HEMMING THIN GAUGE ADVANCED HIGH STRENGTH STEEL

AUTO/STEEL PARTNERSHIP PROJECT #AS-8004

Mark Hineline - AutoForm Engineering

May 11, 2016

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Forming Reality

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Auto/Steel Partnership Participants

Superior Cam

AutoForm
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AK Steel

GM

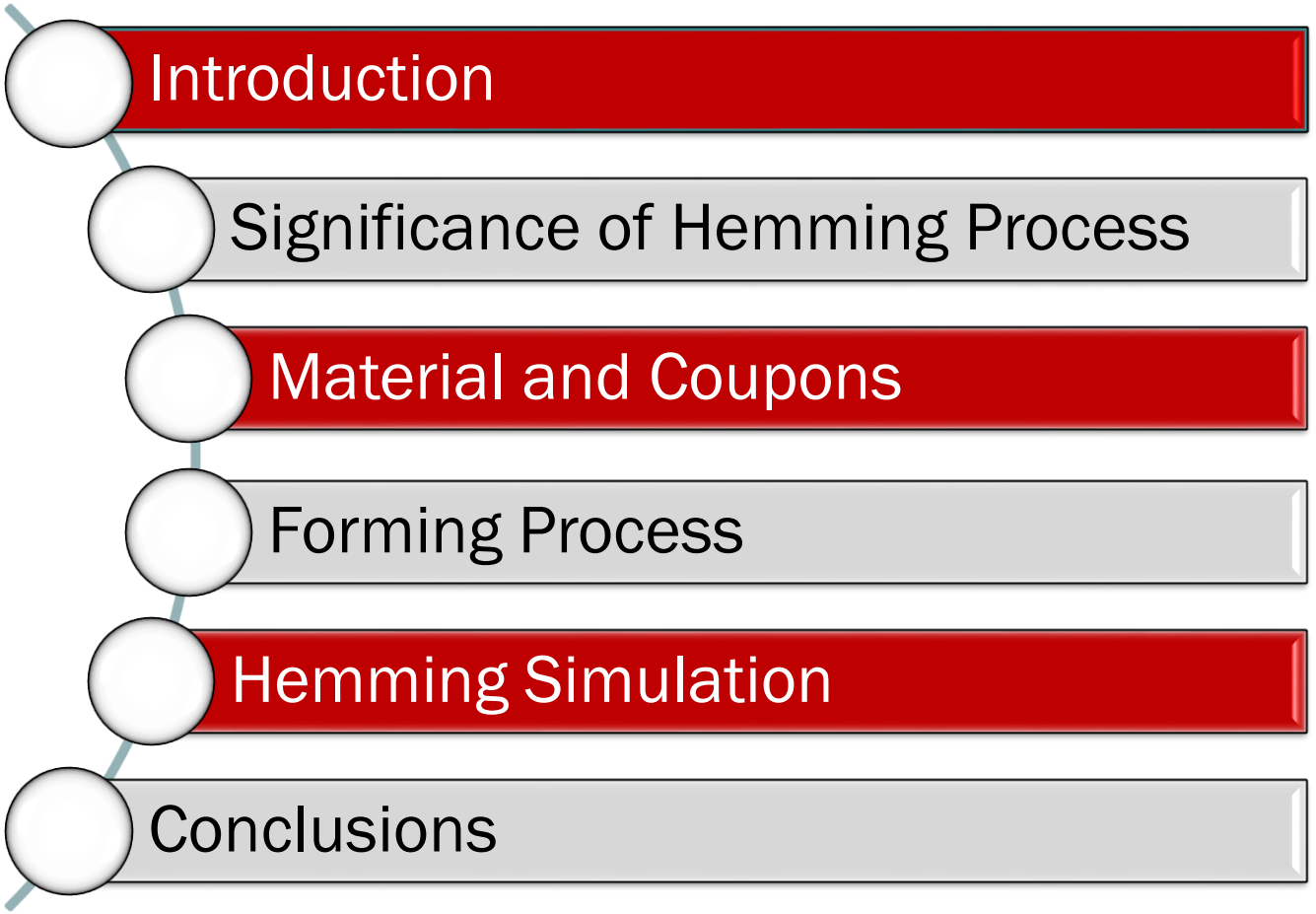
A/S P Auto/Steel Partnership

ArcelorMittal

Ford

FCA
FIAT CHRYSLER AUTOMOBILES

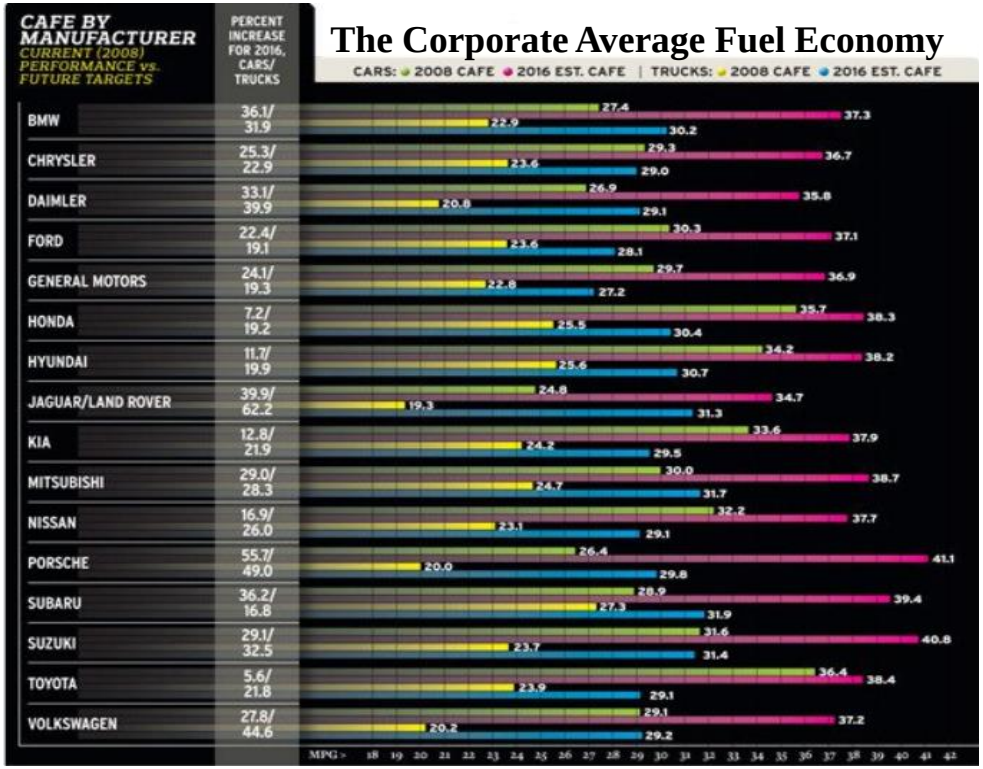
Project Outline

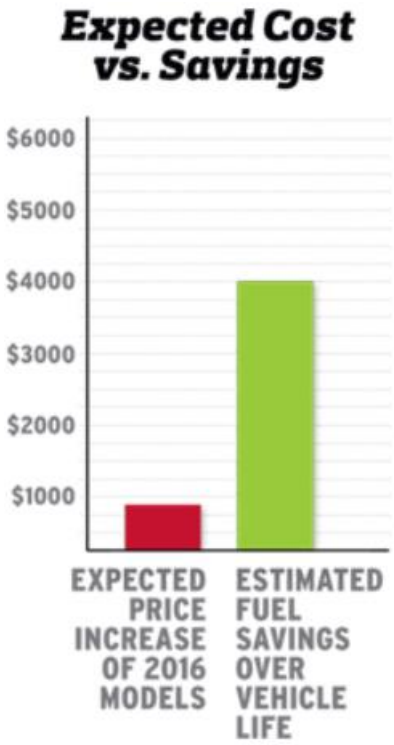


Introduction

Why do the project:

- By now we are all aware of the mandated C.A.F.E. standards for fuel consumption, 54.5 mpg by 2025





Source from http://www.caranddriver.com/features/how-automakers-will-meet-2016-cafe-standards

Introduction

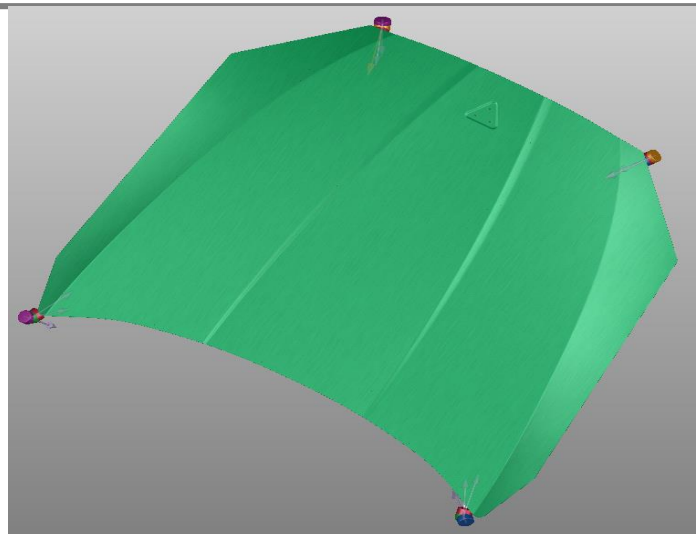
Why do the project:

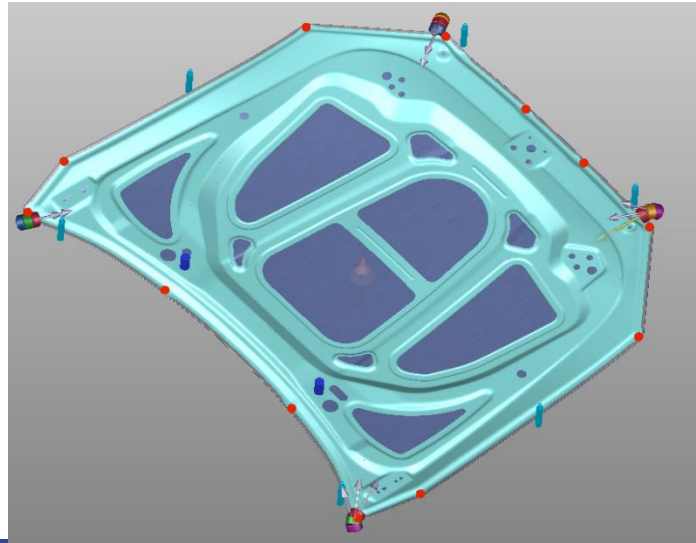
- Due to the C.A.F.E. Standard there is a common drive to reduce weight in automobiles in an effort to lower fuel consumption.
- One obvious option to reduce weight is to target the largest panels.
  - Body sides & Roofs
  - Hoods & Doors
  - Deck lids
- The purpose of this project is to demonstrate thin gauge AHSS is an acceptable option for automotive outer panels to reduce the weight of these outer panels.
- Discover if simulation software is capable of detecting problems if present in the process

Significance of Hemming Process

Hemming:

- The main concern of this project was to prove that AHSS materials are indeed formable and capable of being hemmed.
- The A/SP project concentrated heavily on the hemming process.
- Class “A” closure panels are of great importance due to the visibility which influences potential sales. Hemming is the final forming process and must not cause failures or surface defects.

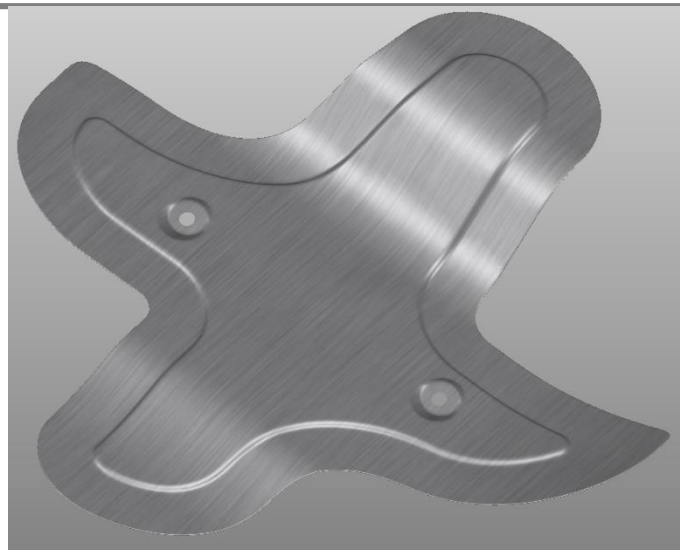


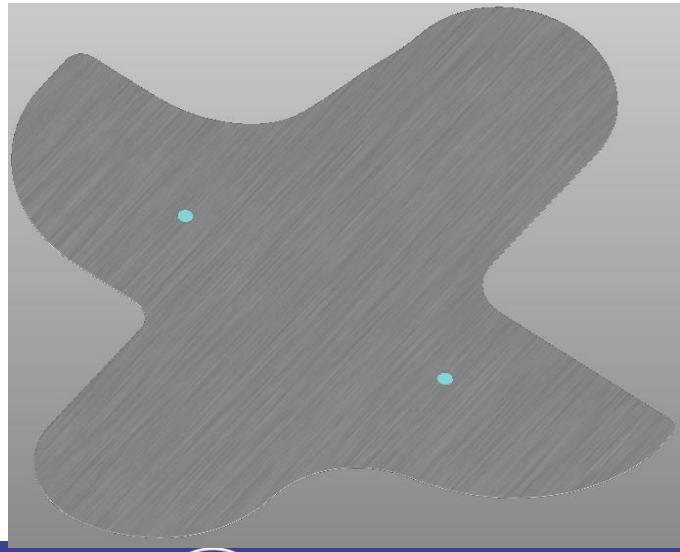


Significance of Hemming Process

Hemming:

- Six panels
  - 3 panels with shape designed to reflect features found in typical hemmed outer panels
  - 3 panels that are completely flat
- All hemmed panels considered to be flexible panels to demonstrate the influence of the forming process, as well springback, during and after the hemming





Material Overview

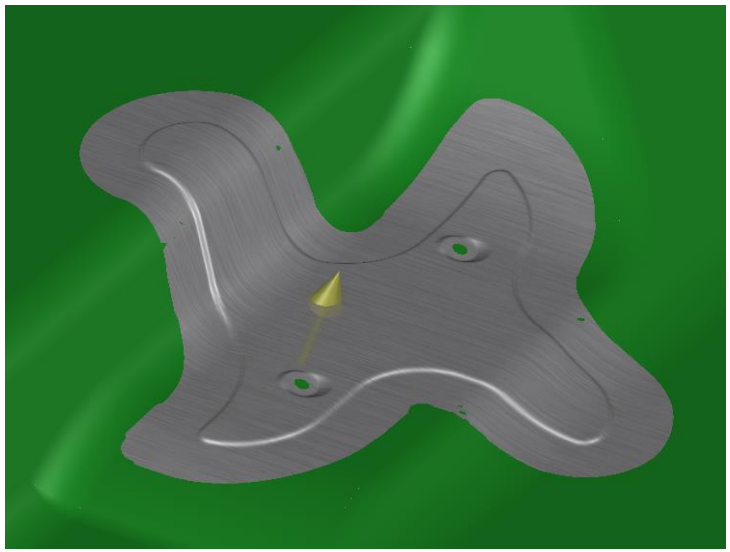
Material:

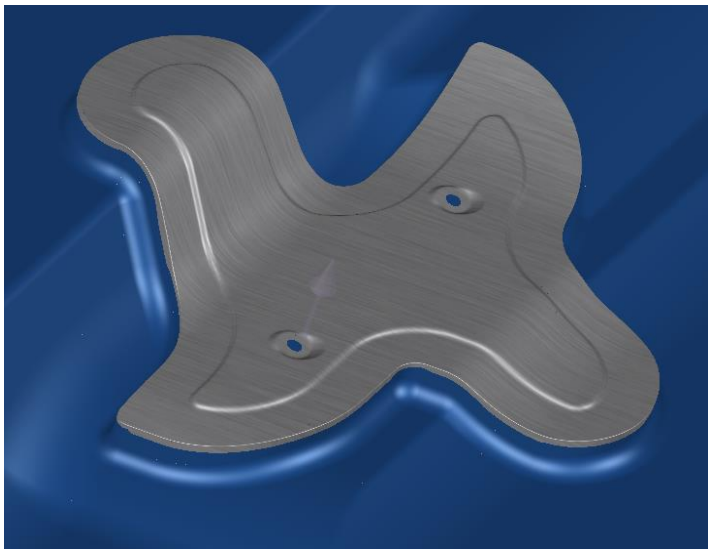
- AHSS material provided by the participating member steel companies
  - Outer class A panels: *(For more information please contact supplier)*
    - Supplier A
      - BH 280 0.55mm
    - Supplier B
      - BH 440 0.55mm
    - Supplier C
      - DP 490 0.50mm
- Inner panel:
  - DC04
    - 0.7mm thick typical deep draw quality material from the AutoForm material library

Forming Process

Forming Outer Panels:

- **Superior Cam** designed and built the stamping dies
- The stamping process was simulated using *AutoForm*^{plus}*R6*
  - Two operations
    - Forming operation
    - Flanging operation





Forming Process

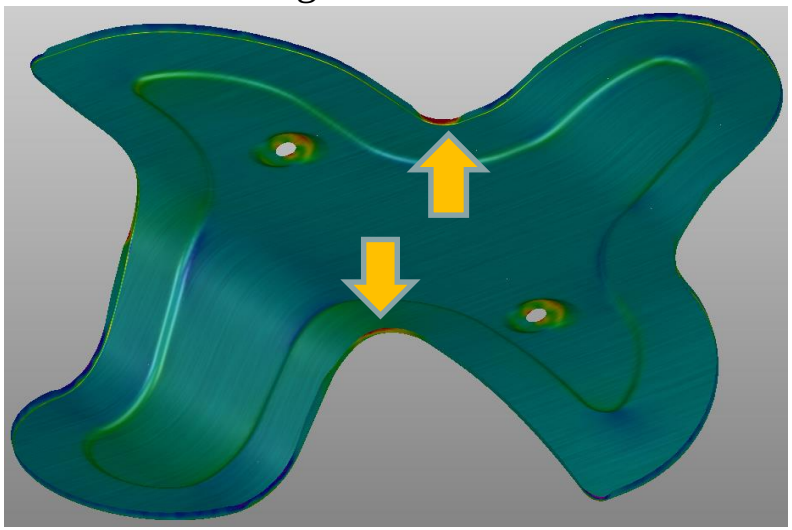
Formability Outer Panels:

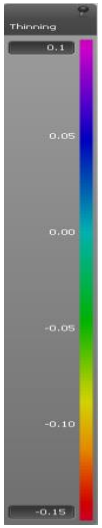
- There are some minor stamping formability concerns for the outer panel
  - Thinning is small in stretch-flanges *(indicated with arrows)*
- Similar in severity as any other steel panel with similar features

Formability Inner Panels:

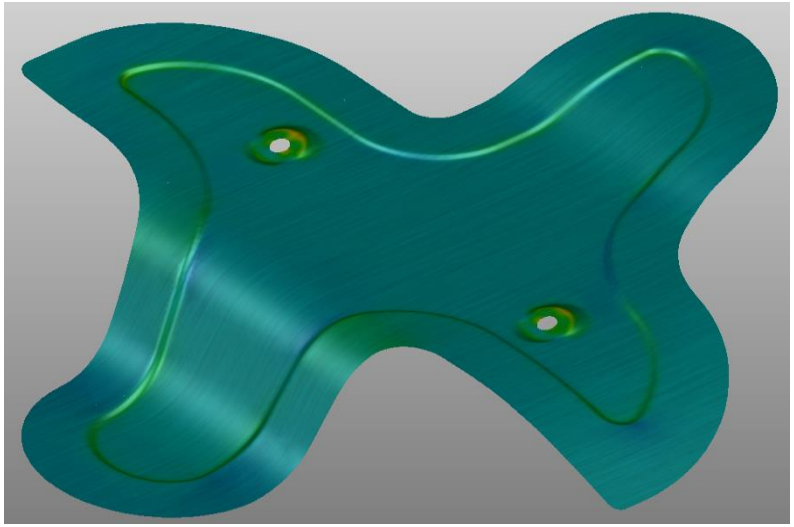
- Very safe

Flanged Outer Panel





Inner Panel



Forming Process

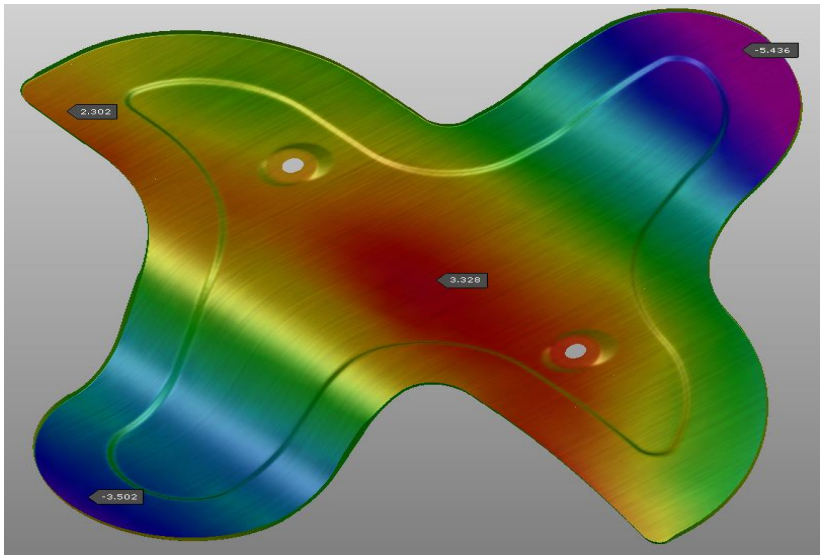
Spring Back Outer Panels:

- 2mm to 5mm of spring back after forming is present for all 3 materials
- No compensation (tool geometry adjustment) applied prior to hemming

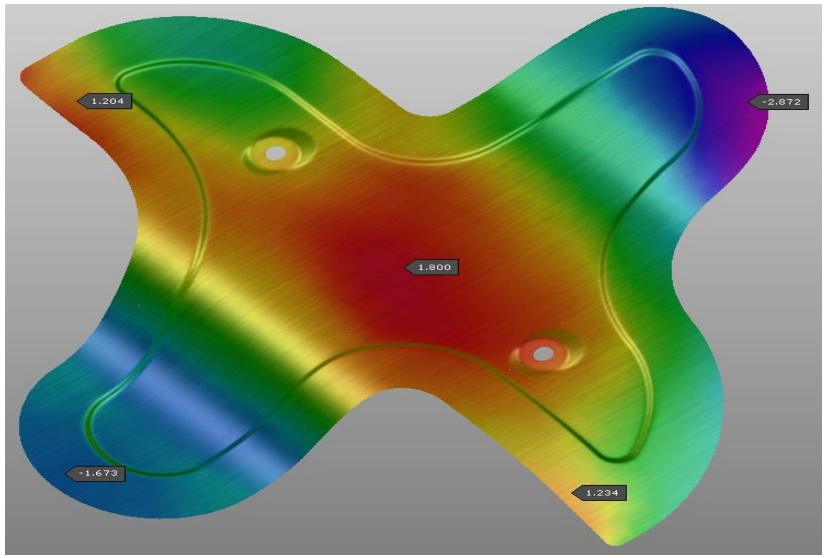
Spring Back Inner Panels:

- 1mm to 3mm spring back present
- No compensation applied before hemming

Flanged Outer Panel



Inner Panel



Forming Process

Hemming Assemblies:

- Superior Cam/Diversified Tooling performed hemming process

Photo courtesy of Diversified tooling

Hemming Simulation

Hemming Simulation:

- Complete hemming simulation in AutoForm-HemPlanner^{plus}R6
- Roll hemming was selected for this project as the preferred hemming method:
  - Process typically encountered in production
  - Generally more robust than press hemming—panels not feasible with a roller process are not likely be hemmed using press hemming
  - Roll hemming is more cost effective, albeit slower, than press hemming, but speed is not a concern here

Hemming Simulation

- In AutoForm^{plus}R6 there are two options for simulating hemming:
- “Quick Hemming”
  - Minimal inputs required
    - Finished class A part
    - Unfolded/flanged part geometry
    - Inner part (optional)
    - Hemming bed (optional)
    - Process can be rigid or flexible using material properties
    - Assumes inner and outer are nominal thickness and strength
  - Excellent for early hemming feasibility based on inner / outer product designs

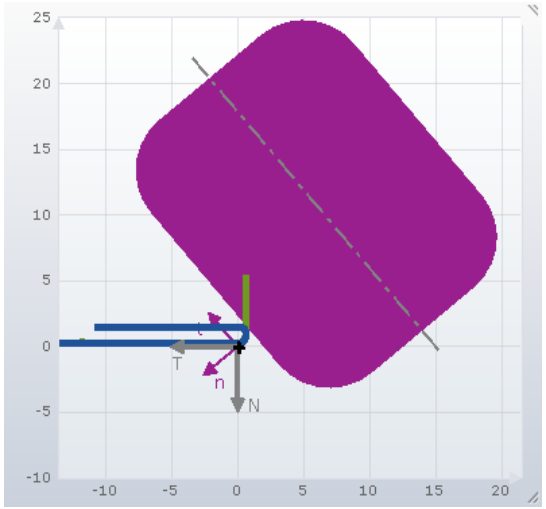
Hemming Simulation

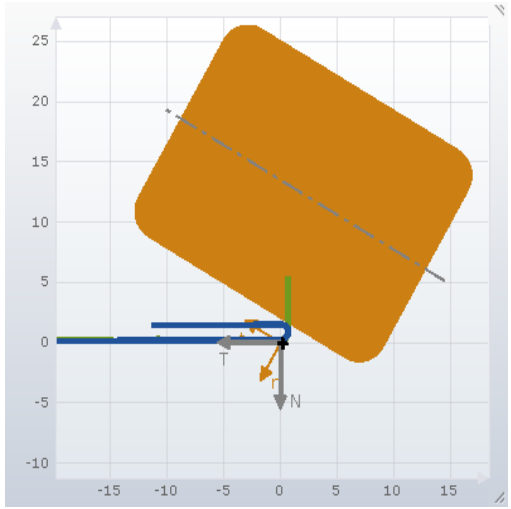
- "Advanced Hemming"
  - Takes advantage of the entire simulated forming process
    - Outer and inner panels imported with forming history
      - Thinning and thickening
      - Strains and stresses
      - Spring back
      - More …
  - Product inputs same as quick hemming
    - Beneficial to use real inner simulation
  - After hemming process, one can analyze how the outer and the inner effect each other as an assembly
- The "Advanced Hemming" process was performed for this project

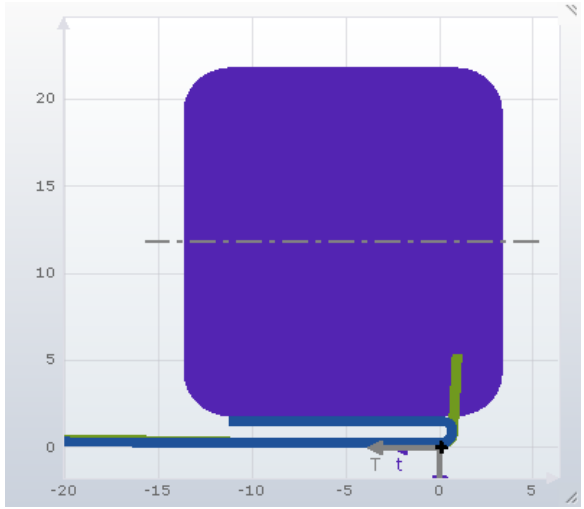
Hemming Simulation

Set up views:

- Three roller passes were used
  - 50 degree angle
  - 30 degree angle
  - Finish pass



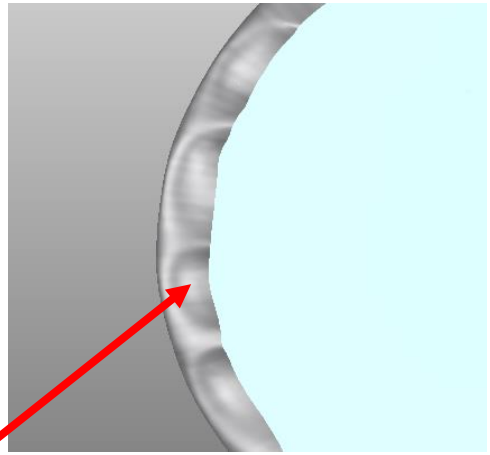


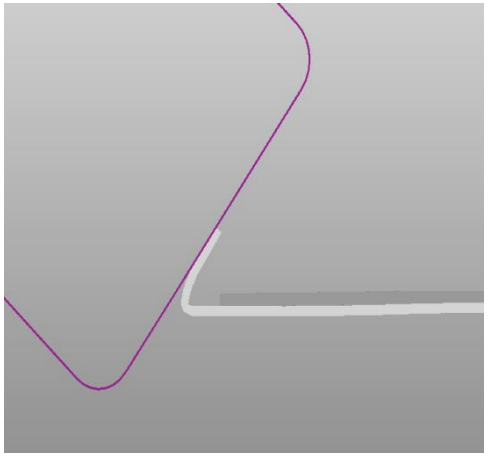


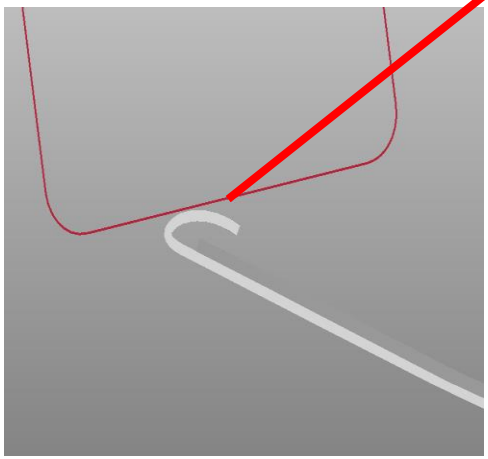
Hemming Simulation

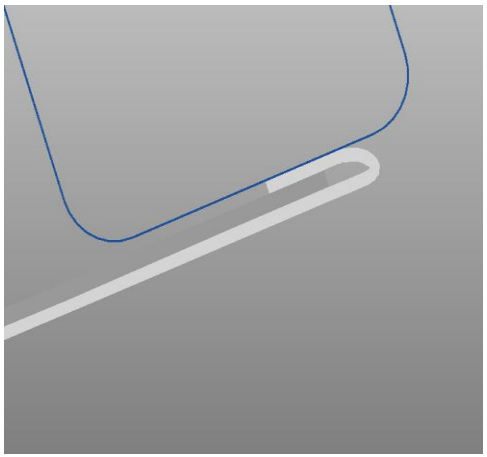
Hemmed section views:

- Three roller passes were used
  - 50 degree angle
  - 30 degree angle
  - Finish pass





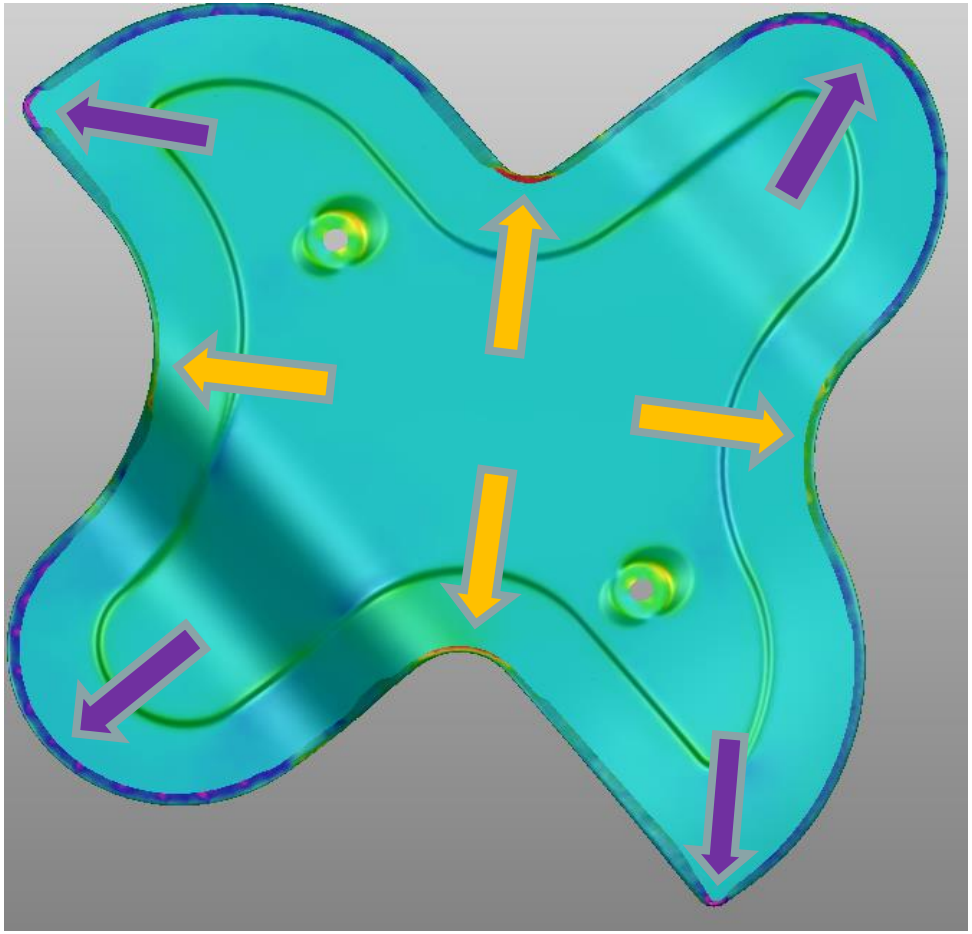




Hemming Simulation

Hemming Results:

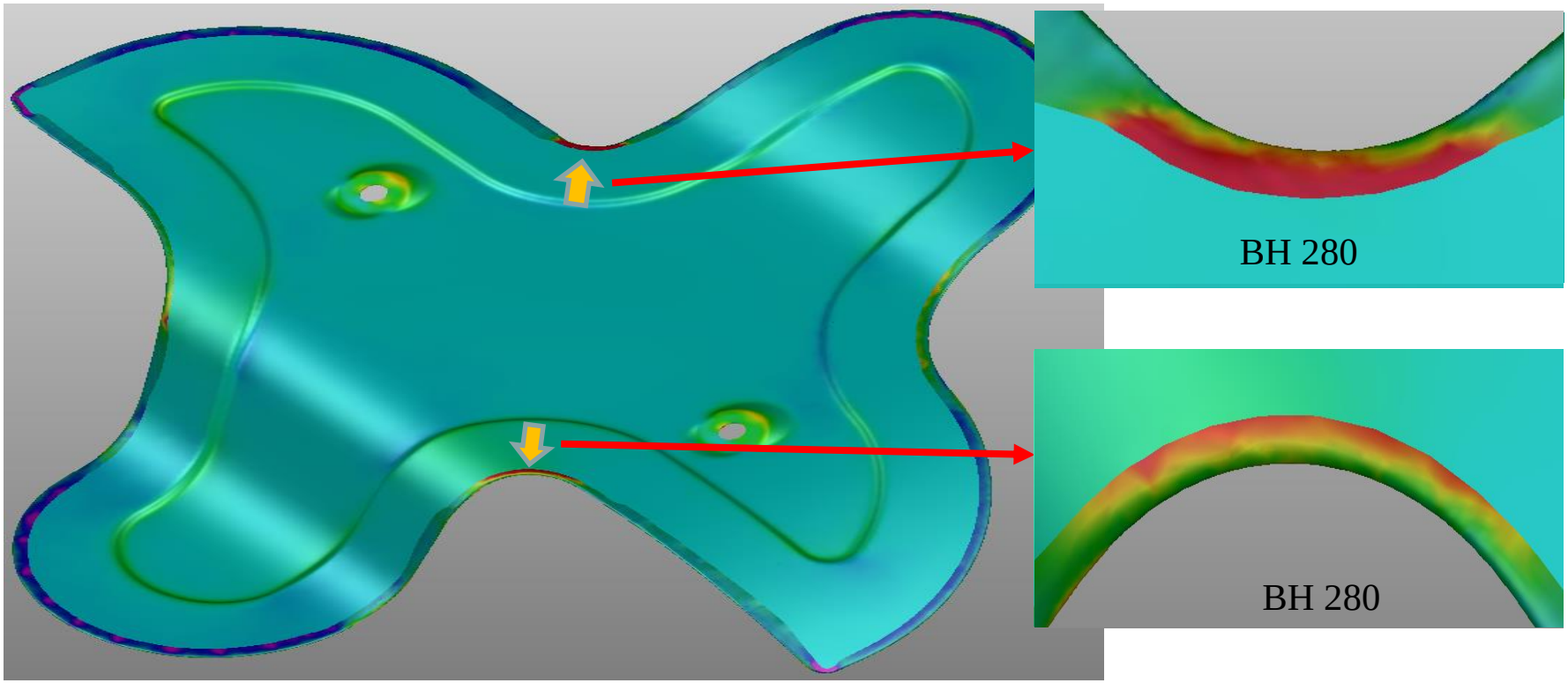
- Typical issues identified in expected locations
- Wrinkling
  - Outer corners tend to overlap
- Splitting
  - Inner corners tend to split



Hemmed Assembly

Finished Hemming Results:

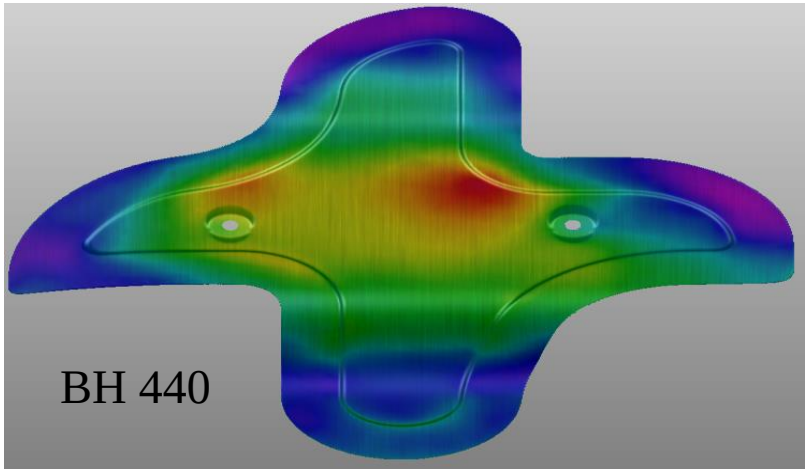
- Areas with thinning more severe after hemming
- Expected and common in hemming any material.

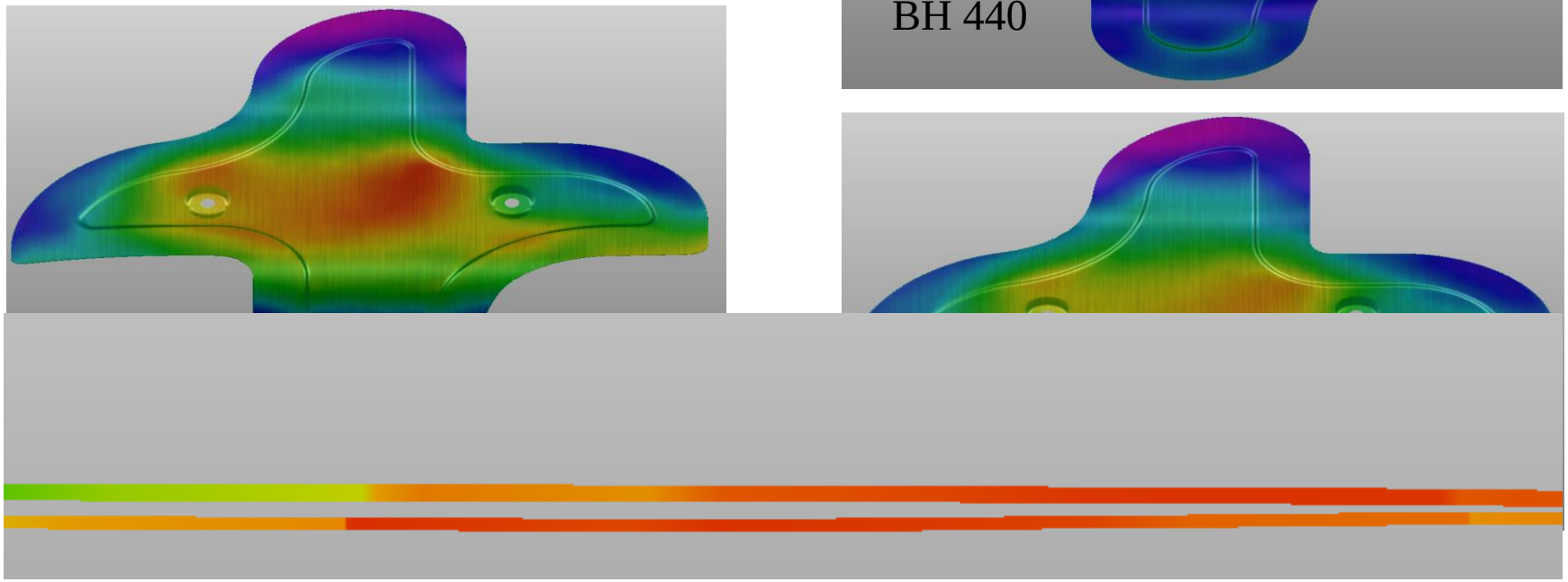


Hemmed Assembly

Free Spring Back:

- Consistent results for all assemblies
- Spring back deformation in the center is trapped material resulting in oil-canning

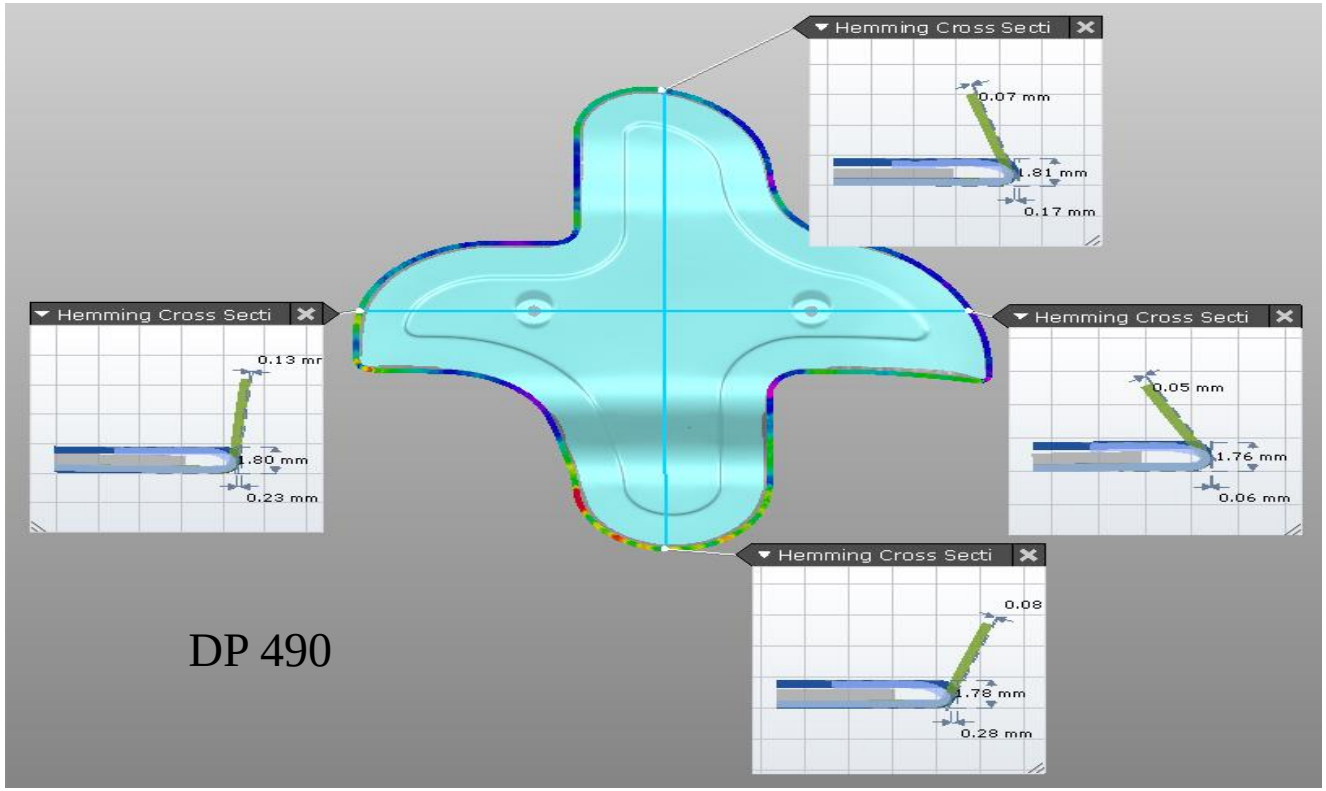




Hemmed Assembly

Finished Hem Measurement:

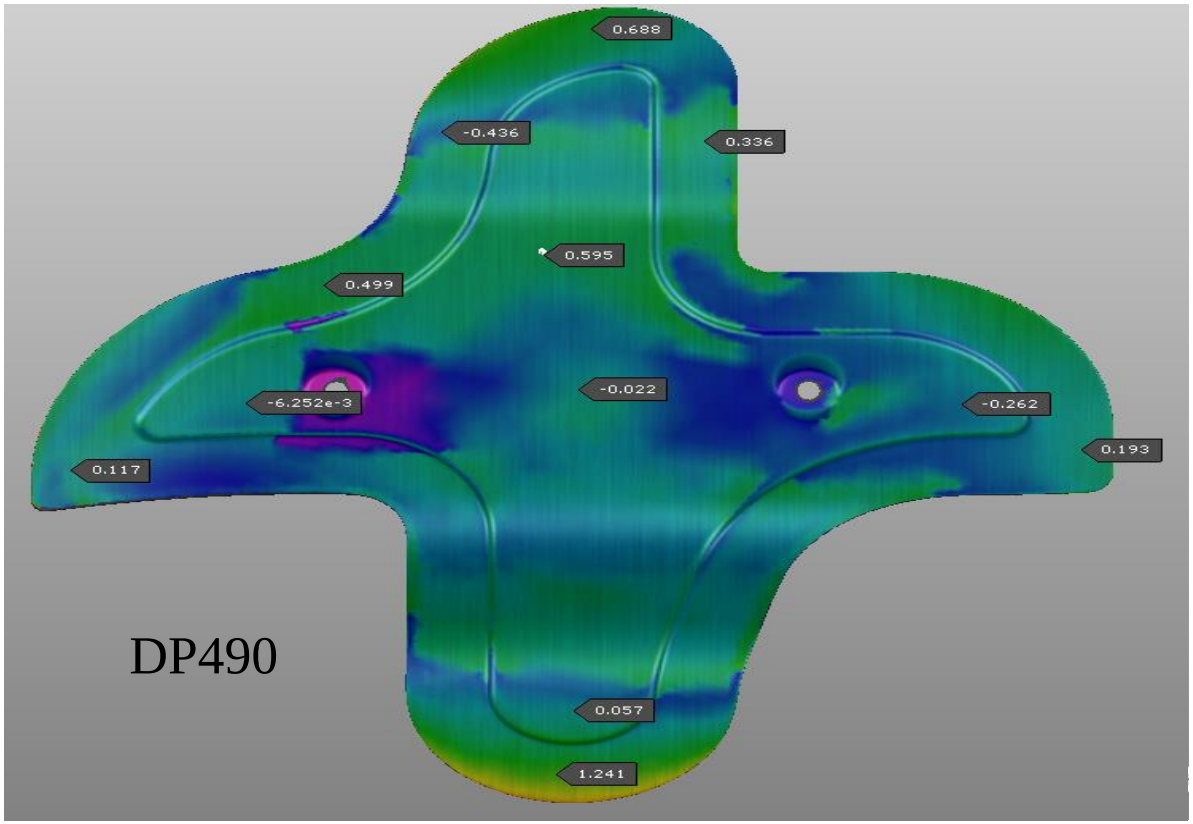
- Simulation results show roll out, creepage & hem thickness
- All of these are necessary results from simulation



Hemmed Assembly

Constrained springback:

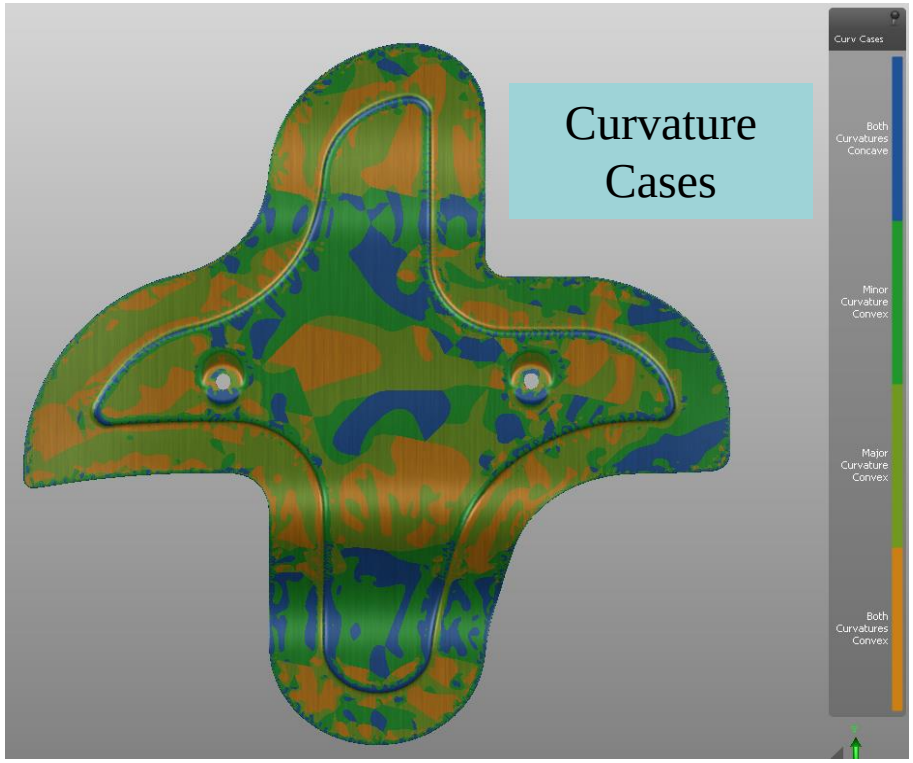
- Comparison of simulated panel to scanned geometry in hemming position. No actual fitting was done.

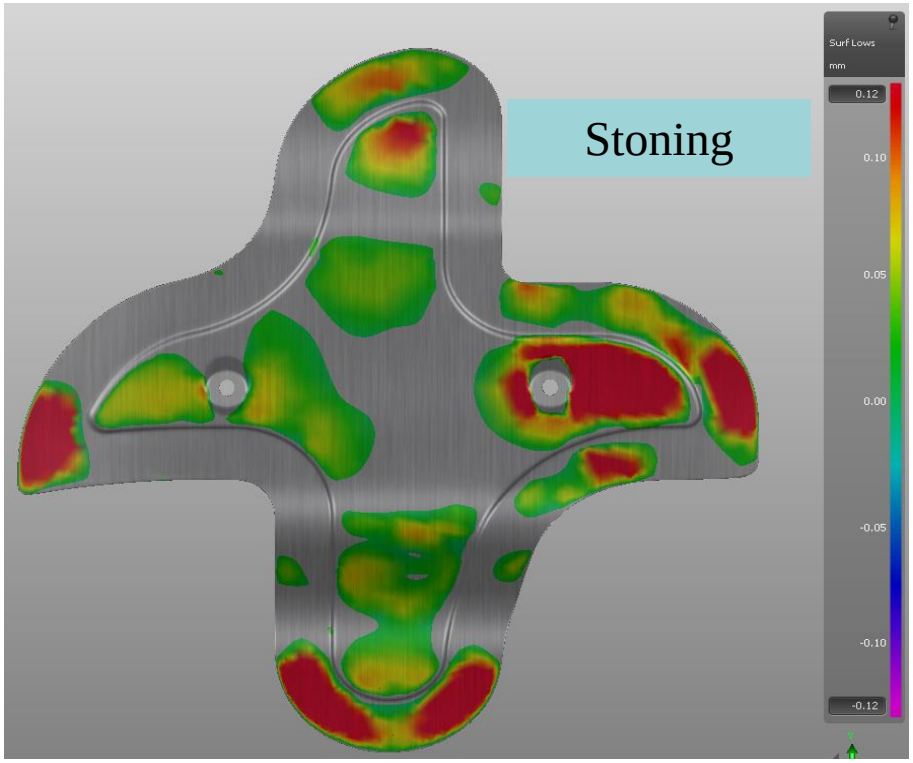


Hemmed Assembly

Surface Defects:

- Surface defects of the assembled panel can be assessed. Here you can see the different curvatures of the panel as well as stoning results.





Summary

- The target of this project is two-fold:
  - ✓ First is to discover if the materials can be formed and hemmed without adding more complexity to the forming process.
  - ✓ Second is then to discover if simulation software has the ability to capture the results.
    - Both of these targets have been achieved.
- Additionally with AutoForm simulation:
  - ✓ Creepage, roll out and hem height are reported.
  - ✓ Springback of the assembled panel can be analyzed.
  - ✓ Surface defects can be assessed after hemming.

Summary

- All materials displayed the similar traits in forming and assembly
  - There are differences that seem to be deciding factors for material selection
  - However, all three materials could produce a manufacturable part
- Based on this simple part
  - Thin gage high strength steel is a viable alternative for lightweight closure panels
  - Continued testing with a true outer panel should follow
- Please stop by the AutoForm booth to see the real panels

Thank You Very Much