Dual-Phase Steel for Door Outer Application

Great Designs in Steel
February 19, 2003
Azfar Qamar
Ford Motor Company
Dual Phase Steel for Door Outer Application

- Background
- Front Door Outer Study
- Summary
Background

- Drivers for Improved Dent Resistant Steels
- Factors that Influence Dent Resistance
- Dual Phase (DP500) as Potential Solution
Background
Drivers for Improved Dent Resistant Steels

• Increase Customer Satisfaction
• Reduce Warranty Claims
• Reduce In-Plant Damage
• Vehicle Weight Savings/Avoidance
• Cost Savings/Avoidance
  – Beta Patch Removal
  – Thickness Reduction
  – Allow Displacement of Aluminum Applications
Factors That Influence Dent Resistance

- Material Yield Strength
  - After Forming and Paint Bake
- Panel Thickness
- Stiffness
  - Elastic Modulus
  - Geometry (Curvature)
  - Support and Reinforcement
Background
DP500 Steel as Potential Solution

• Good / Excellent Formability
  – Superior Formability for Given Strength Level
    • Low YS/TS Ratio
    • High N-value
Background

DP500 Steel as Potential Solution

DP500 Microstructure

15% Martensite, Ferrite Grains
Background
DP500 Steel as Potential Solution

- High Final Panel Strength
  - Rapid Strain Hardening
  - High Bake Hardenability

- Exposed Surface Quality Capability
Background

DP500 Steel as Potential Solution

True Stress - True Strain Curves
As Shipped

True Stress (ksi) vs True Strain

- DP500
- BH300
- BH280
- BH250
- BH210
- BH180
- DS
Background

DP500 Steel as Potential Solution

True Stress - True Strain Curves

Paint Baked after 2% Prestrain

True Stress (ksi)

True Strain

DP500

BH300

BH280

BH250

BH210

DS

www.autosteel.org
Ford Front Door Outer
(Test Case Study)
Front Door Outer Study

- Steel Products Analyzed
- Manufacturability
  - Without any changes to tooling and/or process
- Dent Resistance Performance
Front Door Outer Study
Steel Products Analyzed

<table>
<thead>
<tr>
<th>Product</th>
<th>YS (Min)</th>
<th>Part YS* (Min)</th>
<th>UTS (Min)</th>
<th>n-bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH210 EG (0.8, 0.9 mm)</td>
<td>210</td>
<td>260</td>
<td>N/A</td>
<td>0.20</td>
</tr>
<tr>
<td>DP500 EG (0.8 mm)</td>
<td>270-350</td>
<td>370</td>
<td>500</td>
<td>0.20</td>
</tr>
</tbody>
</table>

* YS after 2% Strain and Paint Bake
Front Door Study
DP500 Manufacturability

• Stamping
  – Draw Die Formability
  – Flanging
  – Dimensional Control

• Assembly
  – Welding
  – Hemming

• Surface Quality
DP500 Manufacturability
Stamping - Draw Die Formability
DP500 Manufacturability
Stamping - Draw Die Formability (FLD)

FRONT DOOR OUTER - BH210
\( t = 0.80\text{mm} \)

FRONT DOOR OUTER - DP500
\( t = 0.80\text{mm} \)
DP500 Manufacturability
Stamping - Draw Die Formability (Panel Strain)

![Graph showing major and minor strain comparison between BH210 and DP500 across different locations.]

- Major Strain, %
- Minor Strain, %

Location: A B C D E F G H I J K L M N O

BH210 vs DP500
Minor trim and flange die modifications have since been made to alleviate issues.
Passed Dimensional Control Requirements
Successful Welding With No Process Changes
Successful Hemming With No Process Changes
• Panel Surface Inspection
  – Passed Ford Product Audit (FPA) Criteria

• Paintability
  – High Quality Rating
    • “Wave Scan” Analysis
Front Door Outer Study
Dent Resistance Performance

Dent Locations
Dent Resistance Performance
A/SP Static Dent Test

Location

- 0.80mm BH210 (w/ Patch)
- 0.90mm BH210 (w/ Patch)
- 0.80mm DP500 (w/ Patch)
- 0.80mm DP500 (No Patch)

0.10mm Dent Load, N

Location

1 2 3 4 5 6 7 8
Dent Resistance Performance
A/SP Dynamic Dent Test

Dynamic Dent Test .9mm BH210 vs .8mm BH210 vs .8mm DP500

Graph showing the mean of dent depth at different locations for .8mm BH210, .9mm BH210, and .8mm DP500.
• No significant manufacturability issues
• Good surface quality
• CMM study - comparable to production doors
• Dent Resistance Performance:
  - .8 mm DP500 better than 0.9 mm BH210 (w/patch)
• Application of DP500 appears feasible
Dual Phase Steel (DP500) indicates performance attributes that result in improved dent resistance.

The application of DP500 for door outer applications appears feasible.
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