New Zn Multistep Hot Stamping Innovation

Paul Belanger
Gestamp
Multistep Hot Forming Transfer - Process

- Transfer press cycle times = cost reduction
- Laser cutting process eliminated = cost reduction
- Formability increased = more complex geometrical possibilities (Negative angles possible)
- Zn-coated material = Cathodic corrosion protection
- Tailored Properties as Soft-Zones, -Flanges, -Spots
- Similar mechanical properties to conventional 22MnB5
- No Microcracks > 10 µm
- Prototypes available
- Serial production line ready by the beginning of 2018
Zn Hot Stamping Market Overview

**Indirect iPHS Process**
- Blanking
- Cold stamping
- Heating
- Stamping
- Shotblast
- Hydraulic press 5 SPM
- 2-4 Blanks/stroke

**Direct dPHS Process**
- Blanking
- Heating
- Cooling
- Stamping
- Laser
- Shotblast
- Hydraulic press 5 SPM
- 2-4 Blanks/stroke

**Direct MSHc Process**
- Blanking
- Heating
- Stamping
- Shotblast
- Mech transfer press 15 SPM
- 1-2 Blanks/stroke

**Processes**
- **Special-Process** 22MnB5 + Zn
- **Standard-Process** AlSi & (Zn) 22MnB5
- **High-Speed Transfer-Process** 22MnBx + Zn
Multistep Hot Forming Transfer - Tryout line

ZN PHS material | Process and product development

Offering to support today’s vehicle requirements, the most advanced and complete PHS solution.

Factors:
• Size of part
• Wet area vs not
• Customer Pref
• Joining tech

PROCESS EQUIPMENT (direct MSHc process)

- Thermo-stabilized tool technology

Patent pending
Multistep Hot Forming Transfer – Serial line

Transfer Press
2,000 Ton
2400x6000 mm

OP10 to OP50

Gestamp

- Servo Mech Press
- Transfer system
- Cycle time = 15+ SPM
- 3,000k Stokes/yr
- Thermo-stabilized tools

Tooling & material technology

Thermo-stabilized tooling technology
Multistep Hot Forming Project – Base Steel

**Multistep material**

Base material (~22MnB5) zinc coated (GA) with chemical modifications:
- Si (anti self tempering)
- Mn (hardenability)

- Mechanical properties similar to standard PHS

→ Delayed Bainite & Ferrite transformations
Multistep Hot Forming Project – Microcracks

Basic Research  Functional Validation  Industrial Validation  Industrialization  Global Implementation

Microcrack investigation

Variations: Coating Type - Furnace time - Forming temp

Optimized process window

Crack depth (μm)

50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00

Crack depth - mean value (μm)
Crack depth - max value (μm)
Crack depth - mean value for three deepest cracks (μm)
Multistep project status overview – GDOES

GDOES measurement of Zinc (Zn) and Oxygen (O)
heat treated with Short (S), medium (M), and long (L)
furnace dwell times.

Zn content [%]

Distance from surface [µm]

Microcrack investigation
# Multistep Hot Forming Transfer – Corrosion

## Corrosion Delamination Results (VDA 233-102)

<table>
<thead>
<tr>
<th>Process</th>
<th>Material</th>
<th>Multistep GA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect process</td>
<td>22MnB5</td>
<td>(not hardened)</td>
</tr>
<tr>
<td></td>
<td>Z100</td>
<td>(short dwell time)</td>
</tr>
<tr>
<td></td>
<td>22MnB5+AS150</td>
<td>(mid dwell time)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(long dwell time)</td>
</tr>
</tbody>
</table>
Multistep Hot Forming Transfer – Corrosion

Corrosion Delamination Results (VDA 233-102)

- Delamination [mm]
- Cross section of the corrosion attack

22MnB5 (Uncoated)
22MnB5 AlSi Coated
MShc GA short dwell time
Multistep Hot Forming Transfer – Project status

Material Properties

Coating thickness (μm)

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Condition</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galvanneal 22MnBX – raw condition</td>
<td>Typ. 15</td>
<td></td>
</tr>
<tr>
<td>Galvanneal 22MnBX – hardened condition</td>
<td>Typ. 25</td>
<td></td>
</tr>
</tbody>
</table>

Mechanical properties

<table>
<thead>
<tr>
<th>Condition</th>
<th>0.2% Yield Strength ( R_{p,0.2} ) (MPa)</th>
<th>Tensile Strength ( R_m ) (MPa)</th>
<th>Elongation</th>
<th>Hardness ( H_V )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw</td>
<td>Typ. 700</td>
<td>Typ. 800</td>
<td>Typ. 5</td>
<td>A80 Typ. 7, A50 Min 7</td>
</tr>
<tr>
<td>Hardened</td>
<td>Typ. 1000</td>
<td>Typ. 1400</td>
<td>-</td>
<td>Typ. 7</td>
</tr>
</tbody>
</table>

Similar mechanical properties to 22MnB5:
Multistep Hot Forming Transfer – Project status

Basic Research | Functional Validation | Industrial Validation | Industrialization | Global Implementation

Formability

Forming temperature

Formability / Break-stroke (mm)

- New GA
- AISi-Reference
- Typical forming temperatures
Multistep Hot Forming Transfer – Project status

Basic Research | Functional Validation | Industrial Validation | Industrialization | Global Implementation

Component Crash Correlation

- 2mm elements
- Quasi-static test
- No failure modeling

Simulation

Test

3pt bending Test

- Test_1
- Test_2
- Test_3
- Simulation

Maximal force level OK

Elastic and plastic behavior validated

Maximal force level OK

Bending force (kN)

Displacement (mm)
Multistep Hot Forming Transfer – Project status

Basic Research | Functional Validation | Industrial Validation | Industrialization | Global Implementation

OP10 | OP20 | OP30

LOADING UNLOADING LOADING UNLOADING LOADING UNLOADING

Process window and Industrial Validation

✓ Best forming temperature
✓ Microcrack containment
✓ Trimming/Piercing temperatures
✓ Mechanical properties
Multistep Hot Forming Transfer – Project status

Basic Research  Functional Validation  Industrial Validation  Industrialization  Global Implementation
Multistep Hot Forming Transfer – Project status

1. Material characterization analysis
   - Mechanical properties
   - Coating behavior and Corrosion
   - Formability
   - Bending tests
   - Tribology

2. Process definition
   - Heating possibilities
   - Shot blasting
   - Joining technologies (RSW/TWB)
   - Tailored properties (Flex laser / TPP)

3. Product definition
   - Crash material data card
   - Forming material data card
   - Design Guidelines

4. Prototyping

5. Industrial validation

6. Full scale line installation in Gestamp

Basic Research

Functional Validation

Industrial Validation

Industrialization

Global Implementation

- Thermo-stabilized tool technology
- Advanced process equipment

Today
# Multistep Hot Forming Transfer – Project status

### Timing Plan

<table>
<thead>
<tr>
<th>Activity</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line Kickoff</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procurement Process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Basement for Existing Press Line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacture New Zn MSHc Line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Move Existing Press Line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilities for New Zn MSHc Line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assemble &amp; Commission New Zn MSHc Line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production Trials &amp; Training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ready for Serial Production</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Timeline

- **2016**: Line Kickoff, Procurement Process
- **2018**: Production Trials & Training

**Timeline Notes**
- 2016: Line Kickoff, Procurement Process
- 2018: Production Trials & Training

**Status**
- Star symbol indicates completed or in progress tasks.
Multistep Hot Forming – Serial Production Line
Applications

- Solution in PH for cost efficient body structures
- All NEW technologies can be mixed together
- All NEW applications can run in AlSi and Zn

HS Wheelhouses
- HT700 Soft Flanges
- Ultra thin USIBOR t0.8mm
- TPP Opportunities

Side Impact Beam
- Ultra thin USIBOR t0.8mm
- TPP Opportunities

Front Rails
- HT700 Soft Zones
- HT700 Soft Flanges
- Ultra thin USIBOR t0.8mm
- TPP Opportunities
  - Monitored deformation

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

A-Pillar
- HT700 Soft Flanges
- TPP
- Tubular Design with Laser Remote Technology
  - Improve Stiffness
  - Mass saving

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

Rear Side
- TWB
- Cladding
- Ductile

1 piece Body side

TPP to increase stiffness

Various soft zone grades available

RSW Failure

VG1000 | #GDIS | #SteelMatters
Zn Multistep Hot Stamping – At a glance

~10% of press hardened products moving to the multistep technology

**Cost-Saving**

- Zn can run in all parts but Multistep technology shows highest saving potential in key parts
- Here we show the part where the biggest cost savings can be achieved
Zn Multistep Process Potential

German OEM development

Press Plan

Pre-cooling  Forming  Cutting / Piercing  Cam  Trimming

Cost Potentials

<table>
<thead>
<tr>
<th></th>
<th>Material</th>
<th>Stamping</th>
<th>Shotblast</th>
<th>Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Hot Stamping</td>
<td>4/stroke @12 sec</td>
<td>Slower</td>
<td>Not required</td>
<td>Required</td>
</tr>
<tr>
<td>Multi Step Hot Stamping</td>
<td>2/stroke @6 sec</td>
<td>Similar</td>
<td>Faster</td>
<td>Required</td>
</tr>
</tbody>
</table>

Material cost similar
Process higher investment
No laser cutting needed
Limited to 2000 ton, Bolster: 2.5 m x 6 m

-10%

Good for parts with significant laser content and up to 4 parts / stroke

Saving potential as function of complexity and cutting requirements
Zn Multistep Process Potential

German OEM development

Press Plan

Pre-cooling  Forming  Cutting / Piercing  Cam  Trimming

Cost Potentials

<table>
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<th>Material</th>
<th>Stamping</th>
<th>Shotblast</th>
<th>Laser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Stamping AHSS</td>
<td>2/stroke</td>
<td>Higher</td>
<td>@4 sec</td>
<td>Not required</td>
</tr>
<tr>
<td>Multi Step Hot Stamping</td>
<td>2/stroke</td>
<td>Faster</td>
<td>@6 sec</td>
<td>Required, Not required</td>
</tr>
</tbody>
</table>

Material cost significantly different
Limited to 2000 ton, Bolster: 2.5 m x 6 m

- Good for parts with significant laser content and up to 4 parts / stroke

Saving potential as function of complexity and cutting requirements
Zn Multistep Product/Process Summary

- **Base material**
  - Modified version of the well-known 22MnB5
  - Similar mechanical properties to 22MnB5
  - Better formability at lower temperatures than 22MnB5

- **Zn-coating GA**
  - Cathodic protection
  - Lower friction compared to AlSi coated material → complex parts
  - Suitable for direct hot stamping process
  - Micro cracks under 10 µm

- **Hot Stamping process**
  - High productivity due to short cycle time (aim 2-3 seconds)
  - No protective atmosphere required into the furnace
  - Multiple hits - Possibility to produce complex parts, negative angles
  - No Laser cutting is needed
Summary

Evolution of Hot Stamping

1%    5%    9%    18%   28%   38%

Gestamp’s historical performance

1) Gestamp Hardtech > 30 years experience
2) Quadrupled # Lines since 2007
3) Co-Development Partner BIW content 1% - 38%
4) Driving the tailored material properties

Gestamp ‘growing’ forward

1) 1st to break 10 s cycle time
2) 1st to in-die soft zone
3) 1st to Multistep & eliminate laser
4) 1st to Hot Stamping cost reduction

Hot Stamping is Becoming the “Standard”
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