Advanced High Strength Steel Outer Body Panels in Ford Mustang

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Outline

• Background
• Production Implementation
  - Issues and solutions
• General aspects of DP500 Formability
• Summary
Drivers for Improved Dent Resistance

• Increase customer satisfaction
• Reduce warranty claims
• Reduce in-plant damage
• Vehicle weight savings /avoidance
• Cost savings /avoidance
  – Stiffening patch removal
  – Thickness reduction
  – Evaluate aluminum applications (Holistic approach)
Efforts to Improve Dent Performance

- Ford formed a cross-functional 6-sigma team
- Involved Steel/Tier-1 suppliers & Internal departments
- Solutions to immediately/quickly improve dent performance of panels included
  - Increase material thickness
  - Stiffening patches
  - Use of higher strength steel grades
DP500 Doors – Implementation Steps

- Initial trial run (small volume)
  - FLD Strains
  - Surface Quality (FPA)
  - Welding Assembly
  - Dimensional (CMM check)
  - Paintability (Wave scan and Adhesion)
  - Validation Testing (NVH, DV&P)
- Tooling Evaluation and Modification
- Validate Manufacturing Feasibility
  - 300 Piece Production Trial
  - Best case and worst case trial
- Final Approval by Product Engineering
Door Feasibility Study - Conclusions

- No significant manufacturability issues
  - No major stamping issues
  - No welding issues
  - No hemming issues
- Good surface quality/paint appearance
- Dent resistance performance:
  - 0.8 mm DP500 better than 0.9 mm BH210 (w/patch)
- Feasible for implementation
  (Presented at 2003 GDIS)
- Approved for production
Production Implementation

• Stamping/Forming Observations
  – Issues
  – Select Solutions
  – Tooling Modifications
  – General Guidelines
Forming Issues

- Double draw line control
- Gentle buckle lines
- Cracking in mirror pocket area
- Intermittent Edge cracks at stretch flange
Stamping Issues Identified

Double-draw/skid lines noted along belt line
Vertical buckle lines observed on the front upper panel

Edge splits noticed in the trim/flange operations in stretch flange area on RH panel.
Draw-die Modification

Eliminate Skid Lines

Adjustments made to the Balance Blocks located at the front of the draw die to eliminate double-draw/skid-line condition.

Decrease height of the blocks to increase the binder pressure.

Fig. #1
Draw-die Modification

Eliminate Buckle Lines

Polished/smoothen the radii on lower and upper dies to avoid zinc build up.

Polished and smoothened the Binder beads for better material flow.
Trim-die Modification

Eliminating Edge cracks

Sharpened Upper and Lower trim dies to obtain Clean flange edge

Build pad underneath to support metal for cleaner trim

Sharpened and polished the trim edges for clean cut reduce burr on rear side of door panels
Trim-die Modification

Eliminating Edge cracks

Re-nested (welded) the sail area to provide support to the metal and avoid burrs on the trim edge and edge cracking.
Flange-die Modification

Re-contour Punch/Radii

Edges cleaned on the flange die to prevent burrs that cause edge splits

- Re-contour the punch by increasing the radii
- Provides better metal flow – compressive mode
- Eliminates edge split
FLD Results – 0.80mm DP500

Safe Panel

Thinning Strain Diagram

Failure
Marginal
Worst Case Marginal
Safe

Forming Limit Diagram

Failure
Marginal
Worst Case Marginal
Safe
Other General Forming Aspects

- Press loads
- Forming in the draw die
- Die wear
- Post-forming operations
- Springback
Stamping Press Loads
Considerations for DP500

- DP500 exhibits higher work hardening behavior
- Important for
  - Estimating the press capacity needed for a part
  - Product engineers like to down gage when applying DP500
- Estimating press loads
  - Use of FEA
  - Empirical equations (used in tool shops)
- Experience
  - Closure panels (~ 15% increase at the same gage)
  - Type of operations that are being performed
Draw-die Formability
Impact of DP500

- Higher n-value for the high strength level
- Higher envelope of safe formable region
- Issues similar to that of conventional steels
  - Nothing unique to DP500
Die Wear and Tear
Impact of DP500

• Die wear
  – Draw beads
  – Radii
    • Such as at the die entry
    • Features with small radii – local contact loads can be very high

• In parts prone to wrinkling the die wear can be an issue
  – Increased load response
  – Attention to die process to minimize wrinkle can be very important
Post-forming Operations

- Trimming
- Flanging
- Hemming
- Re-strike operation
- Embossing
- Coining
DP500 – Trimming

- Factors affecting edge condition after trimming
  - Influenced by the clearance and die wear
- Attention to proper support of the panel while trimming operation
  - Eliminates bad burr after trim
  - Avoids edge cracking or tear
- Materials for trim dies
  - Tensile strength increase > 50%
DP500 – Flanging

- Straight flange
  - Not an issue
- Curved flange
  - Stretch flange
  - Compression flange
Flanging - Stretch Flange
Flanging – Curved Flange

- Slight difference in flange length
- Metal gainer to reduce the localized tensile stress

RH Door DP500
LH Door DP500
Stretch Flanging – Metal Gainer

Mechanism of Gainers

METAL GAINER

TRIM LINE

TRIM LINE RADIUS R1

FLANGE BEND LINE RADIUS R2

FLANGE AFTER FORMING

F →

F ←

F →

F ←
• Implement aspects that will reduce the level of tensile stress at stretch flange edge
  – Reduce local flange length
  – Engineer metal gainers in the development
    • Compensate for the change in length of line
  – Transition of flange length should be gradual
    • Abrupt changes in flange length act as stress raisers locally leading to edge cracks.
  – Avoid the use of sharp notch features in curved flanges
    • Trim development
• Flange
  – Has not been a major issue
  – Compensated by over bend of the flange
• CMM checks of the assembly of production trials
  – No issues
Summary – Mustang Doors

• Stamping issues identified and addressed
• Door Outer Panels currently in production 0.80mm DP500
• Production being monitored for impact of DP500 on the Dies/Die surfaces and its effect on the quality of the panels
  – Monitoring die wear
• Change in gauge helped achieve weight savings of 2.3 lbs./vehicle
Summary - General

- Unique microstructures
  - Unique mechanical behavior
- Good understanding of the metal flow
  - FEA simulation very informative
- Engineer the process and design to accommodate the DP500
  - So as to make the forming system robust
# Acknowledgements

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