments

- Completed the material characterization work through microscopy, elevated temperature tensile testing and formability experiments on alloys from four suppliers.
 - Low Cost CC materials gave mechanical properties comparable to DC material
- Demonstrated the formability of the continuous cast alloys with both tensile testing, lab-scale formability experiments and full warm forming trials. Developed forming limit curves at CANMET for all test alloys at two different temperatures.
- Completed first full-scale forming trial and determined a forming window for Mg sheet with respect to temperature, binder pressure, lubricant and blank size.
- Developed a strategic approach to automating the warm forming system based on existing equipment donated to the project from GM (sheet pre-heater) and Ford (robot).
- Established the feasibility of using a new lower-cost synthetic oil lubricant for forming at temperatures up to 275C.

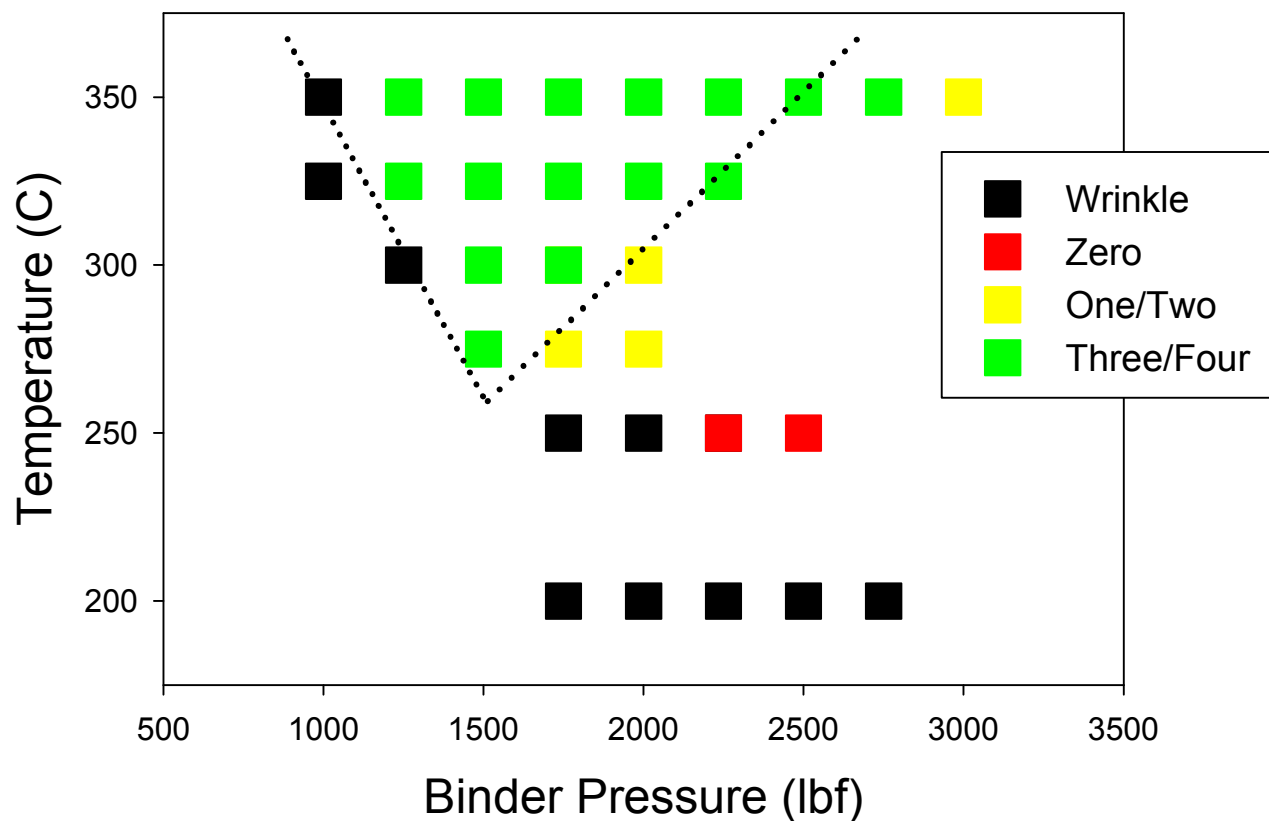
FY2008 Accomplishments

Observed conditions after forming



FY2008 Accomplishments

Forming Window with Dry (BN) Lubricant

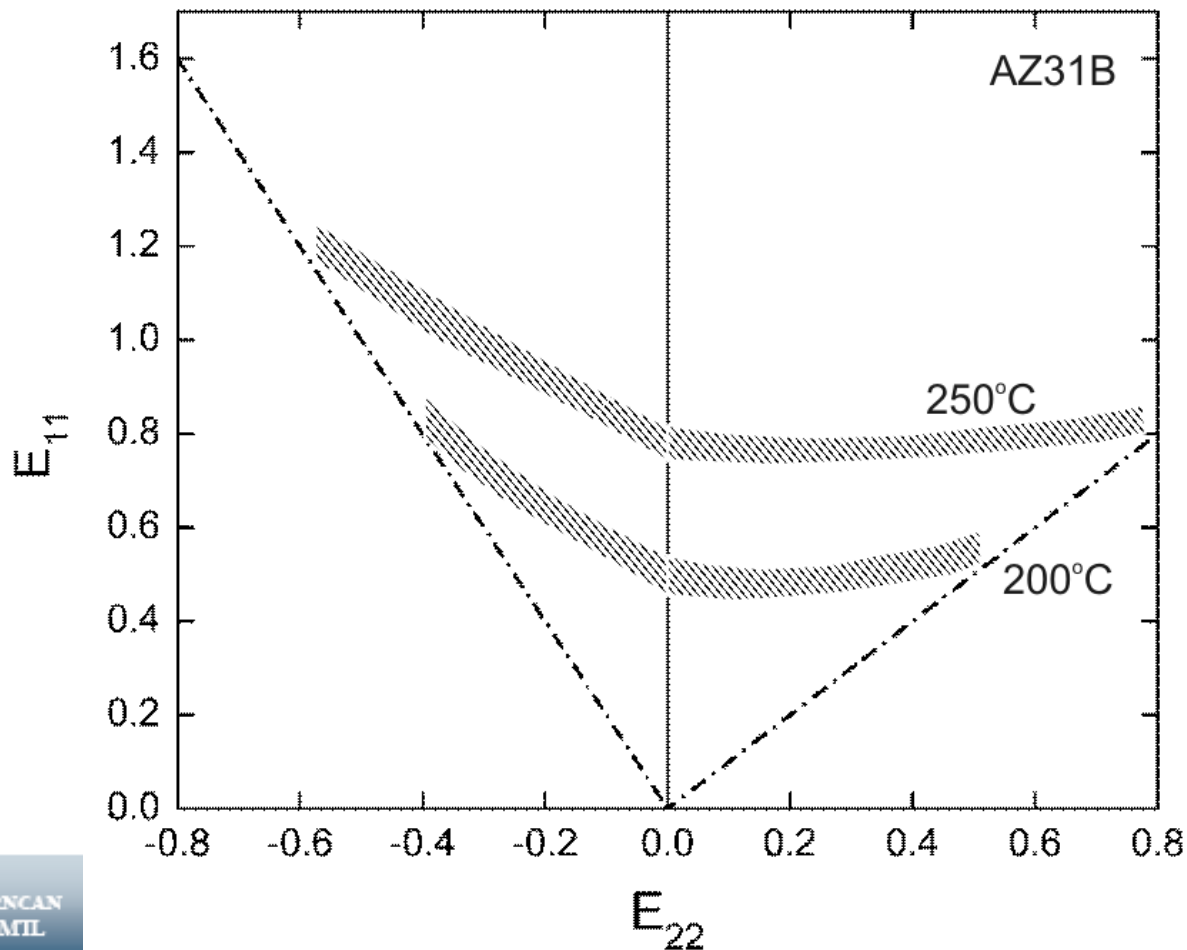


Legend shows number of corners which successfully formed

FY2008 Accomplishments

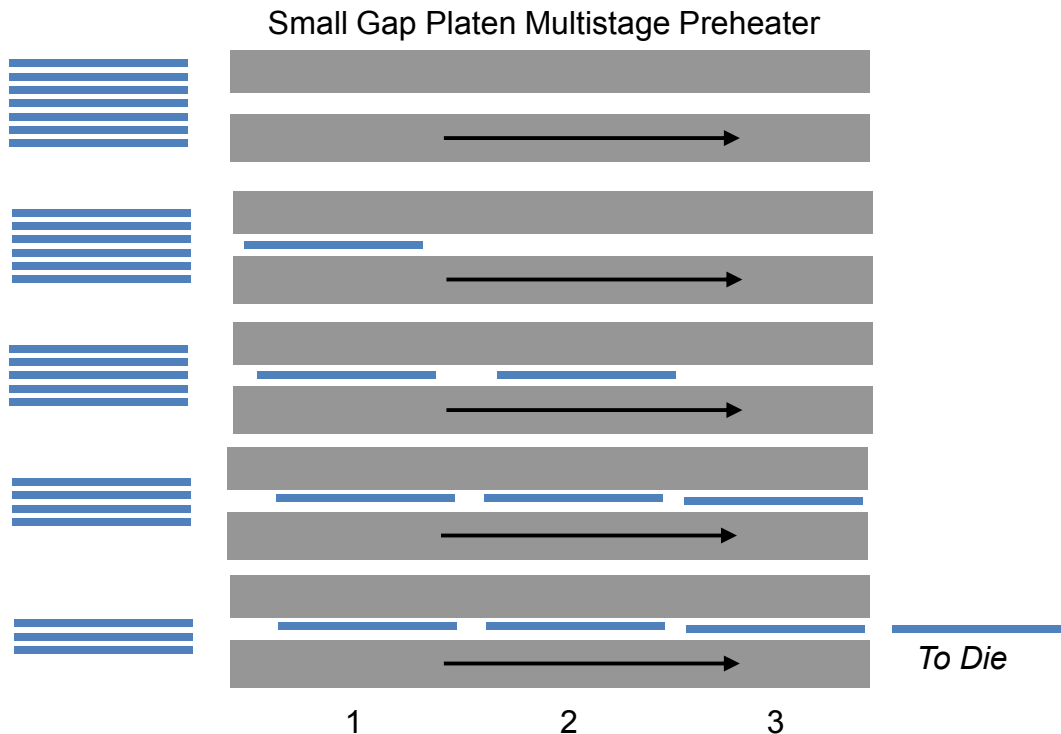
Example of family of temperature effect FLDs being developed by CANMET

Forming Limit Diagram for AZ31



Future Work

- Develop and integrated warm forming cell and demonstrate high volume warm forming of magnesium sheet at a production rate of 5-10 jpm.





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Summary

- AMD602 is proceeding as scheduled
- All AZ31 materials have been provided by suppliers
- Materials testing ongoing
- Baseline forming trials complete
- Material Comparison trials begun 1Q09
- Process integration and demonstration on track for 3Q09
- Patents filed on both die and process technology.