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
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

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## Project Budget

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

### Amounts in X $1000

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<th>Resources</th>
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**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
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
AA5182 Forming Window

Blank Temperature, °C

Binder Pressure, psi

Split and Wrinkle

Split

Wrinkle

Split
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.