Steel Innovations in Hot Stamping

Paul Belanger
Director, Gestamp R&D North America
1974 Objective: Replace cold stamping + batch hardening with forming/quenching in one tool.
Hot Stamping Innovation History

**First Hardening Line**

**First Products**

- Wear resistance
- Cutting knives
- Lawn mower knives
- Shovel blades
Hot Stamping Innovation History

Collaboration with Luleå University of Technology 1974-1979
- Process
- Tool
- Material
- Joining

Key Attributes
- Formability as mild steel
- UHSS material data after hardening
- Yield strength/density ~ extruded Al
- Tight tolerances
- Good weldability
Hot Stamping Innovation History

1983 First Automotive Product

- SAAB 9000: Side impact beam, Front & Rear door
Hot Stamping Innovation History

EVOLUTION OF PHS IN TERMS OF TECHNOLOGY AND MATERIAL

PH 1G

Weight % of BIW possible

1% Door Beam
5% FR/RR Bumper
9% B-Pillar A-Pillar Upper
18% Tunnel X-MBR Sill
28% RR Rails
38% FR Rails

B-Pillar Local Soft Zone

1st Gen. [Uncoated]
Hot Stamping Innovation History

EVOlution of PHs in Terms of Technology and Material

PH 1st Gen. [Uncoated]
- PH 1G

PH 2nd Gen. [Corrosion Protection]
- PH 2G

1980-2016

Weight % of BIW possible
- 50%

Evolution of PHSs in terms of technology and material.

- Door Beam: 1%
- FR/RR Bumper: 5%
- FR Rails: 38%
- A-Pillar Upper: 9%
- B-Pillar: 18%
- Tunnel X-MBR Sill: 28%
- RR Rails: 28%
- B-Pillar Local Soft Zone: 38%
Hot Stamping Innovation History

Evolution of PHS in terms of technology and material:

- PH 1st Gen. [Uncoated]
- PH 2nd Gen. [Corrosion protection]
- PH 3rd Gen. [Softzone]

- Weight % of BIW possible: 50%
- Material: AISi
- Components: Door, Beam, FR/RR Bumper, B-Pillar A-Pillar Upper, Tunnel X-MBR Sill, RR Rails, FR Rails, B-Pillar Local Soft Zone, Local

Phases:
- PH 1G
- PH 2G
- PH 3G


Weight % of BIW possible: 50%

Steel Matters Demand Nothing Less www.autosteel.org
Hot Stamping Innovation History

**EVOLUTION OF PHS IN TERMS OF TECHNOLOGY AND MATERIAL**

- **PH 1G**
- **PH 2G**
- **PH 3G**
- **PH 4G**

**Weight % of BIW possible**

- **PH 4G** [Laser improved]
- **PH 3rd Gen. [Softzone]**
- **PH 2nd Gen. [Corrosion protection]**
- **PH 1st Gen. [Uncoated]**

**Process**

- **FR Rails**
- **RR Rails**

**Local**

- **B-Pillar Local Soft Zone**

- **B-Pillar Upper**
- **A-Pillar**
- **Tunnel X-MBR Sill**
- **FR/RR Bumper**
- **Door Beam**

- **1%**
- **5%**
- **9%**
- **18%**
- **28%**

- **2000**
- **2001**
- **2002**
- **2003**
- **2004**
- **2005**
- **2006**
- **2007**
- **2008**
- **2009**
- **2010**
- **2011**
- **2012**
- **2013**
- **2014**
- **2015**
- **2016**

**Great Designs in STEEL**

**Steel Matters**

Demand Nothing Less

www.autosteel.org
Co-development examples

5 Technologies yielding 4 innovation products

**PROCESS TECHNOLOGY**

1. NEW Zn Hot Stamping

2. Remote Laser Seam Welding

3. In-Die Soft Zones

4. Flex Laser Soft Zones

5. 3D Laser Cladding (TPP)
Co-development examples

5 Technologies yielding 4 innovation products

<table>
<thead>
<tr>
<th>PROCESS TECHNOLOGY</th>
<th>PRODUCT INNOVATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 NEW Zn Hot Stamping</td>
<td>1 NEW Zn BODYSIDE</td>
</tr>
<tr>
<td>2 Remote Laser Seam Welding</td>
<td>2 NEW Front Rail LWT</td>
</tr>
<tr>
<td>3 In-Die Soft Zones</td>
<td>3 NEW Rear Rail LWT</td>
</tr>
<tr>
<td>4 Flex Laser Soft Zones</td>
<td>4 NEW B Pillar LWT</td>
</tr>
<tr>
<td>5 3D Laser Cladding (TPP)</td>
<td>5</td>
</tr>
</tbody>
</table>
Process Technology 1: Zn MSHc

ALSI PROCESS EQUIPMENT (direct PHD process)

Blanking  Heating  Stamping  Laser

Hydraulic press
5 SPM
2-4 Blanks/stroke
**Process Technology 1: Zn MSHc**

**ALSi PROCESS EQUIPMENT** *(direct PHD process)*

- Blanking
- Heating
- Stamping
- Laser

Hydraulic press
5 SPM
2-4 Blanks/stroke

**Zn PROCESS EQUIPMENT** *(direct MSHc, Multi-Step Hot Stamping Process)*

- Blanking
- Heating
- Stamping
- Shotblast

Mech. transfer press
Multi-step operation
> 15 SPM
1-4 Blanks/stroke
Modified 22MnB5

**Technology Innovation Status:**
- Zn without Microcracks (<10µm)
- Steel modified to reduce forming start temp, enable mechanical transfer press
- Production ready ~2017-2018

*Patents Pending*
Process Technology 1: Zn MSHc

Zn MSHc (Multi-Step Hot Stamping Process*)

- High speed centering & transfer system (OP05)
  - Transfer system

- Press
  - Servo transfer
  - Cycle time = 15-up SPM
  - Blanks per stroke = 1 – 4
  - 3,000k S/a

- Tooling
  - Max OP = 4 – 5
  - Thermostabilized tools

* Patents Pending
Zn Multi-Step Hot Stamping Process (MSHc*) Summary

- **Base material**
  - Similar post hot stamped mechanical properties to 22MnB5
  - Increased formability vs. 22MnB5 at lower temperatures

- **Zn-coating**
  - Offers cathodic protection
  - Capable for direct hot stamping process
  - Micro cracks < 10µm

- **Hot Stamping process**
  - High productivity (target cycle time 2-3"
  - Furnace protective atmosphere not required
  - Possibility to produce complex parts including negative angles
  - Good weldability and savings using LWB (Ablation not required)
  - No Laser cutting needed
  - Tailored properties also possible!!

*Patents Pending*
Product Innovation 1: New Zn Bodyside

Increasing safety requirements... ... with current multipart concept... leads to TWB PH optimized Door Ring

- Enhanced SOF performance
- Part number reduction
- Simplify Assembly Complexity
- Single stroke
- Cost reduction (no ablation)
- Mass saving

...with Blank optimization
Process Technology 2: Remote Laser Seam Welding

Technology: Remote Laser Seam Welding

- Laser welding: With seam tracking - continuous joint along an edge or short flange

- Benefit: Mass savings (reduced flanges) while maintaining or improving energy absorption

Application opportunities...

...on BIW structural parts
Process Technology 2: Remote Laser Seam Welding

- **B-Pillar inner flange reduction**

- **A-Pillar inner flange reduction**

Resistant welding
Process Technology 3: In-Die Soft Zones

- Technology: In-die partial hardening
  - Tailored properties on hot stamped parts
  - Controlled heating/cooling tool technology
- Benefits:
  - Optional grades obtained: HT400, HT550
  - Application freedom: Geometry and strength
  - Wide areas feasibility
  - Application opportunities…
Process Technology 3: **In-Die Soft Zones**

**Soft flange** on A pillar to improve weld ductility

- Material grade HT400
- Oblique pole crash test on vehicle

NEW VOLVO XC90 Soft flange
Technology: HT700 Flex Laser
→ Obtain tailored properties
→ Material grades obtained: HT700, HT550, HT400
→ Narrow areas and complex patterns feasible
→ Application to low thicknesses [0.8 mm]
→ Rivet solutions to aluminum structures

Application opportunities...

4 seconds each spot

...as combination with press hardened parts
Process Technology 4: **Flex Laser Soft Zones**

**Innovative use of the technology: Advantages**

→ Increased bending areas energy absorption

✓ Through higher range material

![Diagram showing HT400, HT550, and HT700](image)

**Loading Capacity**

- HT400 Flex Laser: +18%
- HT550 Flex Laser: +35%
- HT700 Flex Laser: +37% abs.

**Energy abs.**

- +19% abs.
- +37% abs.
Process Technology 4: Flex Laser Soft Zones

Innovative use of the technology: Advantages

→ Increased bending areas energy absorption
  ✓ Through higher range material...
  ✓ ... combined with more flexible process

![Pattern NOK]

Energy abs.
+33% abs.
+13% abs.
+9% abs.

![Loading Capacity]

- HT700 Flex Laser
- HT700 Flex Laser 1
- HT700 Flex Laser 2
- HT700 Flex Laser 3

![Bending Moments (kN.m)]

- 0
- 0.5
- 1
- 1.5
- 2
- 2.5
- 3

- 0
- 0.02
- 0.04
- 0.06
- 0.08
- 0.1
- 0.12
- 0.14
- 0.16
- 0.18
- 0.2
- 0.22
- 0.24

Time [s]
Process Technology 5: 3D Laser Cladding (TPP)

Technology: Tailored Product-Process (TPP)

- Melt powdered metal with a laser
- Put material at the right place for
  - Crash
  - NVH
  - Stiffness management

Applications
- Upper B-Pillar in Side crash
- A-Pillar in frontal SORB crash

Structure sustainment (Buckle resistance)

- Increase Stiffness
- Increase Loading capacity

Energy absorption

- Increase Energy

Applications
- Lower B-Pillar in Side crash
- A-Pillar in Side Pole crash
Product Innovation 2: Front Rails

**Baseline**
Cold stamping

**GESTAMP Current Best in Class**
Press Hardening + SZ Multiband

**Product Innovation**
- PH + SZ Multiband
  - Progressive force increase
  - Controlled bending mode

-25% weight saving

**GESTAMP Future Best in Class**
Press Hardening + SZ Multiband & Laser applications

- Controlled kinematics with local SZ
- Increased stiffness with same geometry
- Improved failure management

-37% weight saving

**Future Best-In-Class Technologies**
Flex Laser Soft Zone:
Decrease hat thickness 1,5mm → 1,1mm

3D Laser Cladding - TPP:
Increase local stiffness/buckle resistance

**Spot Welding → Remote Laser Seam Welding:**
- Reduce flanges
- Create continuous joint

**Technologies**
Cold stamping

**Steel Matters**
Demand Nothing Less
www.autosteel.org
Product Innovation 3: Rear Rails

**Baseline**
- Cold stamping

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP600</td>
<td>t. 1.4mm</td>
</tr>
<tr>
<td>DP780</td>
<td>t. 1.2mm</td>
</tr>
<tr>
<td>DP600</td>
<td>t. 1.4mm</td>
</tr>
</tbody>
</table>

**GESTAMP Current Best in Class**
- Press Hardened + local SZ “snake”

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHS 1500 + SZ</td>
<td>t. 1.1mm</td>
</tr>
<tr>
<td>HT400</td>
<td>t. 1.0mm</td>
</tr>
<tr>
<td>PHS 1500</td>
<td>t. 1.1mm</td>
</tr>
</tbody>
</table>

**Product Innovation**
- PH + Local SZ “snake” design
- Controlled kinematics with local SZ
- -11% weight saving

**GESTAMP Future Best in Class**
- Press Hardened + local SZ “snake” & Laser applications

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHS 1500 + SZ</td>
<td>t. 0.8mm</td>
</tr>
<tr>
<td>HT700</td>
<td>t. 1.0mm</td>
</tr>
<tr>
<td>PHS 1500</td>
<td>t. 1.0mm</td>
</tr>
</tbody>
</table>

- -30% weight saving
- Controlled kinematics with local SZ
- Increased stiffness with same geometry
- Improved failure management

**Flex Laser Soft Zone:**
- Decrease hat thickness 1.1 mm→0.8 mm

**3D Laser Cladding -TPP:**
- Reduce patch size due to TPP cladding

**Spot Welding → Remote Laser Seam Welding:**
- Reduce flanges
- Create continuous joint
Product Innovation 3: Rear Rails

Co-development success example: Honda Rear rails

- 20% weight saving
- Stability
- Efficiency
- Repeatability
- Complexity
- Single piece
- Patches not required for mode control/energy absorption
- Minimal spot weld count & reduce piece cost...
- Location, size, and properties of soft zones were developed using CAE

Published by HONDA R&D America (GDIS Seminar 2015)
Product Innovation 4: B-Pillar

**Baseline**
Cold stamping

**GESTAMP Current Best in Class**
- PHS 15000 Mono SZ + PHS Reinforcement
- Bending mode: local

**Product Innovation**
- Flex Laser Soft flanges
  - Create soft material locally
  - Improvement of failure management
- 3D Laser - TPP
  - Increase top stiffness
  - Improve part bending

**GESTAMP Future Best in Class**
- PHS 1500 Mono SZ + PHS reinforcement & Laser applications

**Product Innovation**
- Flex laser soft flanges
- Improved failure management
- Remote Laser Seam Welding:
  - Reduce flanges

**Future Best-In-Class Technologies**
- 3D Laser - TPP:
  - Reduce patch due to laser cladding

- 14% weight saving
- -27% weight saving

- Performances improvement
- Great Designs in STEEL

Steel Matters
Demand Nothing Less
www.autosteel.org
Product Innovation 4: B-Pillar

Co-development success example: AUDI B-Pillar

- ultra®-lightweight design
- Connection and fixation concept aluminium side panel

- GEO-points
- Hemming areas

- Connection aluminium side panel with hot-formed steel solved with hemming.

- Process design of soft flanges / zone: heated tool

- Soft zones
- Hard zones

- Location, size, and properties of soft zones were developed using CAE

- Weight saving and fixation concept
- Smaller cross sections
- Connection hot formed B Pillar to aluminum bodyside through hemming
- Soft zones in flanges to join with riveting
- Soft zone in lower B Pillar area to ensure smooth crash kinematics

Z Cross Section

- 223 mm
- 207 mm

Q7 pre-series

Q7 series
Product Innovation Summary

**HS Wheelhouses**
- HT700 Soft Flanges
- Ultra thin PHS 1500, \( t = 0.8\text{mm} \)
- TPP Opportunities

**Front Rails**
- HT700 Soft Zones
- HT700 Soft Flanges
- Ultra thin PHS 1500, \( t = 0.8\text{mm} \)
- TPP Opportunities
- Controlled deformation

**A-Piller**
- HT700 Soft Flanges
- TPP
- Tubular Design with Laser Remote Technology

**Side Impact Beam**
- Ultra thin PHS 1500, \( t = 0.8\text{mm} \)
- TPP Opportunities

**B-Piller**
- HT700 Soft Zone
- HT700 Soft Flanges
- TPP
- Laser Remote Technology
- Deformation area

**Rear Rails**
- HT700 Soft Zones
- TPP to increase stiffness
- Laser Remote Technology

**Rear Rails**
- HT700 Soft Zone
- TPP to increase stiffness

**1 piece Body side**
- TWB
- Cladd
- Ducti

Improve Stiffness

RSW Failure

Controlled deformation

Deformation area

(TW grades available)

Great Designs in STEEL
Thank you