Full Cycle Simulation for Accurate and Representative Springback Results

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AutoForm Engineering
AutoForm Engineering – Who We Are

Development and Sales of Software Solutions for the Sheet Metal Forming Industry

- Product manufacturability
- Tool and material cost estimation
- Concept and CAD quality die face design
- Process validation and optimization
- Tryout and part production
AutoForm Engineering – Main Innovations

1995 – Rapid and Accurate Stamping Simulation: Sheet metal forming simulations in 2 hours instead of 2 days

2000 – Rapid die Face Design: Validated die face design in ½ day instead of 1 week

2003 – Tool and Process Design of Hydroformed Parts: Part geometry analysis and forming simulations in 1 day

2003 – Cost-Optimized Nesting of Blanks: Minimization of material costs and material usage

2005 – Robust Manufacturing: Reduction of scrap and reject rates in stamping operations

2007 – Process Plan: Standardized and cost-optimized process plan
2009 – Comprehensive Digital Process Planning: Simultaneous consideration of function, quality, lead time and cost

2011 – Systematic Process Improvement (SPI): New approach for systematic and reliable process engineering

2012 – Semi-Automatic Results Evaluation: Easy and fast issues identification and interpretation

2012 – Usage of Company Standards: Efficient usage and management of individual company standards

2013 – Adaptive Line Beads: Increased accuracy and computing speed

2015 – Efficient Planning of Hemming Processes: Easy definition of tool geometry and tool kinematics as well as fast process simulation in 4 hours instead of 4 days

2017 – AutoForm Sigma (SPI & Robustness) default functionality as of version R7
AutoForm Engineering – Customers

- 100% of the Top 20 automotive manufacturers
- 80% of the Top 50 automotive manufacturers
- > 700 suppliers: Tools & dies, steel & aluminum, components, engineering, design
- 3000 users worldwide in 40 countries
Software Solutions along the Entire Process Chain

**Full Cycle Simulation for Accurate and Representative Springback Results**

- **Concept, Styling**
  - Solution for **Product Development**
  - Engineering of Manufacturable Sheet Metal Parts

- **Product Design**
  - Solution for **Planning & Bidding**
  - Efficient Process and Cost Planning

- **Production Planning**
  - Solution for **Tooling**
  - Rapid Creation of Tooling Concepts and Final Process Validation

- **Process Engineering**
  - Solution for **Tryout & Part Production**
  - Efficient Tryout Support and Robust Part Production

**AutoForm**
Forming Reality
Phases in the Tool Development Chain

The process engineering
- 3D Die design
- Milling data preparation

The tryout control
- Try to add as much knowledge as possible to the tryout.
- To reduce the number of iterations to define the final shape.
- Raw materials and punch designs, component strength requirements.
- To replace the physical with the virtual world.

The comparison between simulation and real parts

Springback Simulation and Springback Compensation of an Aluminum Outer Panel
Dr. Renping Luo, Zengqiang Wang, SGM VME Press
Dr. Xiaojing Zhang, Peter Grimm, AutoForm
Shenghua Zhang, Dr. Yuqiang Li, SSDT
Numisheet 2014
Springback is the next challenge!

- Physical tool geometry correction loops are time- and cost-intensive
- Simulation-based springback compensation eliminates compensation loops

Accurate Springback Simulation
- Material Modeling
  - Hardening curve
  - Kinematic hardening
  - Yield surface
- Material Data
- Element Formulation
- Boundary conditions

Start

Simulation based tryout

Physical tryout

Dimensional Accuracy Fit

Part geometry
Springback result
Match with reality depends on representativeness of a simulation

• **Forming Simulation:**
  - Drawing
  - Trimming
  - Flanging
  - Springback

• **Full Cycle Simulation:**
  - Drawing operations plus all subsequent operations
  - All the tool functions, incl. closing between operations, real support surface etc.
  - The scaling of the tool
  - The non-active radius
  - Material properties, etc.

• **Boundary conditions of simulation and practice should be identical or at least similar**
Content

• Introduction

• Forming of an A-Pillar
  • Forming Simulation vs Full Cycle Simulation

• Stress Distribution
  • A detailed look at the Full Cycle Simulation

• Springback in Fixture

• Conclusions
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Forming of an A-Pillar

Blank

Drawing

Trimming

Flanging

Die

Blank

Binder

Punch

Full Cycle Simulation for Accurate and Representative Springback Results - Engineering Community Conference 2017
Process Setup A – Forming Simulation

• Basic forming operations represented
  • Drawing
  • Trimming – trimming and piercing at curves
  • Flanging – simple clamping and flanging up
  • Springback
Process Setup B – Full Cycle Simulation

- Forming operations represented similar to real process
  - Drawing
  - Segmented Trimming – tool closure and trim segments
  - Flanging – sheet positioning with pilots during tool closure
  - Springback
Free Springback

Forming Simulation

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<tr>
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<tr>
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<td>-0.615</td>
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<td>1.046</td>
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Full Cycle Simulation

<table>
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<th>1.205</th>
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<tr>
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<td>-0.100</td>
</tr>
<tr>
<td>-0.231</td>
<td>-0.147</td>
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</table>

Different springback results only because of different process representation
Content

• Introduction

• Forming of an A-Pillar
  • Forming Simulation vs Full Cycle Simulation

• Stress Distribution
  • Types of springback
  • A detailed look at the Full Cycle Simulation

• Springback in Fixture

• Conclusions
Intermezzo - types of Springback

• Based on the stress distribution along the material thickness we can distinguish:

  • Membrane Springback

  • Bending Springback

• Note: in a part both types of springback occur, not really possible to distinguish them.
Plastic Strain Rate during Closing

Top

Middle

Bottom
Tool Closing Full Cycle Simulation at Trimming OP

Sheet positioned at post just before pad is in contact.

Sheet slightly deforms during tool closure.
Cross Section of Major Stress at Radius

- End of drawing – membrane dominant with bending component stress distribution
- Springback after drawing – stress relaxation
- Closing pad & post – (re)bending of radius
- SB after trimming – stress relaxation results in S-shape stress distribution

Throughthickness major stress distribution

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<th>Major stress</th>
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<th>Major stress</th>
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<tbody>
<tr>
<td>End of drawing</td>
<td>SB after drawing</td>
<td>Closing pad &amp; post</td>
<td>SB after Trimming</td>
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</tbody>
</table>

Tool closure significantly changes local stress distribution
Content

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- Springback in Fixture

- Conclusions
Clamping station / fixture (examples)

The gauge fixture (including the clamping and fixing points) is used for checking the dimensional accuracy of the stamping in a reproducible way.

- In tolerance?
- No deformation?
- Clamp forces < 30 N
Fixture

• Measurement Concept
  • 2 Pilots
  • 8 Clamps
Maximum Clamping

- All Clamps active
- Overconstrained
  - Deformation of part
  - Unacceptable high reaction forces on clamps

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<th>Normal Force (N)</th>
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<td>8</td>
<td>74.1</td>
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Minimum Clamping

- Three clamps active
  - Minimal number of constraints to be statically determined

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<thead>
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</tr>
<tr>
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<td>8.4</td>
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Minimum Clamping plus Support

- Three clamps active plus one support
  - One support significantly reduces twisting

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<th>Springback Value</th>
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<tr>
<td>4</td>
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<tr>
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<td>4.4</td>
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<tr>
<td>7</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4.6</td>
<td>Green</td>
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</tbody>
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Constrained Springback

• Boundary conditions influence the springback values
• When comparing simulation with reality the boundary condition must be defined carefully
Conclusions

• Process representation influences the deformation history of the sheet
• Even small deformations can significantly change stress distribution which can result in changing springback results

• Fixture definition influences final springback results
• An accurate representation of actual pilots and clamps is inevitable to compare simulation and reality

• In case boundary conditions of simulations and reality are identical springback results will be accurate...
Thank you for your attention

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