Warm Forming of Aluminum – AMD 307

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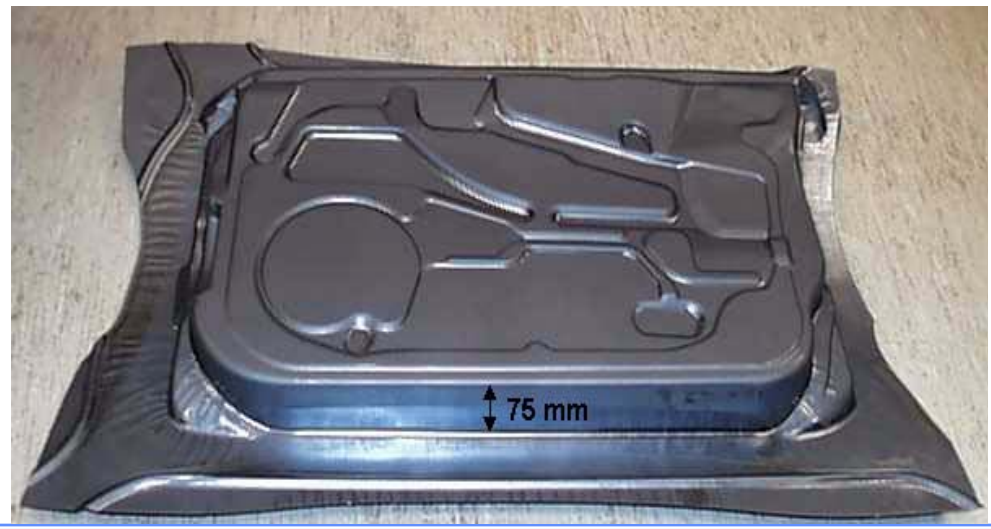
Background

- **The formability of aluminum is less than that of steel which necessitates multi-piece structures, design compromises, or alternate forming technologies.**

- **Warm Forming AMD Project *Phase I*:**
  - Successfully demonstrated that depth of draw for a door inner panel could be made using warm forming.
  - Demonstration done in “prototype” mode with long cycle times.
    - Specially processed Al alloy
    - MoS_2 lubricant
    - Poor thermal control
    - In die preheating



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Goals for AMD 307

- To develop the key elements of a warm forming process including lubrication, blank preheating, die thermal control, and material handling.
- To deliver a fully-demonstrated warm forming process.
- To determine financial viability of warm forming using a technical cost model.

Relationship to FreedomCAR

"Enable the high volume production of vehicles that are: half the mass, are more recyclable, match or surpass quality & durability versus today's vehicles"

- **The proposed project will be very important to allow FreedomCAR to meet their goals. Expanded formability is essential for the cost-effective application of aluminum sheet in automotive structures and closures.**

- **This project will develop the key technologies needed to make warm forming a production solution for high volume manufacturing.**

AMD 307 Project Team

- **AMD 307 OEM Committee**
  - DaimlerChrysler – Ken Oikarinen
  - Ford – Peter Friedman, George Luckey
  - GM – Paul Krajewski, Richard Hammar
  - NCMS – Debra Lilu / Connie Phillips

- **AMD 307 Contractors**
  - Troy Tooling Technologies – Dennis Cedar
  - Pechiney Rolled Products – Paul Kobe, Pierre Litalien
  - Fuchs Lubricants – Jim Mieczkowski, Marvin Phillips, Anand Kakar
  - Camanoe Associates – Rich Roth
  - Jay and Kay Manufacturing – Carol Young, Scott McKean
  - Ricardo Meda – Dajun Zuo
  - U. of Michigan - Amit Ghosh, Hong Seok Kim, Muammer Koc, Jun Ni

Project Budget

Time-line: 4/1/2001 - 9/31/2006

Amounts in X $1000

Resources							
	Govt. Funds	Industry match					Total Industry Match
		Cash	In-Kind				
Time Period (CY)	DOE		DCX	Ford	GM	Suppliers	
4/1/2001-12/31/2001			Actuals in 2001----------				$52.5
1/1/2002-12/31/2002	$231.2		Actuals in 2002----------				$11.1
1/1/2003-12/31/2003	$188.7		Actuals in 2003----------				$70.5
1/1/2004-12/31/2004	$170.2		Actuals in 2004----------				$109.8
1/1/2005-3/31/2005	$316.9		$110.0	$90.0	$90.0	$197.6	$487.6
1/1/2006-12/31/2006	$136.2		$90.0	$70.0	$70.0	$122.4	$352.4
TOTALS	**$1,043**		$110	$90	$90	$198	**$1,084**

Total Budget: $2.13 million

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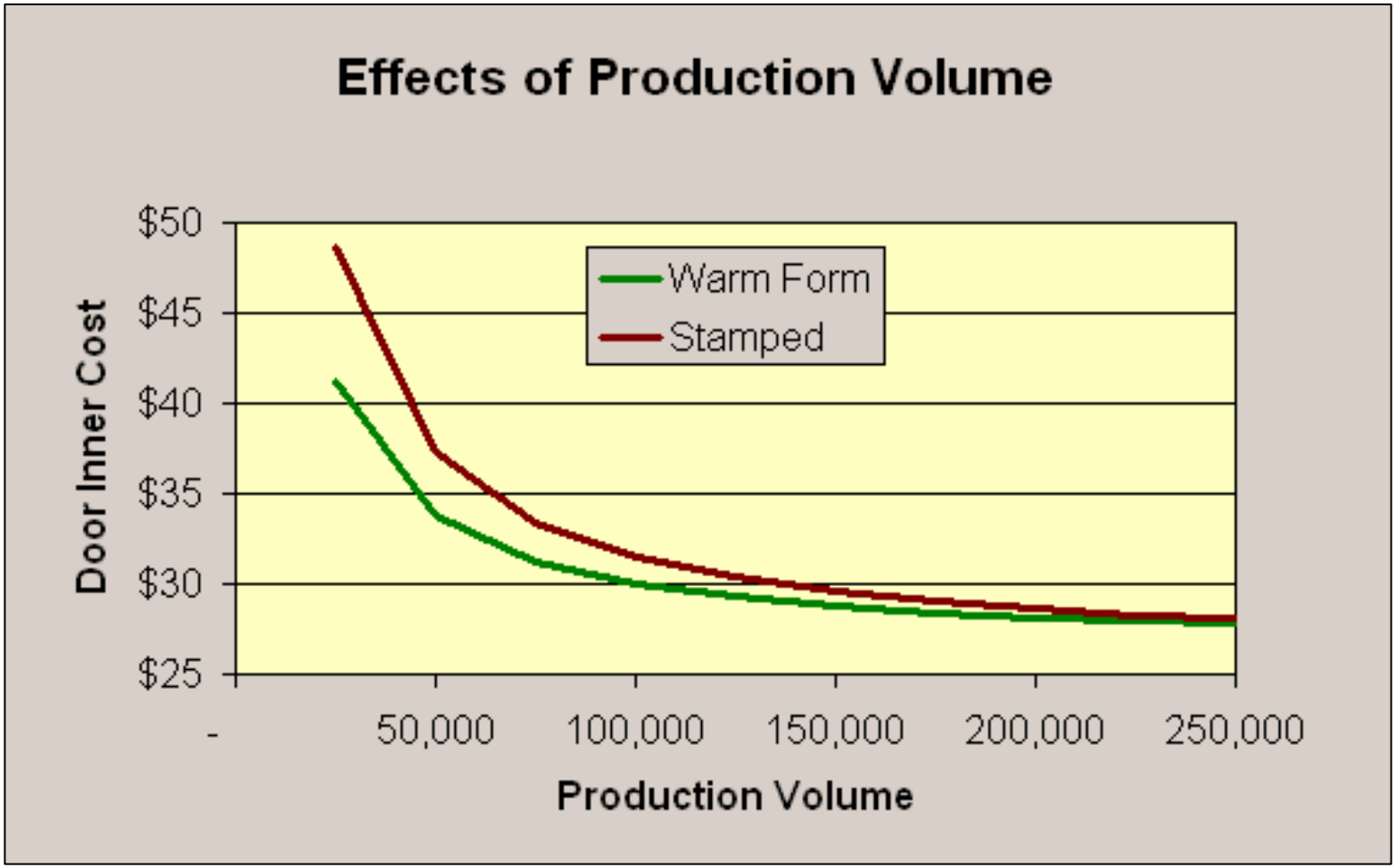
Warm Forming Technical Cost Model



Comparing multi-piece stamped assembly with single piece warm formed panel

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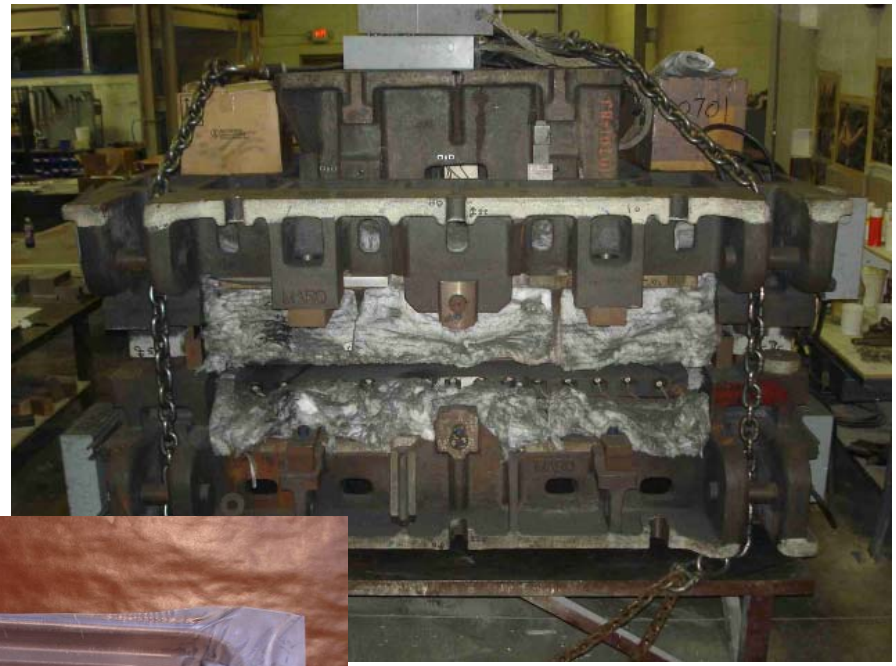
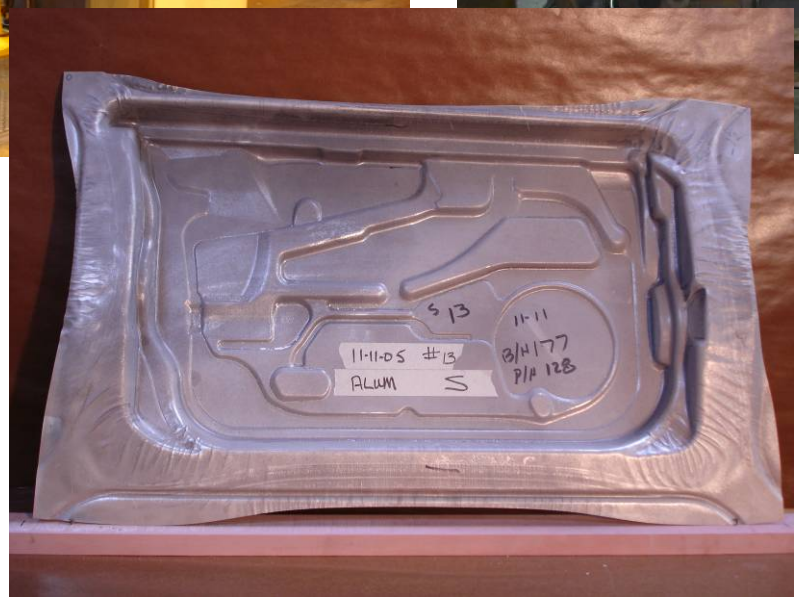
Warm Forming Alloy

- Initial project targeted a “new” warm forming alloy
- Project team changed focus to “commercial” or commodity alloys
- AA5182 was selected as the target alloy

Press and Warm Forming Die





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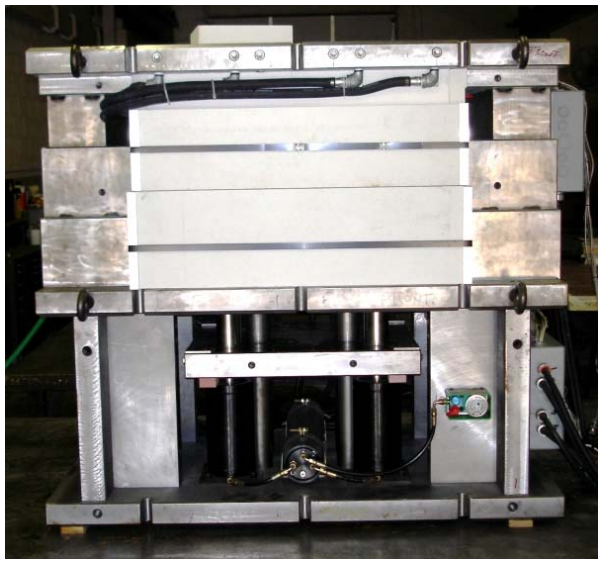
Results and Next Steps

- **Lessons Learned**
  - Can successfully make deep draw panels from commodity Al and Mg sheet alloys.
  - New lubricant works well.
  - Die thermal control was improved but not ideal.
  - Validated thermal modeling work.
  - Tool dimensions were not stable.
  - Need to design die from scratch, not retrofit.

- **New die designed for a deep draw panel must be able to…**
  - Reach and maintain steady state
  - Be compatible with current press stamping technology
  - Allow for non-isothermal controlled conditions
  - Transition to future projects (e.g. warm forming of magnesium)
  - Lead to the development of design rules for WF tooling
  - Be flexible allowing multiple forming regimes (draw, stretch, etc.)

New Die Design

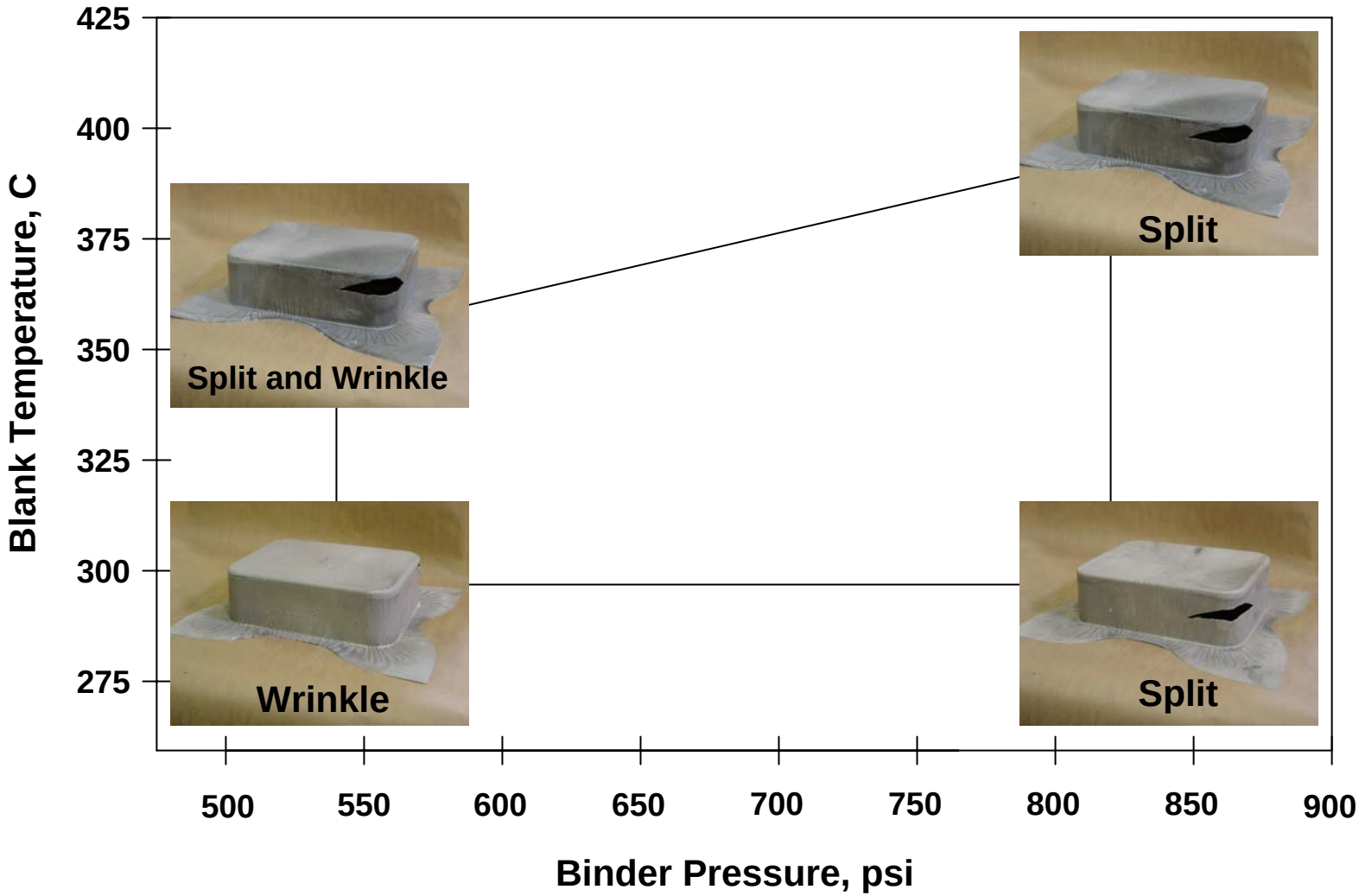
- **Troy Tooling Technologies selected as source**
- **Die features include:**
  - Isolated hot zones with water cooling
  - Multiple heating zones for precise control of temperature
  - Incorporated gas cylinders for the blank holder
- **Trials completed in October 2006**



Aluminum - Room Temperature

Aluminum – Warm Formed

AA5182 Forming Window



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Summary

- Developed the key elements of warm forming technology and demonstrated them with the forming of door inner panels from commodity aluminum and magnesium alloys.
- Established capability and accuracy of both thermal and forming simulation tools.
- Applied simulation tools and lessons learned from trial work on door inner tool to design and build an optimized warm forming die.
- Die design for warm forming is a challenge and needs additional research.