Experience with Advanced High Strength Steels – Die Development

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Toolers, what do you need to do to be competitive in the future??
Organizational Approach

- Dimensional quality for body in white
- International manufacturing benchmark studies
- Advanced technology development

- Modeling of economic significance
- Human resource issues
- Productivity measures

- Transportation planning
- Transportation Strategy and policy analysis
- Vehicle Information Integration
Program for Automotive Change

Transitioning from “old” way to “new” way: Collaborative
Forming AHSS

Several Heads are Better than One

Tool-and-die shops collaborate to help automotive OEMs and their suppliers form advanced high-strength steels.

BY JAY BARON AND JODY SHAW

In the quest for safer and lighter cars, automotive and steel companies are rapidly introducing new advanced high-strength steels (AHSS) for body structures. AHSS alloys include high-tensile strengths—500 MPa or greater—with good formability, and include grades like dual phase (DP), complex phase (CP), transformation-induced plasticity (TRIP), and some maraging steels. The high strengths of these materials allow for mass-efficient designs for improved fuel economy, while simultaneously increasing crashworthiness. Unlike many competitive materials, AHSS can accomplish these objectives without increasing the overall cost to the manufacturer.

Several full vehicle concept designs and subsystem concept designs have demonstrated 25-percent mass savings while providing improved high-strength-steel designs while improving crash performance, without increasing cost. The advantages of these materials for meeting automotive manufacturers’ goals are well recognized by the design community and, consequently, are being incorporated into nearly every new vehicle design in increasing percentages and strength levels. Several vehicles on the road today contain as much as 20 percent AHSS.

The challenges of implementing these new materials come in forming and welding. As steel strength increases...
Challenges due to AHSS during:

- Die tryout
  - Die re-cuts (due to springback)
  - Continuity/supply of material
  - Cpk buyoff

- Production (at OEMs and Part Suppliers)
  - Die wear (inserts wearing out within a run)
  - Die breakage
  - Dimensional quality (material uniformity assumed?)
Premise

• Tool shops in Michigan possess extensive AHSS experience which has been kept in-shop.
• Part producers (stampers) possess additional knowledge.
• They will share this information in exchange for new/shared knowledge.
• Sharing of IP can be managed through A/SP and CAR relationships.
Tooling Coalitions: A New Business Model

- **Cost Reduction:**
  - Group purchasing
  - Work load balancing
  - Share best practices
  - Lean manufacturing
  - International relationships

- **Innovation:**
  - Advanced high strength steels
  - Low volume tools
  - Functional build

There are over 10 tooling coalitions now in Michigan
Plate-F/Panel #3 C/Bar Reinf Anchor R&L

DP780 / Prog. Die

- Material availability
- Form 1 time only
- Springback uncertainty, more re-cuts
- Prone to cracking
- Tool wear
- Better feeding in prog. die

- Important design influences (radii, consistent flange, darts, beads, etc.)
- Constrained measurement to get quality
Body Rocker Panel
Inner RH / LH

- One re-cut
- Significant springback (>7mm) requiring more tryout and buyoff coordination
- Galv. 60g/60g separation from base material

- Future move to transfer press will have thermal management issues
- Minimal tool wear, use D2 inserts and S7 trim steel

American Tooling Center

DP600 / 5 tandem dies (Incl. restrike)
Radius critical to sidewall curl and springback

Springback prediction accurate due to product design

Springback can be controlled with die process parameters – need research

Important for prototype tool source to work with production tool source
Cowl

Steel Grade: MS 6000 44VA 590DT

- 5-station transfer press (L&R)
- Engineered blank
- Springback and down-stream nesting concern
- PAM Stamp (incremental) analysis (every die)

- Bead restraining force greatly influences springback
- Die simulation should accurately model all die face geometries, especially beads
- Use of virtual beads can lead to errors in springback prediction
Scope of Problem –
Based on Meetings With Tool Shops

1. Springback (not formability)
   • Springback prediction
   • Springback management (or elimination)
2. Product Design
   (add rigidity, eliminate difficult features, etc.)
3. Special Tool Standards (unique to AHSS)
4. Material Availability and Uniformity
   (also, what specs. are appropriate?)
5. Tool Buyoff Process – Functional Build
Myth

Body Shop

Give me “perfect parts” and I can make perfect bodies.

Reality

The body shop can make high-quality bodies cheaper, and with shorter lead-time than making perfect parts if:

Parts that are “close”.

Parts are consistent.

This is because of the importance of the assembly process.
Functional Build

• Manufacturing focuses on achieving a functional end-product (meeting all requirements).

• This often means compromising several basic engineering principles, particularly in sheet metal processes.

• Dimensionally, this often means that check points can be accepted out of specification if it does not adversely affect final quality.
Summary of Stamping
Tryout Challenge

What should be done?

1. Change Tolerances
   • Widen tolerances? -- [from +/- 0.7 to +/- 1.2]
   • Adjust nominal (or shift tolerances)? -- [from +/- 0.7 to -0.7~1.2]

2. Rework dies

Mean = 0.5

Tolerance +/- 0.7mm
Cp = 1.83 (Pass)
Cpk = 0.52 (Fail)
Summary of Stamping
Tryout Challenge

Mean = 0.5
-0.7 Old Nominal +0.7

Tolerance +/- 0.7mm
\[ \text{Cp} = 1.83 \text{ (Pass)} \]
\[ \text{Cpk} = 0.52 \text{ (Fail)} \]

Mean = 0
-0.7 -0.5 New +0.7 + 0.5

Tolerance +/- 0.5mm
\[ \text{Cp} = 1.83 \text{ (Pass)} \]
\[ \text{Cpk} = 1.83 \text{ (Pass)} \]

Old Nominal

New Nominal
<table>
<thead>
<tr>
<th>Product Design</th>
<th>Part features (wall angle, radii, flange length, etc.) need careful consideration to help control springback.</th>
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<tbody>
<tr>
<td>Process Design</td>
<td>Product design will have to allow forming to be completed in the first die.</td>
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<tr>
<td>Steel Supply</td>
<td>The production steel supplier should be selected early in the design forming simulation stage so accurate steel specification data is available.</td>
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<tr>
<td>Tryout</td>
<td>Functional buyoff will be necessary rather than chasing unnecessary Cpk on dimensions.</td>
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<tr>
<td>Cost</td>
<td>Dies will be more expensive due to die construction, hardened inserts, and tryout time (additional re-cuts).</td>
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Technology Transfer

- Collection of anecdotal case studies
- Preliminary product/process design guidelines
- Recommendations for improving AHSS performance:
  - Springback
  - Product design (to simplify tooling)
  - Tool standards
  - Dimensional quality
  - Tool buyoff
- Presentations of findings to ASP members
End