AHSS FORMING SIMULATION FOR SHEAR FRACTURE AND EDGE CRACKING

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Outline

- AHSS characteristics
- Conventional formability evaluation
- Edge cracking
- Stretch bending at tight radius
- Solutions
  - Tool/Process modifications
  - Optimized material selection
Automotive Sheet Steels

LOW STRENGTH STEELS (<270MPa)

HIGH STRENGTH STEELS

ULTRA HIGH STRENGTH STEELS (>700MPa)

Total Elongation (%)

Tensile Strength (MPa)
AHSS Characteristics (Advantages)

- High tensile strength
- High crash energy absorption
- High dent resistance
- Good combination of strength and formability
- High stretch limit and durability (Stretch flange high strength steel)
AHSS Characteristics
(Disadvantages)

- Edge splitting
- Stretch bending in tight radius
- Springback
- Tool wear & deflection
- High press and binder force
- Weldability
• Conventional formability evaluation
• Edge cracking
• Stretch bending at tight radius
• Case studies
Conventional Simulation Prediction
DP600 Panel Forming

Draw split
DP780 Forming
DP980 B_PILLAR

FLD curve: CRLCS (t=1 n=0.1, True strain)
Edge Stretch Cracking

- Stretch flanging - out of plane
- Edge Stretch in draw - in plane

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Poor Correlation in Predicting Edge Cracking
• Deformation Mode at stretch edge is Uniaxial tension
• Point A: Limit of ideal edge condition
• Point C: Limit in worse condition
Simulation of Conical Punch Hole Expansion

Plot of strain mode along edge
Strain path along uniaxial tension
Hole Expansion Test

![Diagram of Hole Expansion Test]

\[(\text{HER}) \quad \lambda = \frac{D_f - D_0}{D_0} \times 100\]
Lowest HER for limit in production environment
Case Study 1
Major Strain Exceeds Edge Stretch Limit

Principal Strain 24.5%
Case Study 2
DP780 Steel Flanging
Max stretch is 22% which exceeds the edge stretch limit
Modify Pre-form

deform locations in pre-form stage

undeform locations for stretch in flanging stage
Modified Pre-form

No edge stretch in pre-form

(Major strain = 10.5%)
No Pre-form

(Major strain = 15.5%)
Comparison of Different Pre-forms

Major strain = 22%
No pre-form
Major strain = 15%

Modified pre-form
Major strain = 10%
Stretch Comparison of Different Pre-forms

Edge Stretch Comparison

- Scallop Pre-form
- No Preform
- Modi Preform

Time (ms)

Major Strain

0 0.01 0.02 0.03 0.04
Optimal Material Designed for High Edge Stretch Application

SF590 for stretch greater than 100%
Stretch Bending Fracture

DP980

DP780
Poor Prediction Correlation

DP780
Stretch Bending Limit Study for AHSS

BENDING FRACATURE
STRETCHING FRACATURE

BENDING ROD
STRIP
BACK
MOTION
FRONT
Stretch Bending Limit

Graph showing the relationship between Restraining Stress (MPa) and Radius/thickness for different materials (DP600, TRIP800, CP800, DP800).
### Material Improvement

<table>
<thead>
<tr>
<th>Steel</th>
<th>n</th>
<th>YS (MPa)</th>
<th>UTS (MPa)</th>
<th>Total Elongation (%)</th>
<th>Yield Ratio</th>
<th>λ (5)</th>
</tr>
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<tbody>
<tr>
<td>High Yield</td>
<td>0.086</td>
<td>744</td>
<td>1023</td>
<td>12.2</td>
<td>0.73</td>
<td>25</td>
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<td>Low Yield</td>
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</tbody>
</table>

**Stress-Strain curves**

![Stress-Strain curves](image)

- **True stress in MPa**
- **True strain**

- LY
- HY
Improved HER

AHSS Hole Expansion

Hole Expansion (%) vs. Pre-strain (%)

- LY
- HY

Pre-strain (%)

0.0 1.6 4.4

Hole Expansion (%)
Improved Stretch Bending

DP780HY

DP780LY

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• Conventional FLD is suitable for general deformation mode only
• Utilize appropriate hole expansion limit in the simulation for edge stretch
• Check major strain in stretching edges
• Check R/T ratio in stretch bending
• Optimal material selection based on specific applications
References
