Development of Innovative Steel Grades and Their Applications in Automotive Structures

Eric Petersen, Ed Case, Sajan (George) Elengika, Jaehyon Choi, Jeremy Hansman, Amrinder Gill, Mauro Losz
AK Steel’s Commitment to Innovation
Innovative AHSS Products from AK Steel

- **Coated Bake Hard 440** provides light weighting opportunities for surface-critical applications

- **Next Generation AHSS 1000 and 1200** with improved elongations over Dual Phase steels with equivalent strength

- **NITRONIC® 30** existing stainless steel grade with optimized cost, good formability, high strength, corrosion resistant and premium surface finish

- **NanoSteel NXG™ 1200** 3rd generation AHSS, for high strength and great formability in multiple applications
Bake Hard 440 GI/GA

- Exposed Surface Quality
- Improved Dent Resistance
- Material Commercially Available

<table>
<thead>
<tr>
<th>Grade</th>
<th>YS, MPa</th>
<th>UTS, MPa</th>
<th>TE, %</th>
<th>BHI MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bake Hard 440</td>
<td>300</td>
<td>475</td>
<td>33</td>
<td>55</td>
</tr>
</tbody>
</table>
Next Generation AHSS, CR/GI

- New Process / Product Technology
- Significantly improved formability over conventional AHSS
- Product available early 2017

<table>
<thead>
<tr>
<th>Grade</th>
<th>YS, MPa</th>
<th>UTS, MPa</th>
<th>TE, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Next Gen 1000</td>
<td>630</td>
<td>1030</td>
<td>19</td>
</tr>
<tr>
<td>Next Gen 1200</td>
<td>1070</td>
<td>1210</td>
<td>13</td>
</tr>
</tbody>
</table>
NITRONIC 30 - Tensilized Properties

- Lean metastable austenitic stainless steel specialty product
- Material Commercially Available

<table>
<thead>
<tr>
<th>Grade</th>
<th>YS, MPa</th>
<th>UTS, MPa</th>
<th>TE, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NITRONIC 30</td>
<td>730</td>
<td>990</td>
<td>31</td>
</tr>
<tr>
<td>NITRONIC 30</td>
<td>830</td>
<td>1130</td>
<td>22</td>
</tr>
<tr>
<td>NITRONIC 30</td>
<td>1100</td>
<td>1330</td>
<td>15</td>
</tr>
</tbody>
</table>
# Comparative Formability

<table>
<thead>
<tr>
<th>Dome Height</th>
<th>NanoSteel</th>
<th>DP980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stopped just before failure (see images)</td>
<td>2.01” (51.1 mm)</td>
<td>1.107” (28.1 mm)</td>
</tr>
<tr>
<td>Failed samples</td>
<td>2.26” (57.4 mm)</td>
<td>1.24” (31.5 mm)</td>
</tr>
</tbody>
</table>
Stamping Validation with T-Shaped Panel

NanoSteel NXG 1200

draw depth: > 25 mm
Thickness: 1.46 mm

DP 980

Max. draw depth: 14 mm before failure
Thickness: 1.4 mm
Light Weighting Case Studies

Review 5 case studies:

• CS1: BH440 Exposed Door Study
• CS2: Full Size Truck on Frame Front Structure
• CS3: B-Size Sedan Door Ring Study
• CS4: B-Sized Sedan PHS vs Cold Stamping
• CS5: C Size Sedan Small Offset Rigid Barrier (SORB)

Considerations:

• Only major load cases are evaluated
• All parts are reviewed for stamping feasibility
• Other load cases will affect results
• More savings can be achieved if materials are considered early in the design process
CS1: BH440 Exposed Door Study

Gauge reduction to 0.55 mm
- Passes all door loading requirements
- Stamping feasibility

<table>
<thead>
<tr>
<th>Material</th>
<th>Frequency</th>
<th>Torsional Rigidity</th>
<th>Belt Squeeze</th>
<th>Denting</th>
<th>Oil Canning</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH210 (0.7 mm)</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
<tr>
<td>BH440 (0.55 mm)</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
</tr>
</tbody>
</table>

Door Outer Study: 21% mass savings potential 0.95 kgs per door
CS2: Full Size Truck on Frame Front Structure

TARGETS

✓ Reduce mass
✓ Meet NCAP front impact
✓ Meet IIHS 40% offset
✓ Minimize torsional stiffness and bending reductions

* Public domain models courtesy of George Washington University
* Fully validated and correlated crash models
CS2: B-Pillar Pulse and Intrusion Comparison
CS2: Optimized Design, Next Generation AHSS

Next Generation 1000
CS2: Optimized Design, NanoSteel AHSS
CS2: Optimized Design, Bake Hard 440

BH 440
CS2: Optimized Design, NITRONIC 30

NITRONIC 30

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Tensile Strength (ksi)

Total Elongation (%)
CS2: Results

<table>
<thead>
<tr>
<th>Parts</th>
<th>Number of Parts</th>
<th>Baseline Weight (Kg)</th>
<th>Reduced Weight (Kg)</th>
<th>% Weight saving</th>
<th>Weight Saving (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail, Cradle Bumper, Bracketss Fender &amp; firewall</td>
<td>18*</td>
<td>99.4</td>
<td>70.20</td>
<td>29.38</td>
<td>29.20</td>
</tr>
</tbody>
</table>

Results:
- Reduce mass of the selected parts by **29.2 kgs**
- Stamping feasibility complete
- Meets front crash requirements
- Plan for reducing torsional rigidity effects
CS3: B-Size Sedan Door Ring Study

TARGETS

✓ Reduce mass
✓ Maintain roof crush performance
✓ Maintain side impact performance

* Public domain models courtesy of George Washington University
* Fully validated and correlated crash models
CS3: Optimized Results

Optimized Door Ring Structure

A-pillar Upper: 1.4 → 1.0 mm
A-pillar Lower: 1.4 → 1.0 mm
Rocker: 1.4 → 1.0 mm
B-pillar Upper: 2.1 → 1.2 mm
B-pillar Lower: 1.2 → 1.0 mm
B-pillar Inner: 1.0 → 1.1 mm
B-pillar Reinforcement: 2.6 → 1.5 mm
Roof Rail: 2.3 → 1.5 mm

Mass savings per vehicle = 9.7 kgs (28.9%)

Iterations | Side Impact Driver Side Survival Space | Roof Crush Strength-to-Weight Ratio | Mass (kg) (One Side) | % Mass Reduction from Baseline
---|---|---|---|---
Baseline | 54.2 | 3.783 | 16.750 | -
Optimized | 68.5 | 3.784 | 11.910 | 28.9

NanoSteel & Next Generation 1200

![Steel Matters Seminar](www.autosteel.org)
CS4: B-Sized Sedan PHS vs Cold Stamping

TARGETS
✓ Reduce mass
✓ Convert PHS to cold stamping
✓ Meet IIHS side impact
✓ Meet NCAP roof crush
✓ Meet NCAP pole impact

SIDE MDB
SIDE POLE
ROOF IMPACT
CS4: Results

NanoSteel & Next Generation 1000

<table>
<thead>
<tr>
<th>Load Cases</th>
<th>Baseline</th>
<th>Modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Pole Max Intrusion (mm)</td>
<td>445</td>
<td>446</td>
</tr>
<tr>
<td>Side Impact Intrusion (mm)</td>
<td>221</td>
<td>228</td>
</tr>
<tr>
<td>Roof Crush Max Force (kN)</td>
<td>63.2</td>
<td>63.9</td>
</tr>
</tbody>
</table>

Total Mass Saving

1.0 kg (4%)
CS5: C Size Sedan Small Offset Rigid Barrier

TARGETS
- Reduce mass
- Meet NCAP Front Impact
- Meet IIHS 40% Offset
- Meet IIHS SORB
- RCAR bumper test
### CS5: IIHS Small Overlap Test – Deflector Assy

<table>
<thead>
<tr>
<th>Part</th>
<th>Baseline Grade</th>
<th>Baseline Thick mm</th>
<th>Baseline Mass Kg</th>
<th>AK Steel Grade</th>
<th>AK Steel Thick mm</th>
<th>AK Steel Mass Kg</th>
<th>Mass Saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deflector Assembly</td>
<td>DP 500</td>
<td>1.5</td>
<td>1.77</td>
<td>NextGen 1200</td>
<td>1.0</td>
<td>1.18</td>
<td>33%</td>
</tr>
</tbody>
</table>

- **Deflector Assembly**
  - **Grade**: DP 500
  - **Thickness**: 1.5 mm
  - **Mass**: 1.77 Kg
  - **Grade**: NextGen 1200
  - **Thickness**: 1.0 mm
  - **Mass**: 1.18 Kg
  - **Mass Saving**: 33%
### CS5: IIHS Moderate Overlap Test – Front Rail Assy

<table>
<thead>
<tr>
<th>Part</th>
<th>Baseline</th>
<th></th>
<th></th>
<th>AK Steel</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade</td>
<td>Thick mm</td>
<td>Mass Kg</td>
<td>Grade</td>
<td>Thick mm</td>
<td>Mass Kg</td>
</tr>
<tr>
<td>Rail Inner</td>
<td>DP 600</td>
<td>1.6</td>
<td>3.76</td>
<td>NanoSteel</td>
<td>1.1</td>
<td>2.58</td>
</tr>
<tr>
<td>Rail Outer</td>
<td>DP 600</td>
<td>1.4</td>
<td>1.51</td>
<td>NanoSteel</td>
<td>1.1</td>
<td>1.18</td>
</tr>
</tbody>
</table>
Product Highlights

Applications of Next Generation, BH440 and NanoSteel

- Energy absorbing parts
- Parts needing improved formability and high strength
- Part consolidation
- Extremely high strength parts
- Mass reduction
- Exposed panel mass reduction

Ongoing customer projects to:
- Fully implement with other load case considerations
  - Durability
  - NVH
  - Crash
  - Local loading requirements
QUESTIONS

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