IMPACT – FABRICATE

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Outline

• Background
• Objective
• Forming
• Welding
• Summary
• Joint Project sponsored by
  – Ford
  – U.S. Army
  – AISI
  – University of Louisville
FABRICATE TEAM

• Ford Motor Company
  Musa Azzouz (Consultant)
  Mike Azzouz (Consultant)
  Peter Miskech
  John Chiang
  Tim Cummins (Consultant)

  Greg Dobieralski
  Paul Geck
  Wen-Sheng Lin
  Bill Riley
  Arnon Wexler

• AISI
  Ken Shaw, Dofasco
  Sean Martin, Dofasco
  Jayanth Chintamani, Ispat Inland
  Liang Huang, Ispat Inland
  Keith Laurin, Ispat Inland
  Wei Wang, Severstal N.A.
  Dave Ruhno, USS
  Mike Grimmet, USS
  Paul McKune, USS

• Others
  Troy Design and Manufacturing
  Quality Metal Craft
  Roman Engineering Services
  Engineering Quality Solutions
General Steel Grades

Current Product

Tensile Strength, MPa

Elongation, %

Low  Medium  High  Ultra-High

Mild  BH  HSS  DP  TRIP  CP  UHSS  FABRICATE
Objective

• Forming
  – Develop an understanding of formability of specific Advanced High Strength Steels (AHSS) parts

• Welding
  – Characterize weldability of AHSS steels
General Approach - Forming

- Preliminary evaluation of part formability using one-step FEA analysis
- Preliminary draw die development
- Reassess product features for robust process
- Detailed incremental FEA analysis
- FEA results evaluated by the team
- Soft tool build
General Approach - Forming ..

- Form parts and review by the team
- Recommend changes
- Check surface quality of part
- Conduct forming strain analysis
- Post forming - Flanging
- Conduct dimensional check
Parts Selected for the Study

Fender
Mid Transverse Cross Member
Door
Shot Gun
Rationale for Selection of Parts

• **Fender**, Door Outer
  – Customer appeal and functional performance
  – Degree of difficulty in tool buy out process
  – Severity of post forming operations

• **Mid-transverse cross member**, Reinforcement front fender inner (Shot gun)
  – Target for improving crash performance
  – Target for down gauging
Steels used in the study

• Fender
  – 0.80mm BH210
  – 0.65mm DP500

• Mid-transverse X member
  – 1.50mm HSLA350
  – 1.50mm DP600
  – 1.40mm DP600
Incremental FEA - Results

WRINKLE

SPLITS

1 2 3 4 Piece Stretch Draw Die

SPLITS & WRINKLE

SPLITS & WRINKLE

www.autosteel.org
Typical Panel Review

Areas of concern consistent with FEA predictions
Final DP500 Panel FLD

Developed production acceptable draw die process
Post Forming – Trimming & Flanging

- More Gradual transition of the flange
- Relief notches eliminated
- Corner splits eliminated
- Gentle relief Notch eliminated
- Edge split eliminated

Hood line flange
Lessons Learned - Fender

• 0.65mm DP500 product showed good potential for a production application with the following considerations
  – Clean edge condition after trimming is important
  – Avoid notches in the door line flange
  – Gradual transition of flange length
  – Stretch flange conditions
    • Minimize the trim flange length
    • Eliminate sharp notches in the flange
**Steels used in the study**

- **Fender**
  - 0.80mm BH210
  - 0.65mm DP500

- **Mid-transverse X member**
  - 1.50mm HSLA350
  - 1.50mm DP600
  - 1.40mm DP600
Incremental FEA - Strain Map

Radii to be softened

Thickness contour map (0 to 20%)

SPLITS & WRINKLE
Wrinkles in the Tunnel Area

In the part, no major forming issue other than wrinkles.
Tunnel Area - Wrinkles at the Bend

Varying length of line across the bend
Modified Tunnel Design

Original Design

Constant length of line across the bend

Modified Product
Springback Data
• DP600 product showed good potential for production of this part with the following considerations
  – Flange radii and radii along the hat section need to be optimized for
    • Safe Formability
    • Controlling springback
  – Engineer stiffeners to optimize springback
IMPACT – FABRICATE Welding
- Screening tests with differential material stackups
  - AC welding
  - AC versus MFDC (1200 Hertz)
- Stackups
  - More than 20 different stackups
  - Up to 3:1 thickness ratio
  - Up to 2mm gage
- Steels
  - Mild steel, HSLA and DP
Screening Study – AC Welding

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<th>Material B</th>
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Potential issues with these grade and gage combinations
AC and MFDC (1200 Hz)

AC

1.80mm DP600 HDG

0.80 Mild Steel HDG

MFDC

1.80mm DP600 HDG

0.80 Mild Steel HDG
AC and MFDC (1200 Hz)

MFDC Weld current range is as good or better
Multiple Stackups DP600 - MFDC

1.8 DP600 HD / 1.5 DP600 HD / 1.8 Mild HD
Min Button Size = 6.0 mm

Increase weld time for DP600
DP500 EG / Mild Steel – AC Welding

**TYPICAL CASE**
0.65mm DP - 0.8mm Mild

0.65mm DP - 2.0mm Mild

**WORST CASE**

Thickness Ratio < 2

Thickness Ratio > 2

Electrode life: 2000 welds, OK

Electrode life: 1250 welds, NOK

- AC Welding OK for thin gage DP500
- Thickness mismatch has stronger effect than material/grade
Summary

• AHSS require better integration between product and manufacturing engineering
• FABRICATE project supported the development of AHSS guidelines for
  – Forming
  – Welding
  – Product design