Validating NEXMET™ AHSS as a Lightweight Steel Solution

Scott Stevens
AK Steel Corporation
Agenda

• Recap of NEXMET™ 1000 & 1200 AHSS
• Qualification & Characterization
• Applications under development
• Focused Study: Roof Bow & Door Beam
• Other considerations
• Q&A
NEXMET™ 1000 & 1200 AHSS
HDGI Mechanical Properties

<table>
<thead>
<tr>
<th>Grade</th>
<th>Yield Strength, MPa</th>
<th>Tensile Strength, MPa</th>
<th>Total Elongation, %</th>
<th>Uniform Elongation, %</th>
<th>n-value (4-6%)</th>
<th>n-value (10%-uniform strain)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEXMET™ 1000</td>
<td>740</td>
<td>1025</td>
<td>21</td>
<td>15</td>
<td>0.17</td>
<td>0.16</td>
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<tr>
<td>NEXMET™ 1200</td>
<td>1070</td>
<td>1230</td>
<td>15</td>
<td>11</td>
<td>0.13</td>
<td>0.11</td>
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</table>

<table>
<thead>
<tr>
<th>Grade</th>
<th>90° Bend, Pass at r/T</th>
<th>VDA Bend Test</th>
<th>Hole Expansion Ratio, %</th>
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<tbody>
<tr>
<td></td>
<td>Parallel</td>
<td>Normal</td>
<td>Parallel</td>
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<tr>
<td>NEXMET™ 1000</td>
<td>2</td>
<td>1.4</td>
<td>120</td>
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<tr>
<td>NEXMET™ 1200</td>
<td>1.5</td>
<td>1.1</td>
<td>77</td>
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</table>
Global Formability

Tensile Strength (MPa) vs Draw Depth (mm)

- Dual Phase
- NEXMET™ 1000
- NEXMET™ 1200

<table>
<thead>
<tr>
<th>Draw Depth (mm)</th>
<th>NEXMET™ 1000</th>
<th>NEXMET™ 1200</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>15.85</td>
<td>10.70</td>
</tr>
<tr>
<td>1200</td>
<td>14.50</td>
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FLC Comparison

- DP590
- DP980
- NEXMET™ 1000
- NEXMET™ 1200

Major True Strain vs. Minor True Strain graph.
Forming with no bead

Forming with draw bead

Forming with stake bead

Forming with stake bead shows the best springback control
Weld Testing

- Good current range and electrode life
- Occasional LME cracking at highest current
Weld Mechanical Properties

NEXMET™ 1000 Shear Tension

NEXMET™ 1000 Cross Tension
Zwick HTM16020 High Strain Rate Test Frame
• Early-Adopter OEM Qualifications complete by mid-year
• Full Commercialization to coincide
• CR/Uncoated – To follow HDGI later this year
• GA – In development
## Applications Under Development

<table>
<thead>
<tr>
<th>Part</th>
<th>Base Material</th>
<th>Base Gauge</th>
<th>New Material</th>
<th>New Gauge</th>
<th>Pass FEA</th>
<th>Prototype</th>
<th>Attribute</th>
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<tbody>
<tr>
<td>Front Panel</td>
<td>DP590</td>
<td>1.2 mm</td>
<td>NEXMET™1000</td>
<td>1.2 mm</td>
<td>Yes</td>
<td>Yes</td>
<td>Performance</td>
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<tr>
<td>Roof Bow</td>
<td>DP980</td>
<td>1.8 mm</td>
<td>NEXMET™1200</td>
<td>1.6 mm</td>
<td>Yes</td>
<td>Yes</td>
<td>Mass Saving</td>
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<tr>
<td>PNL BD Lower</td>
<td>DP780</td>
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<td>NEXMET™1000</td>
<td>1.4 mm</td>
<td>Yes</td>
<td>TBD</td>
<td>Mass Savings</td>
</tr>
<tr>
<td>Front Member</td>
<td>DP780</td>
<td>1.6 mm</td>
<td>NEXMET™1000</td>
<td>1.4 mm</td>
<td>Yes</td>
<td>TBD</td>
<td>Mass Savings</td>
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<tr>
<td>Cross Bar</td>
<td>DP780</td>
<td>1.6 mm</td>
<td>NEXMET™1000</td>
<td>1.4 mm</td>
<td>Yes</td>
<td>Yes</td>
<td>Mass Savings</td>
</tr>
<tr>
<td>Door Beam</td>
<td>PHS</td>
<td>1.8 mm</td>
<td>NEXMET™1200</td>
<td>1.8 mm</td>
<td>Yes</td>
<td>Yes</td>
<td>Performance</td>
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<tr>
<td>Striker Anchor Plate</td>
<td>DP980</td>
<td>1.6 mm</td>
<td>NEXMET™1200</td>
<td>1.6 mm</td>
<td>Yes</td>
<td>Yes</td>
<td>Formability / Springback</td>
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<tr>
<td>Reinf RKR INR</td>
<td>DP980</td>
<td>1.8 mm</td>
<td>NEXMET™1200</td>
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<td>Yes</td>
<td>Yes</td>
<td>Mass Savings</td>
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Additional Work, OEM Directed

- Forming Feasibility for Stamped Parts
Additional Work, OEM Directed

- Forming Feasibility for Stamped Parts
- Laser Welding and Blank Development
Additional Work, OEM Directed

- Forming Feasibility for Stamped Parts
- Laser Welding Development
- Tubing and Hydroforming
Roof Bow Application

• Stamping FEA and Correlation
• Springback Prediction and Correlation
• Performance Comparison
  – 3 Point Bend Modeling, Testing & Correlation
• Gauge Optimization
• Total Mass Savings
Stamping Feasibility

Die Design

NEXMET™1200 FLC

Plastic Strain Max: 0.121

Formability
Stamping Springback Correlation

Thickness Changes - Simulation vs. Tryout

Scan

FEA EP

FEA KH
3 Point Bend Test and CAE Simulation

- 3 Point Bend Test 3 DP980 @ 1.8 mm
- 3 NEXMET™1200 @ 1.6 mm
- 3 PHS @ 1.8 mm

**Not Actual Speed**

Nonlinear analysis using LS-Dyna to predict the load vs. deflection behavior in test
Test to CAE Correlation

DP980 1.8 mm

NEXMET™1200 1.6 mm

PHS 1.8 mm
### Optimization Results

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>PEAK LOAD (kN)</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>TEST</td>
<td>SIMULATION</td>
<td></td>
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<tr>
<td>DP 980 1.8 mm</td>
<td>6.5</td>
<td>6.6</td>
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<td>NEXMET™ 1200 1.6 mm</td>
<td>6.9</td>
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<td>PHS 1.8 mm</td>
<td>8.8</td>
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### Gauge Optimization

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>GAUGE (mm)</th>
<th>WEIGHT (Kg)</th>
<th>WEIGHT REDUCTION (Kg)</th>
<th>WEIGHT REDUCTION %</th>
<th>PEAK LOAD (kN)</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TEST</td>
<td>SIMULATION</td>
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<tr>
<td>DP 980 Baseline</td>
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<td>2.68</td>
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<tr>
<td>NEXMET™ 1200</td>
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<td>6.6</td>
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<td>PHS</td>
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<td>2.23</td>
<td>.45</td>
<td>16.7</td>
<td>-</td>
<td>6.6</td>
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</table>
Door Beam Study

• Cold Stamping NEXMET™ 1200 in Hot Stamp Die
3 Point Bend Test and CAE Simulation
In Conclusion

- GI NEXMET™ 1000 & 1200 AHSS
  - Qualified & Commercially Available by Mid-Year ✓
  - Formability & Springback Correlated ✓
  - Performance Verified ✓
  - Alternative to PHS ✓
  - Mass Savings Confirmed ✓
Committed to Automotive

Scott Stevens
AK Steel Corporation
313.317-0370
scott.stevens@aksteel.com

Jon Powers
AK Steel Corporation
jonathan.powers@aksteel.com
313-317-1326