Auto/Steel Partnership:
Hydroforming Materials and Lubricant
Lightweight Rear Chassis Structures
Future Generation Passenger Compartment

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Auto/Steel Partnership

Project ID: lm_27_heimbuch
Hydroform Materials and Lubricants
OVERVIEW

Timeline
• Start – 10/2001
• End – 09/2009
• 95% Complete

Budget
• Total Project Funding
  – DOE - $941K
  – Cost Share - $728K

• Funding for FY08
  – DOE - $31K

• Funding for FY09
  – DOE - $0K

Barriers
• Fabrication of AHSS tubes
• CAE Tools
• Material properties
• Process knowledge

Partners
• CANMET
• University of Waterloo
• IRDI
• Schuler Inc
• Soudronic
HYDROFORMING MATERIALS AND LUBRICANTS
PROJECT GOALS

• Explore design, manufacturing and material implications/limitations of tubular hydroforming using Advanced High-Strength Steel (AHSS).
• Develop in-depth understanding of critical issues pertaining to fabrication of tubes from AHSS.
• Improve advanced CAE tools to streamline hydroforming process design.
• Facilitate the adoption of cutting-edge hydroforming applications in vehicle structures.
HYDROFORMING MATERIALS AND LUBRICANTS
PROJECT APPROACH

• Investigate fabrication of DP and TRIP Steel Tube on an ERW and Laser Production Lines
  — ERW work nearly complete
  — Laser contract canceled-lack of funding

• Fabricate AHSS Hydroform TWT Lightweight Front Rails
PROJECT RESULTS

Design 2
Progressive Collapse

Schematic of AHSS Hydroform TWT Lightweight Front Rail

Components 4 stampings
Steel Grade DP780
Mass 28.8 kg
Mass Savings 26.5%

Bumper (Inner and Outer)
Mart 1300 1.2 mm

Rail A
DP800 1.2 mm

Rail B
DP800 1.3 mm

Rail C
DP800 1.4 mm

Rail D
DP800 2.0 mm

Rail E
DP800 1.4 mm

Rail F
DP800 1.3 mm
AHSS Hydroform TWT lightweight front rail
Initial unsuccessful rotary draw tube bending attempts at Erin Industries.
AHSS hydroform TWT lightweight front rail
Bent tube preform at Erin Industries.
PROJECT RESULTS

AHSS hydroform TWT lightweight front rail dies at Schuler Hydroform.
PROJECT RESULTS

AHSS hydroform TWT lightweight front rail
Tube collapse during hydroforming at Schuler Hydroform.
TECHNOLOGY TRANSFER

• “Influence of Bending Parameters on the Hydroforming of IF and DP600 Tubes with Welded Ends Caps.”
  - Tech transfer CD.

• “Investigation of Fabricating Dual Phase and TRIP Steel Tube from an ERW Production Line.”
  - Tech transfer CD.

• “Comparing Laser Welded DP and TRIP Steels with ERW Tubes of Same Materials.”
  - Tech transfer CD.

• “Fabricate AHSS Hydroform TWT Lightweight Front Rail.”
  - Tech transfer CD and road show with hardware display to be prepared.

• Great Designs in Steel 2009.

• 2009 SAE World Congress technical paper and presentation.
  - Draft manuscript submitted.
Summary

• Improved understanding of failure criteria for hydroforming.
• Improved understanding of test and evaluation methods for tubes.
• Improved understanding of effect of tribological and bending effects in hydroforming.
• Improved understanding of tube seam welding of AHSS tubes.
• Improved understanding of issues involved in fabricating and hydroforming AHSS TWT tubes.
Lightweight Rear Chassis Structures
PROJECT GOALS

• Develop mass efficient solutions for passenger car chassis structures using AHSS.
• Demonstrate successful use of AHSS in chassis structures.
• Address corrosion issues associated with reduced thickness AHSS.
• Reduce chassis mass by at least 25 percent with no more than a 9 percent cost premium.
• Technology transfer of project results.
Phase I – Material Substitution:
• Design Completed
• Prototype Build Completed
• Performance Testing Completed
• Gap Analysis Completion: June 2008
• Final Report Completion: June 2008

Phase II – Clean Sheet Re-Design:
• Design Completed
• Virtual Testing Completed
• Final Report Completion: June 2008

• Road Shows
• Technical Presentations
PROJECT APPROACH

- Chrysler LX
- Rear Chassis Structure
PROJECT RESULTS - Phase II

27% Mass Reduction – Through Clean Sheet Re-Design (No Loss of Stiffness)
Lightweighting features:

• Advanced High-Strength Steel

• Laser Welded Blanks

• New Architecture

• Extensive optimization and redesign
• Baseline steel grades ranged from: 240 – 345 MPa.
• New grades for Phase II are DP590, DP780, TRIP 780.
PROJECT RESULTS – Phase II

- Through virtual testing, determined that the durability of the Final Design is as good as or better than the baseline.
- Completed corrosion testing.
NEXT STEPS

• Analyze corrosion test results.
• Prepare Phase I Final Report.
• Complete cost analysis for Phase II Final Design.
• Prepare Phase II Final Report.
• Transfer technology.
TECHNOLOGY TRANSFER

• Final Reports for Phases I and II will be posted in the public domain on www.a-sp.org.

• Five technology transfer road shows will be given to Chrysler, Ford, General Motors and Tier 1 chassis structure suppliers.

• Technical presentations will be given at GDIS 2009.
Future Generation Passenger Compartment
## Timeline
- **Start** – 06/2006
- **End** – 06/2009
- 90% Complete

## Budget
- **Total Project Funding**
  - DOE - $1,366K
  - Cost Share - $697K
- **Funding for FY08**
  - DOE - $910K
- **Funding for FY09**
  - DOE - $47K

## Barriers
- Mass efficient design solutions

## Partners
- ETA
- EDAG
- Caminoe
- University of Michigan
- Altair
PROJECT GOALS

• Develop mass efficient design solutions and AHSS applications for the passenger compartment which enable energy savings via mass reduction of 20 to 25 percent and cost parity relative to current architecture/material applications while meeting the increased crash performance requirements of FMVSS and IIHS.

• Focus on side impact and roof strength requirements, but do not exclude front and rear impact load cases, global stiffness and durability performance.
PROJECT GOALS

• Perform study on a four-door, five-passenger, Body Frame Integral sedan, based on rear drive donor vehicle (i.e., the reference Multi-Material Vehicle).

• Apply Phase 1 Concept Development to Phase 2 Validation on the donated vehicle to study applicability to a current production design.

• Build validation properties and subject them to crash testing and correlate with model predictions. Build cancelled due to cost and timing constraints

• Perform cost evaluation.
## Project Timeline

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<th>Deliverables</th>
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<td>04/07</td>
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<tr>
<td>Design Optimization &amp; Confirmation – Complete</td>
<td>12/07</td>
</tr>
<tr>
<td>Parts Consolidation – Complete</td>
<td>03/08</td>
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<tr>
<td>New Concept Design – Complete</td>
<td>04/08</td>
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<tr>
<td>Design Confirmation &amp; Improvement – Complete</td>
<td>06/08</td>
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<tr>
<td>2nd Optimization – Complete</td>
<td>08/08</td>
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<td>Final Design Modification – Complete</td>
<td>08/08</td>
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<td>Final Design Confirmation – Complete</td>
<td>10/08</td>
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<tr>
<td>Sensitivity Analysis</td>
<td>12/08</td>
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<tr>
<td>Final Report</td>
<td>02/09</td>
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CAE CENTRIC PRODUCT DEVELOPMENT

CAE Centric Process

MD OPTIMIZATION

DESIGN

SIMULATION

LS-DYNA/NASTRAN

Parametric Modeling Tools
SFE-Concept

HEEDS
PROJECT RESULTS

Primary Components Candidates for 3G Optimization
Secondary Components
Candidates for Grade & Gauge Optimization
PROJECT RESULTS

New Components Candidates for 3G Optimization
FINAL CONCEPT DESIGN RESULTS
(Mass reduction with doors -39.8kg)

-15%  -12%  -9%

Component Masses  Passenger Compartment  BIW
276.1kg  335.0kg  429.2kg
236.3kg  295.2kg  389.4kg
**FGPC – MODIFIED BASELINE WITH CONTINUOUS JOINING OPTIONS:**

Laser welding

- Welds, rigid links every node

Weld Bonding

- Min 10mm

**PERFORMANCE IMPROVEMENT**

<table>
<thead>
<tr>
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<th>SPOT-WELD ➔ LASER</th>
<th>SPOT-WELD ➔ ADHESIVE</th>
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<tbody>
<tr>
<td>IIHS Side Impact</td>
<td>2%</td>
<td>16%</td>
</tr>
<tr>
<td>IIHS Front Impact ODB</td>
<td>16% to 44%</td>
<td>22% to 60%</td>
</tr>
<tr>
<td>Roof Crush</td>
<td>15%</td>
<td>25%</td>
</tr>
<tr>
<td>Bending</td>
<td>13%</td>
<td>19%</td>
</tr>
<tr>
<td>Torsion</td>
<td>14%</td>
<td>15%</td>
</tr>
</tbody>
</table>
RE-OPTIMIZED GAGE TO BASELINE PERFORMANCE FOR WELD BONDING

FGPC results 15% mass reduction. Continuous joining results in additional 5%.
NEXT STEPS

• This project will be completed in Q2 FY2009

• Further work to be completed includes:
  - Fatigue sensitivity study
  - Cost modeling
  - Final Report
  - Technology transfer
LIGHTWEIGHTING SUMMARY

• Mass reduction projects
  — Achieved 10 to 30% mass reduction
  — Used optimization techniques
  — Applied AHSS steels

• Roof strength project
  — Achieved 63% higher load carrying capacity
  — Minimal mass increase
  — Used optimization techniques
  — Applied AHSS steels with plastic inserts

• Further mass reduction can be achieved by applying mass compounding estimates to drive initial design criteria.