Advanced High Strength Steel Application Guidelines

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PRESENTATION OVERVIEW

- History and purpose of this A/SP project
- Summary of key results to date
- Future Plans
- Directions for obtaining current and future results from the A/SP public website
Practical guidelines for forming AHSS components remain a key enabling technology:

- Product design guidelines to assure manufacturability
- Selection of optimum stamping processes
- Resolving formability issues
- Controlling springback
- Selecting die materials for optimum tool robustness
HISTORY AND PURPOSE

Several programs seek longer-term solutions:

• USAMP AMD 311 – Springback Compensation Project for Advanced Sheet Forming Materials

• USAMP AMD406 – Die Face Engineering for Advanced Sheet Forming Materials

• A/SP HSS Stamping Project

…..but interim solutions are needed today!
HISTORY AND PURPOSE

A/SP AHSS Applications Guidelines Project:

• Initiated in 2005
• Compiling case studies of AHSS components
• Extracting lessons learned on:
  – Part design for stamping feasibility
  – Suitability of chosen forming process
  – Managing springback
  – Dealing with die wear and robustness
## PROJECT TEAM MEMBERS

Chaired by: Blake Zuidema, Arcelor Mittal

<table>
<thead>
<tr>
<th>Car Company Members:</th>
<th>Steel Company Members:</th>
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<tr>
<td>John Siekirk</td>
<td>Mark Hammerl</td>
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<td>DaimlerChrysler</td>
<td>AK Steel</td>
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<td>Matt Walp</td>
<td>Willie Bernert</td>
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<td>John Davis</td>
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<td>Ford</td>
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<td>Jim Fekete</td>
<td>Dean Kanelos</td>
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<td>General Motors</td>
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<td>Gary Telleck</td>
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<td>Ken Schmidt</td>
<td>A. Konieczny</td>
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<td>General Motors</td>
<td>U.S. Steel</td>
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<tr>
<th>Advisors:</th>
<th>Staff Members/Consultants:</th>
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<tr>
<td>Kerry Fitzgerald</td>
<td>Roger Heimbuch</td>
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<td>AZ Automotive</td>
<td>A/SP</td>
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<td>M. Valentine</td>
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<td>Jack Noel</td>
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<td>A/SP</td>
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KEY RESULTS

Elements Selected for Case Study Database

• Part description
• Material description
• Press line constraints
• Stamping process design – process flow block diagram
• Detailed description of each die stage
• FEA formability analysis results
• Negotiated geometry concessions
**KEY RESULTS**

**Elements Selected for Case Study Database**

- Springback compensation methodology
- Springback control history
- Springback model results and accuracy
- Press load predictions and press load prediction accuracy
- Final springback control measures
- Tolerancing requirements
- Fixturing and clamping methods
- Post-launch experience
- Lessons learned
**Current Case Study Library**

01-01-AHSSAG-GIDP590-Reinf Ctr Plr Otr-Final.pdf

2.0 mm gauge HDGI DP590 center body pillar outer reinforcement made by draw forming on a B-class tri-axis transfer press with lower press air cushion.

01-02-AHSSAG-GIDP600-Reinf Ctr Bdy Plr-Final.pdf

1.65 mm gauge HDGI DP600 center body pillar reinforcement made by stretch drawing on a 3000 ton, 6-station transfer press.

01-03-AHSSAG-GADP600-Reinf A-Plr Rr Upr-Final.pdf

1.70 mm gauge HDGA DP600 rear upper A-pillar reinforcement made double attached by draw forming on a six station press line with nitrogen cushion in the draw die. Mating part to that in Case Study 02-02-AHSSAG-GADP600-Reinf A-Plr Frt Upr-Final below.

02-01-AHSSAG-GIDP800-PLT U-Body RR SI Rail TIE-Final.pdf

1.50 mm gauge HDGI DP800 rear side rail plate made double attached by draw forming on a double action lead draw C-class tri-axis six station transfer press.

02-02-AHSSAG-GADP600-Reinf A-Plr Frt Upr-Final.pdf

1.70 mm gauge HDGA DP600 front upper A-pillar reinforcement made double attached by draw forming on a six station press line with die-applied cushion pressure in the draw die. Mating part to that in Case Study 01-03-AHSSAG-GADP600-Reinf A-Plr Rr Upr-Final above.
**Highlights of GIDP600-Reinf Ctr Bdy Plr**

**Process Overview**

- Station #1 Stretch Draw (Solid Upper)
- Station #2 IDLE
- Station #3 Direct Trim and Pierce
- Station #4 Direct Trim, Pierce and Cam Pierce
- Station #5 IDLE
- Station #6 Form, Trim & Restrike

**Process Flow:**

- Sta. #1
- Sta. #2
- Sta. #3
- Sta. #4
- Sta. #5
- Sta. #6

Sta. #3 & Sta. #4 are on one common shoe

Note: Dies initially cut for two-piece LWB
Formability Assessment

Draw bars required for length of line condition

#1 Wrinkles & Splits

#2 Split

#1 - Added depressions to take up wrinkles; opened and smoothed radii to eliminate splits

#2 – Opened radii to eliminate splits
Springback Control

Springback compensation model is a proprietary add-on feature to LS-Dyna

Radii increased to compensate for sidewall curl:

Darts added to control springback:

Initial dies cut to morphed geometry from springback study – however initial dies were cut for LWB steel grades before all final formability compensations were made
Insights gained during production

- Premature wear on the draw beads after a 1000 parts. Substituted hard weld to correct the issue.
- Binder is scored and has micro-fractures
- Major Heat buildup in the draw die
- Tool breakage issues due mainly to improper die construction
- Ram tilt experienced during production
  Draw die & line dies are all under one ram. The large amount of tonnage required in the draw die caused the ram tilt. Added nitrogen cylinders to the final operation to balance out the ram.

- Flexing flange die.
  Trim clearance was ok in static condition. Upper and lower trim steels strike when press is cycled. Picture shows 0.4 mm step worn into upper trim steel after 1500 hits. Caldie steels inserted in place of existing trim steels.
Major Lessons Learned

- Springback compensation software is useful, but do not apply until all formability problems are resolved.

- Keep B-pillar length-of-line constant, if possible, from rocker to roof to stiffen draw panel and minimize camber, twist.

- Restriking AHSS is acceptable to tighten radii or over bend to compensate springback, but not to move previously work hardened metal.

- Try to run draw stage in its own press to balance loads, avoid tilt.

- Sidewalls should be designed with open angles to facilitate over bending for springback compensation. Six degrees should be adequate for DP600.
Major Lessons Learned

• Higher DP600 strength required at least one tool material upgrade for draw beads, trim steels.

• Higher DP600 strength requires overall upgrade in tool robustness.

• Both hard check fixture and white light scanning are recommended. The greater springback encountered in AHSS may be too large for the fixture to accurately measure, but hard check fixture still needed for instant feedback.

• Higher loads with DP600 caused die flexing during flanging. Consider upgrading flange die standards to higher stiffness to minimize flexing under larger flanging thrust loads.
KEY RESULTS

Highlights of GADP600-Reinf A-Plr Frt Upr

A-Pillar Upper Front
HDGA DP600
Subject Part
Mild Steel
A-Pillar Upper Rear - HDGA DP600

(note – see case study 01-03-AHSSAG-GADP600-Reinf A Plr Rr Upr-Final for details of this part)

Process Flowchart: Double Attached

<table>
<thead>
<tr>
<th>Blank</th>
<th>Wash &amp; Lube</th>
<th>Forming Operation</th>
<th>Second Operation</th>
<th>Third Operation</th>
<th>Fourth Operation</th>
<th>Fifth Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight sheared rectangular blank</td>
<td>Roll Coat</td>
<td>Draw</td>
<td>Trim, Pierce, Cam Pierce</td>
<td>Cam Trim &amp; Pierce</td>
<td>Restrike</td>
<td>Cam Pierce &amp; Separate</td>
</tr>
</tbody>
</table>
KEY RESULTS
GADP600-Reinf A-Plr Frt Upr

Geometry Concessions for Wrinkling

From this-----------------------------------------------to this

Autoform
KEY RESULTS
GADP600-Reinf A-Plr Frt Upr

Draw Bead Layout

Orange 50N bead

Dark blue 25N bead

Purple 325N bead

Red 250N bead

Blue 300N bead

Green 125N bead
KEY RESULTS
GADP600-Reinf A-Plr Frt Upr

Planned approach to controlling springback

- Cut to requested product geometry (original design).
- Recut to revised product geometry to obtain a stable process (remove wrinkling condition).
- Enter revised geometry back into model.
- Morph in model, re-cut to morphed geometry.

Normal springback controls were not helpful during die tryout:

- Adjusting binder pressure & draw beads in the draw die had marginal effects
- Adjusting tonnage in restrike made no initial difference
- Five recuts were necessary
- Checking fixture was available for tryout
Unanticipated Formability Problems

- Draw panel split, and restrike panel cracked, in regions not predicted by FLD.
- Draw panel re-modeled with FLD adjusted to match actual failures, and process modified to eliminate splitting under new local failure criteria.
**Major Lessons Learned**

- No knife edge trim conditions – 90 degrees to surface only.

- Any unusual shapes or notch trim conditions should be inserts and considered perishable items.

- Other than standard types of tool steel should be considered for use in trim applications.

- A more robust tool design should be considered next time.

- DP 600 has been observed, under certain stress/strain conditions (often with high shear component), to fracture at strains well below conventional forming limit curve. More research is needed to understand this phenomenon and develop more accurate fracture prediction criteria.
FUTURE PLANS

Adding Additional Case Studies to Database

- Compiling 3 to 6 additional case studies per quarter.
- Priority on most challenging components – rockers, pillars, rails.
- Gathering additional 780, 980 UTS cases.
- Expand to include multiple forming methods for an individual part.
- Continue until A/SP AHSS Formability project develops recommended practices for a full range of components.

Additional participation from the local die development and tier 1 stamping community would be warmly welcomed!
Current and future case studies can be downloaded from the A/SP public website at:

http://www.a-sp.org/publications.htm

Or for more information, please contact:

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