GREAT DESIGNS IN STEEL

HYBRID BEAD DEVELOPMENT AND VALIDATION

Chris Roman
General Motors, Stamping Architect

Eric McCarty
Auto/Steel Partnership, Project Manager

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INTRODUCTION

- Background

As we select higher strength steels for automotive use to aid in light-weighting and improved vehicle performance, we encounter additional springback

How to address springback in cold stamping?

a) Material downgrade

b) Die Compensation

c) Countermeasures in Dies to Control Springback

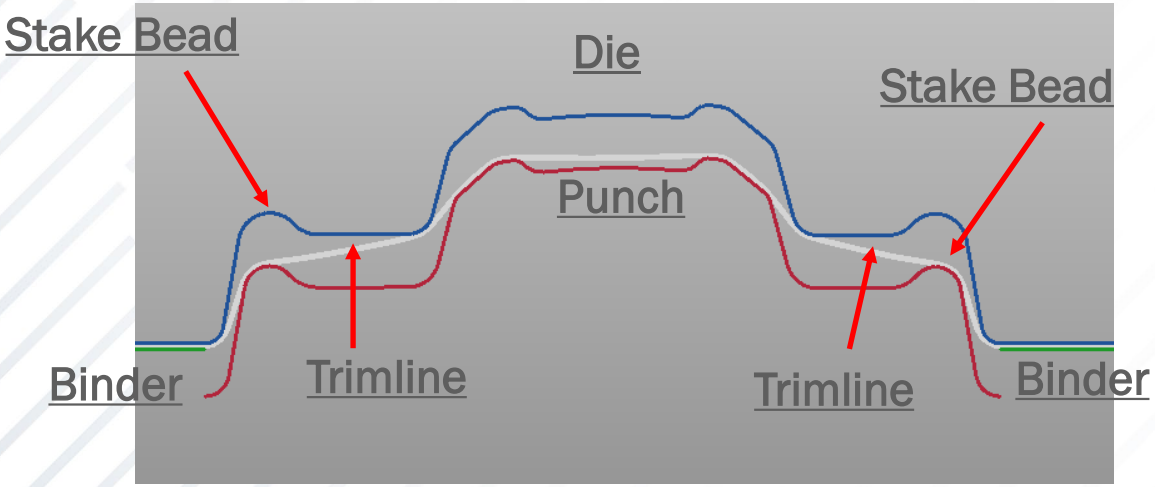
Stake Beads (Traditional approach)

Hybrid Beads (Experimental)

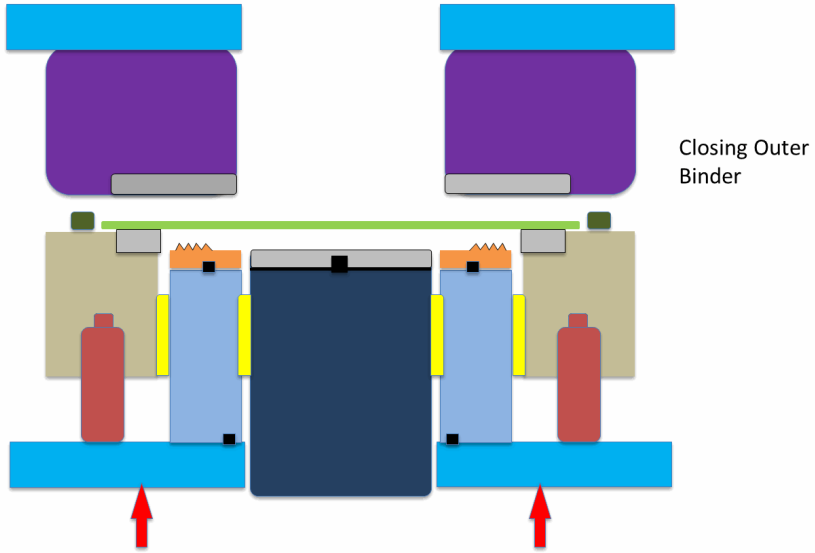
PROJECT GOALS

- To design and validate a manufacturable hybrid bead for springback control
  - Q: How to control springback?
  - A: Post stretch
    - Induce plastic deformation
    - Equalize compressive and tensile stresses in the side walls

Stake Beads



Hybrid Beads



PROJECT DETAILS

Problem Statement:

Typical mechanisms for springback control, such as stake beads, require additional blank material. Hybrid beads have the potential to greatly improve material utilization when compared to Stake beads.

Goal:

To develop a manufacturable hybrid bead for springback control and reduced offal.

Objectives:

Develop and validate a durable hybrid bead design using a laboratory-scale die

Validate viable hybrid bead designs using a production-scale die

Model hybrid bead designs and conduct simulations for clamping force and springback control

Project Deliverables

Proof of concept: Robust hybrid bead design(s)

PROJECT APPROACH

Laboratory-Scale Hybrid Bead Die

- Simulate hybrid bead designs (height, width, geometry, spacing, etc.)
- Conduct laboratory-scale die trials on select bead designs that showed good springback control
- Assess effectiveness of hybrid bead designs in controlling springback

Production-Scale Hybrid Bead Die

- Conduct production-scale die trials on successful laboratory-scale bead designs on a production-scale die
- Assess effectiveness of hybrid bead designs in controlling springback

Hybrid Bead Modeling

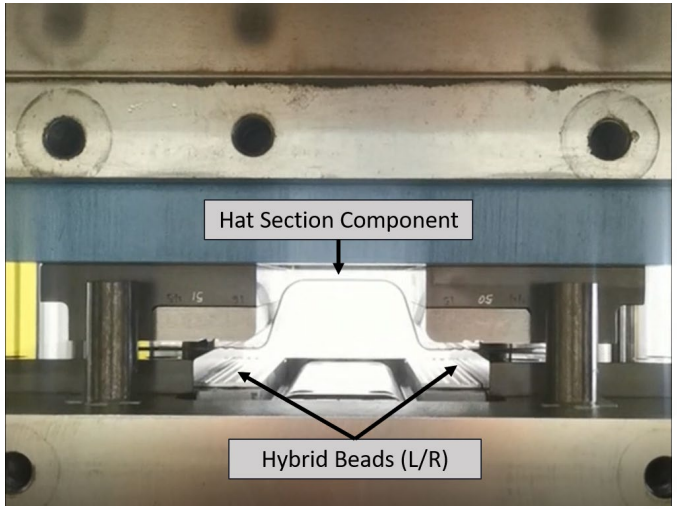
- Simulate minimum press force needed to engage beads and lock metal movement
- Compare simulated press force with both laboratory and production-scale die trial data

PROJECT APPROACH

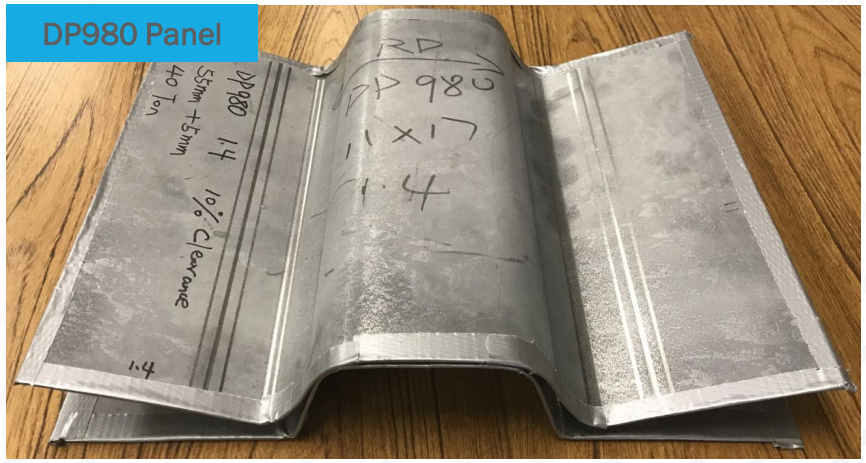
Hybrid Bead

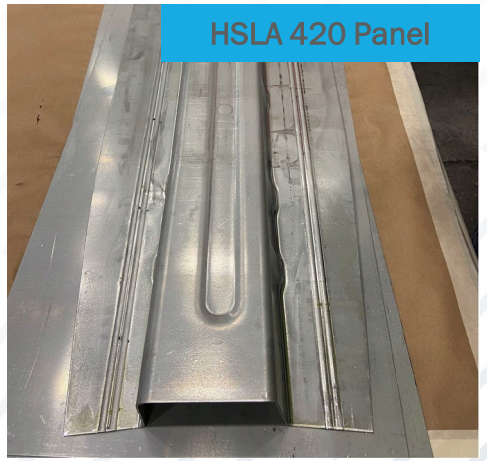
- Laboratory-Scale Die
- Production-Scale Die

Laboratory Scale Die



Production-Scale Die

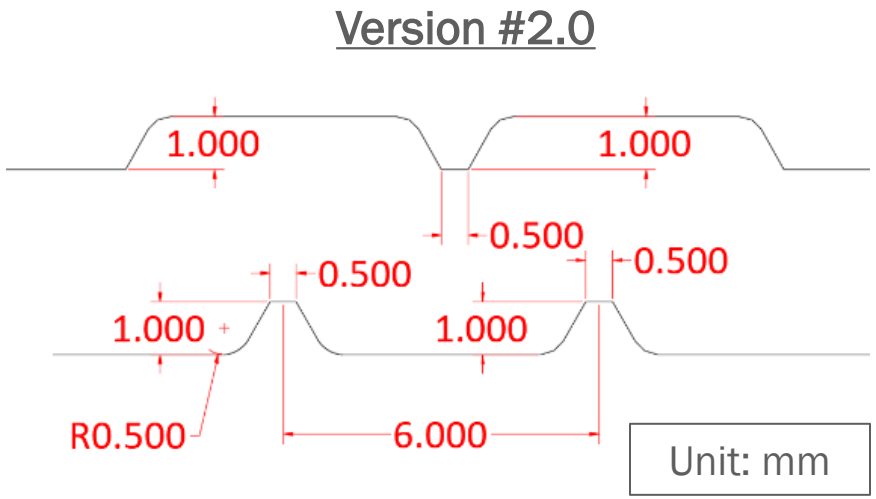


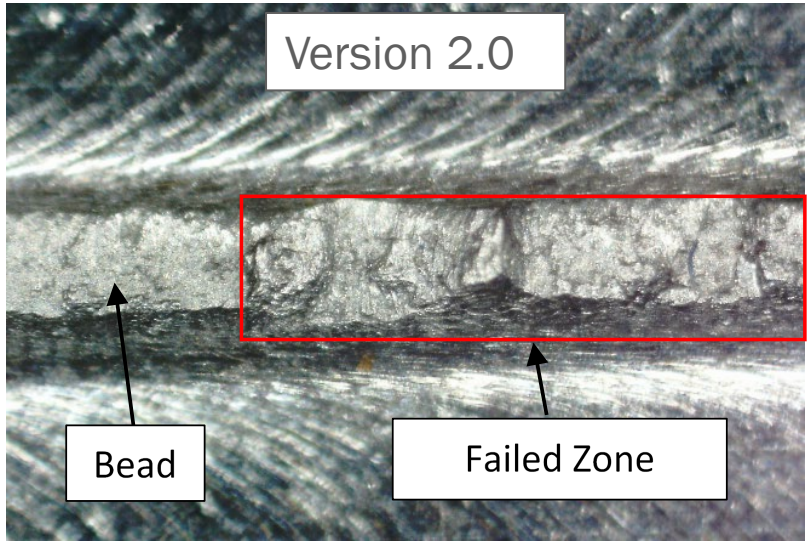


PROJECT RESULTS

Version #2 Hybrid Bead Design

- Three cavity design was effective in simulation
- Performed well in laboratory-scale die trial
- Failed in early production-scale die trial
- Demonstrated that even with broken beads, the hybrid bead could produce an AHSS part with reduced springback
- D2 Tool steel used in initial production scale trial





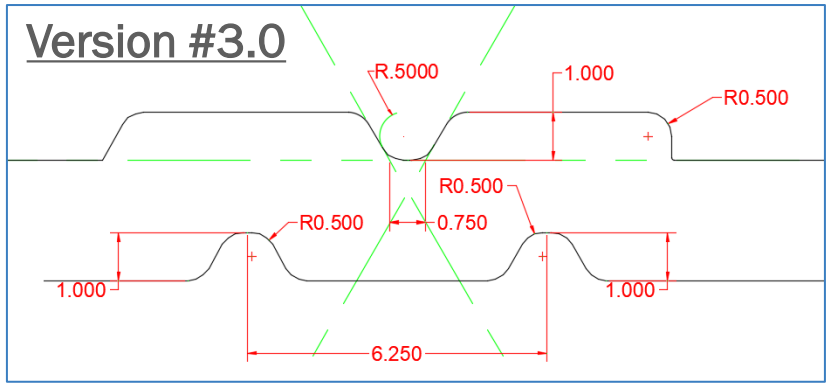
PROJECT RESULTS

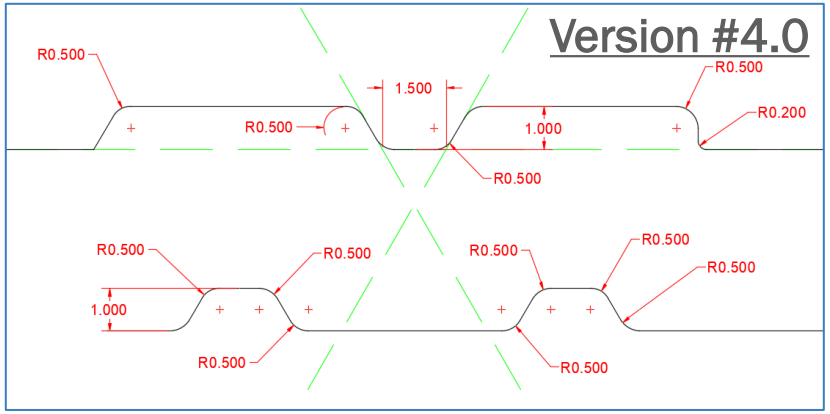
Version #2 to Version #9 Hybrid Bead Design

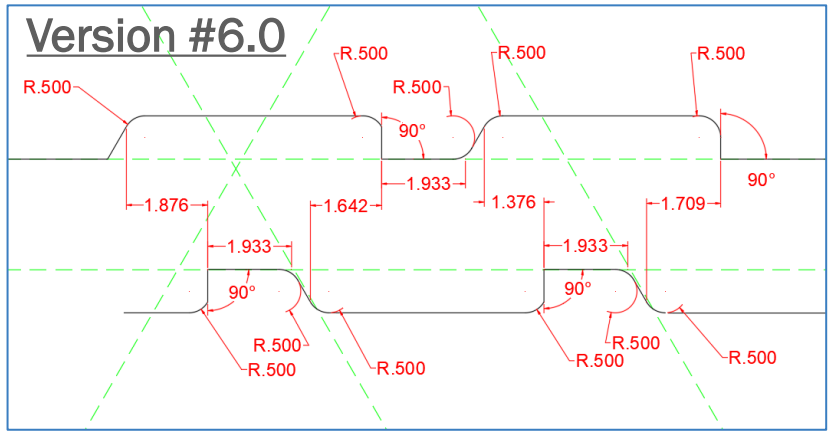
Nine different hybrid bead designs and their variants were evaluated.

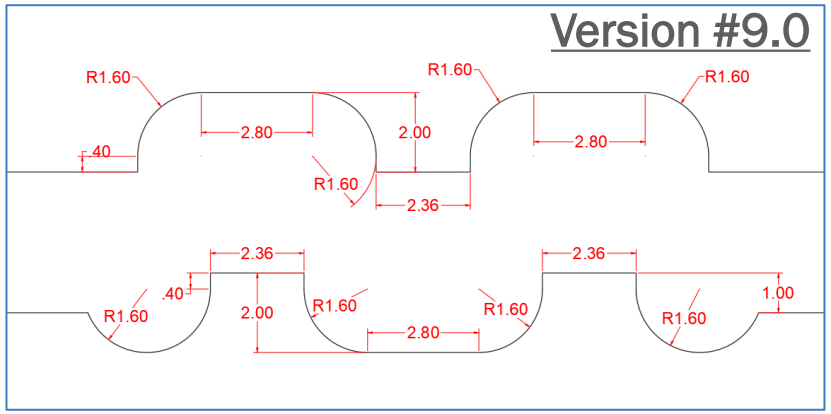
- Version #9 was selected by the team
  - Robust
  - Machinable
  - Similar ability to resist slippage as Version #2.
  - Material flow controlled well
  - S7 Tool Steel selected for inserts

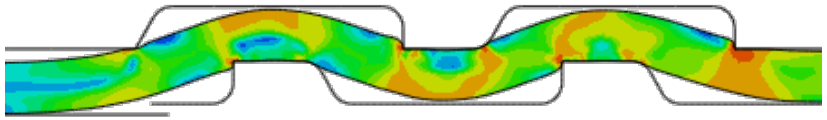
Unit: mm

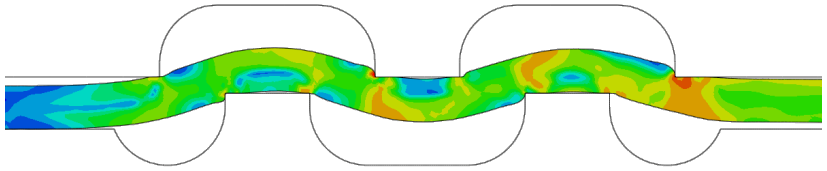










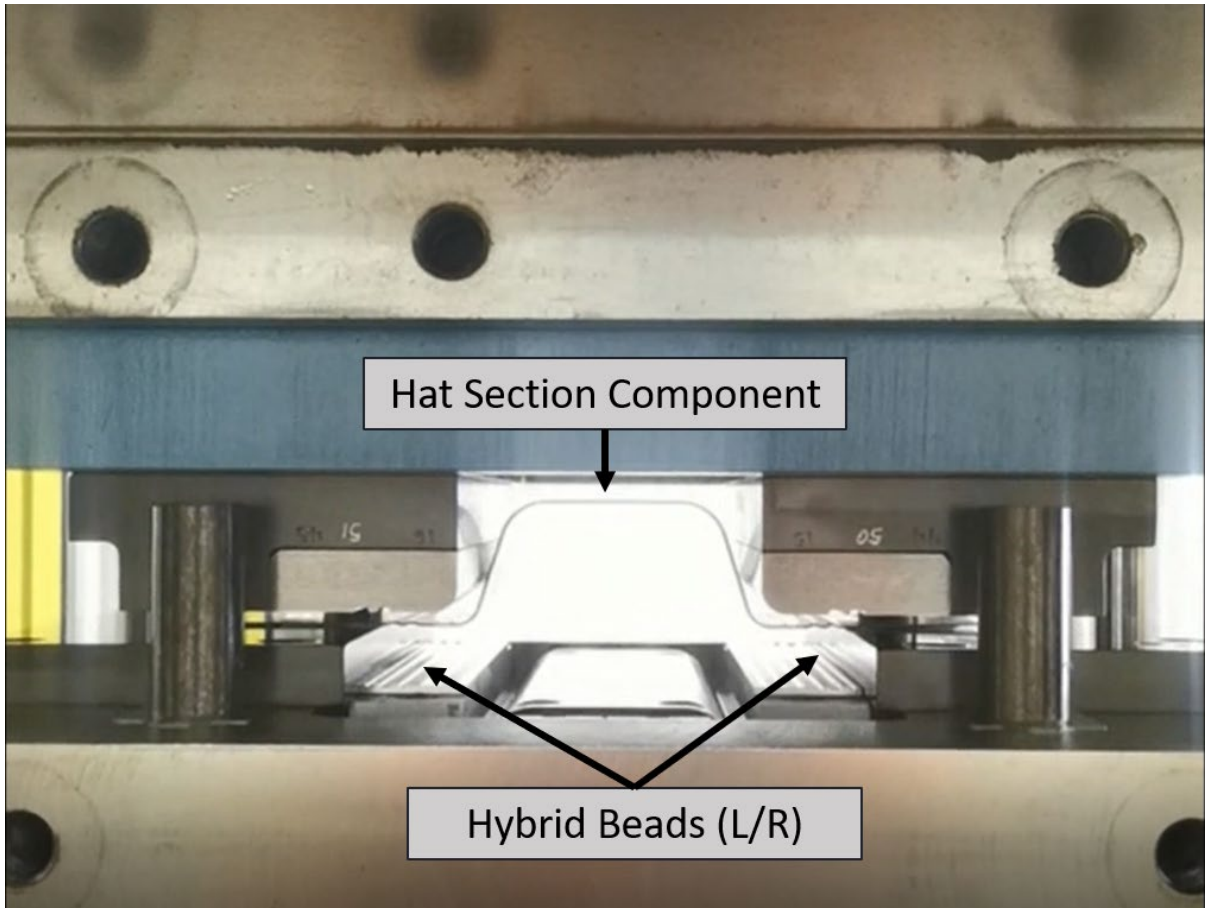


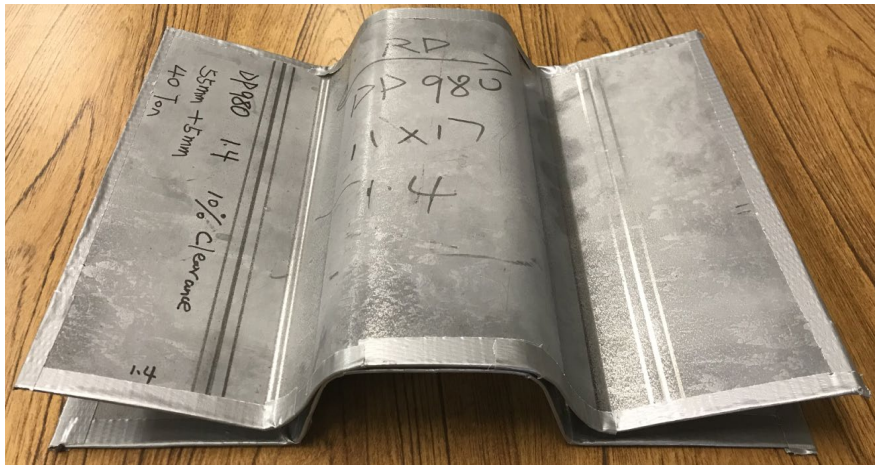
Material Flow

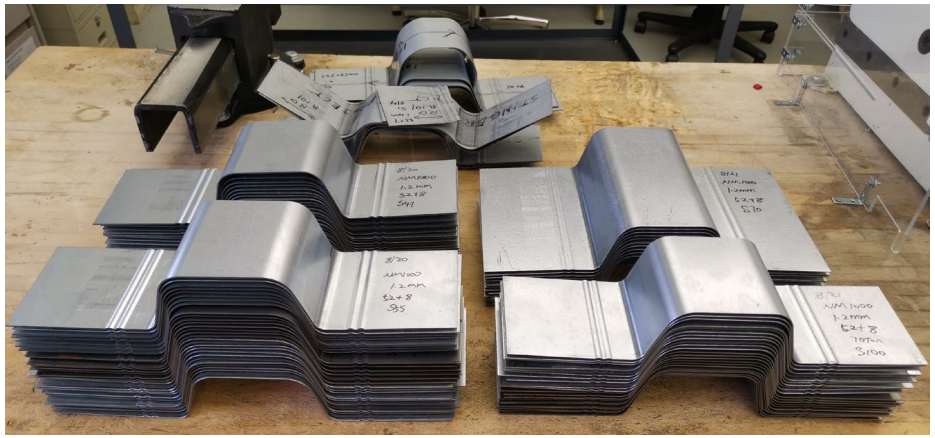
PROJECT RESULTS

A 100-piece laboratory-scale die trial was conducted with the Version #9 Design

The design was effective for all steels tested, including AHSS







PROJECT RESULTS

Hybrid bead version #9 was implemented into an existing draw die.

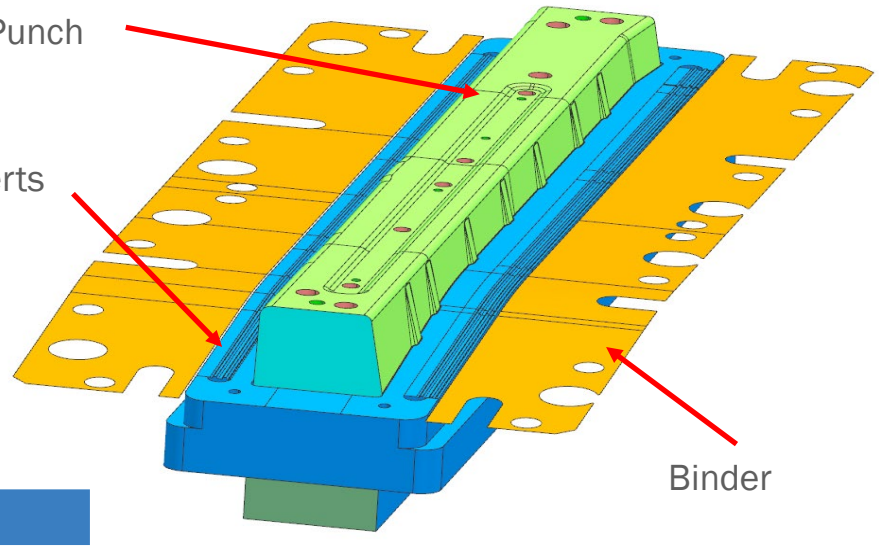
A die trial was conducted on a range of steel grades up to a tensile strength of 1180MPa.

Due to insufficient cushion tonnage of the press (450Tons) the initial matrix of materials to be stamped and scanned required modification.

Materials Studied (2020):
1.5 CR340Y410T-HSLA (Lot 117)
1.4 CR420Y780T-DP (Lot 55)
1.35 CR700Y980T (Lot 129)
1.45 CR700Y980T-RA-SE-GI 60G60G-U (Lot 148)
1.4 CR700Y980T-RA-SE-Uncoated (Lot 108)
1.4 CR850Y1180T-RA-SE-EG (Lot 144)
1.45 CR1000Y1180T-RA-SE-GI (Lot 165)

3rd Gen materials in red

CAD MODEL



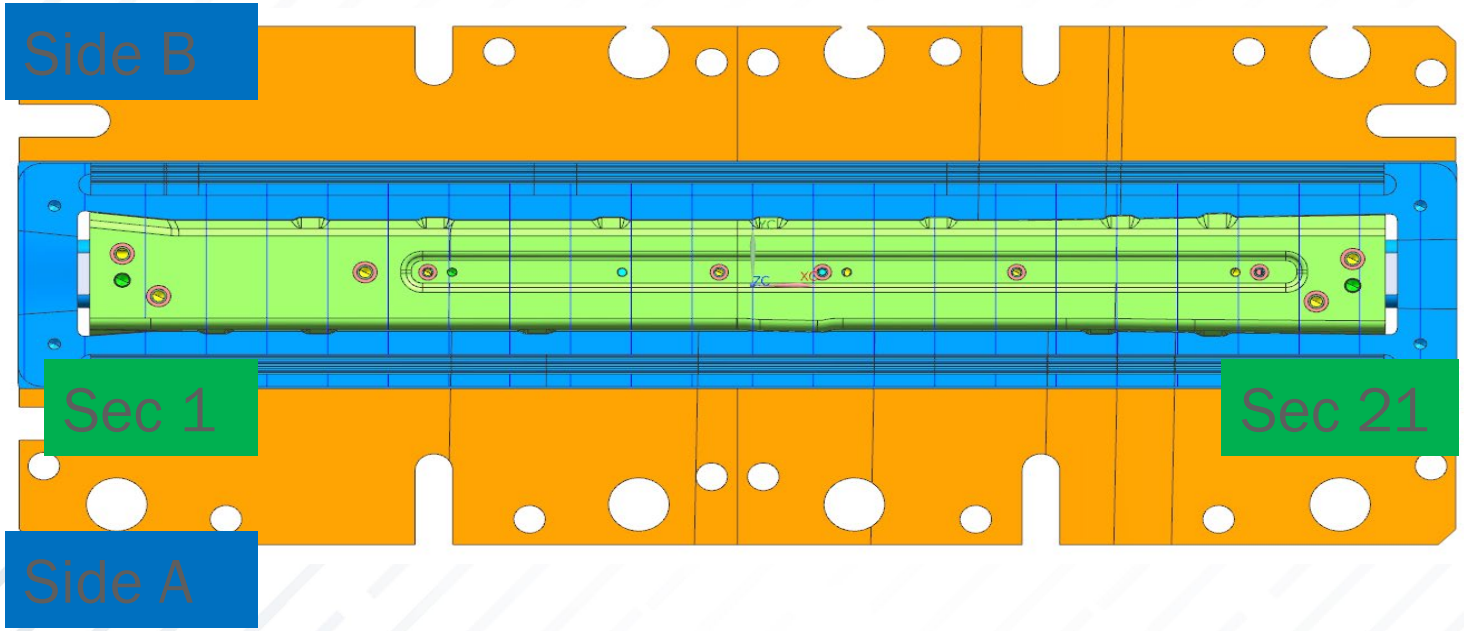
PRODUCTION-SCALE DIE

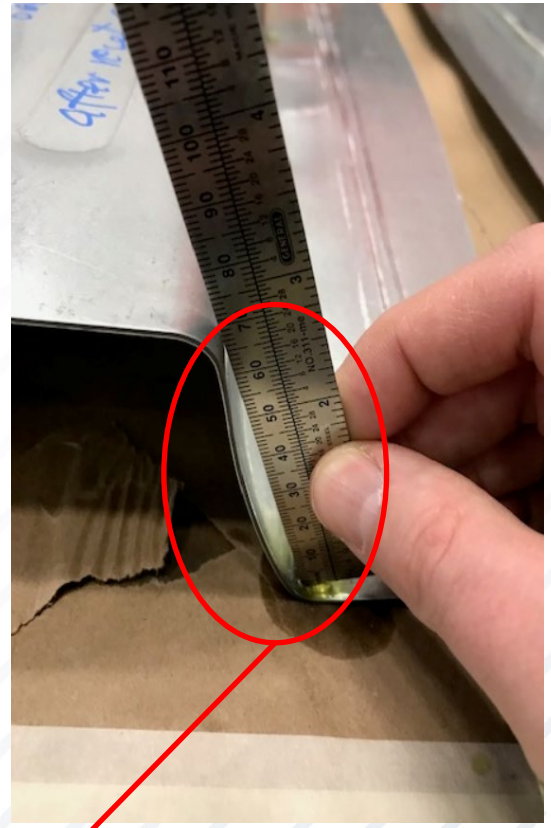
Note: The point in the forming stroke when the hybrid beads can be engaged is adjustable. For this trial, they were engaged 7mm off bottom.

PROJECT RESULTS

After the scan data was aligned to the CAD Draw tool, sections were cut every 50 mm to compare the scan data to the CAD draw surface (See image below).

The difference between the wall angles and “straightness” of the side walls was examined for each sample.





Side wall curl evaluated by determining the straightness of the wall

PROJECT RESULTS, HYBRID BEAD V 9.0

Shown below are the materials used, stamping conditions, and the resulting measurements taken between the scanned samples and the CAD surfaces for the ten panels scanned.

It was apparent at the stamping trial that there was insufficient tonnage available on the lower cushion to properly form the hybrid bead geometry and the panel itself.

Material	Blank Size	Cushion Tonnage	Ram Tonnage	A1 Average (Degrees)	B1 Average (Degrees)	Wall 1 Average Straightness (mm)	Wall 2 Average Straightness (mm)	Comments
M117 CR340Y-410T HSLA	Full	387T	Not Recorded	2.9	3.1	0.418	0.351	No Bead
M117 CR340Y-410T HSLA	Full	400T	Not Recorded	2.0	1.1	0.09	0.07	With Bead
M55 CR420Y-780T-DP	1/2	300T	469T	3.6	3.3	0.20	0.16	With Bead
M55 CR420Y-780T-DP	1/3	180T	457T	4.0	4.7	0.27	0.28	With Bead
M148 CR700Y 980T-RA-SE	1/2	400T	548T	5.2	3.7	0.30	0.26	Fractured Beads
M144 CR850Y-1180TRA-SE	1/3	180T	452T	4.8	4.1	0.30	0.23	Fractured Beads
M144 CR850Y-1180TRA-SE	1/2	400T	558T	7.0	6.5	0.50	0.38	Fractured Beads
M165 CR1000Y-1180T RA-SE	1/2	300T	551T	9.6	9.7	0.64	0.60	Fractured Beads
M165 CR1000Y-1180T RA-SE	1/2	400T	558T	8.3	10.2	0.50	0.63	Fractured Beads
M165 CR1000Y-1180T RA-SE	1/2	400T	570T	7.7	9.5	0.38	0.54	Fractured Beads

3rd Gen materials in red

PROJECT RESULTS, HYBRID BEAD V 9.0

The only material successfully stamped at the trial using a full blank was Lot#117 (CR340Y-410T HSLA). The cushion tonnage (450T) seemed to be sufficient to form the hybrid bead geometry and was somewhat effective in locking the panel out when the hybrid beads were engaged.

The table below shows the results of stamping Lot#117 with and without the hybrid bead inserts being used. As seen in the table, the amount of springback measured in the walls and the straightness of the walls significantly improved when the hybrid beads were used.

Hybrid bead version v.9.0 proved to be robust in the production scale die. A visual inspection of the inserts after the stamping trial showed no significant issues.

Material	Blank Size	Cushion Tonnage	Ram Tonnage	A1 Average (Degrees)	B1 Average (Degrees)	Wall 1 Average Straightness (mm)	Wall 2 Average Straightness (mm)	Comments
M117 CR340Y-410T HSLA	Full	387T	Not Recorded	2.9	3.1	0.418	0.351	No Bead
M117 CR340Y-410T HSLA	Full	400T	Not Recorded	2.0	1.1	0.09	0.07	With Bead

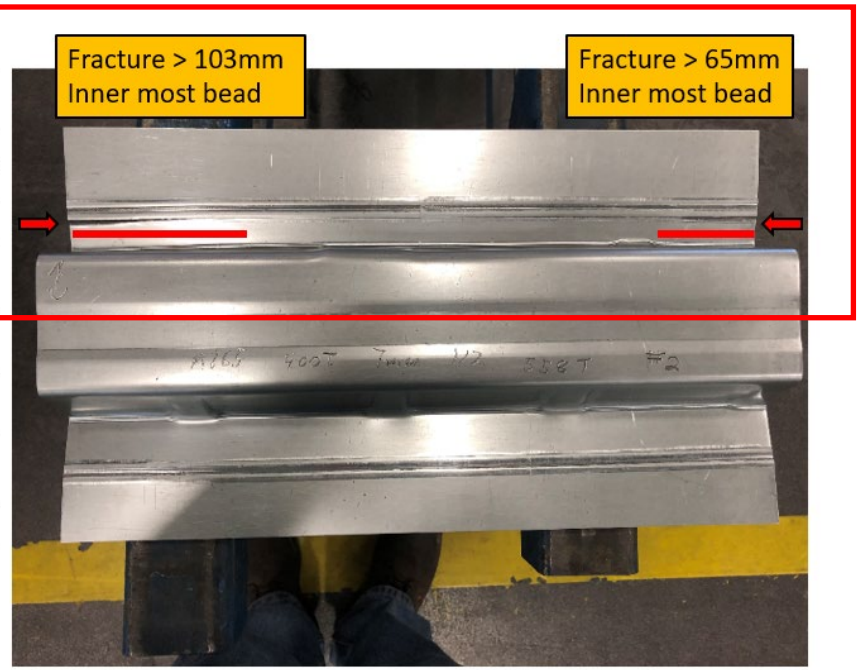
PROJECT RESULTS, HYBRID BEAD V 9.0

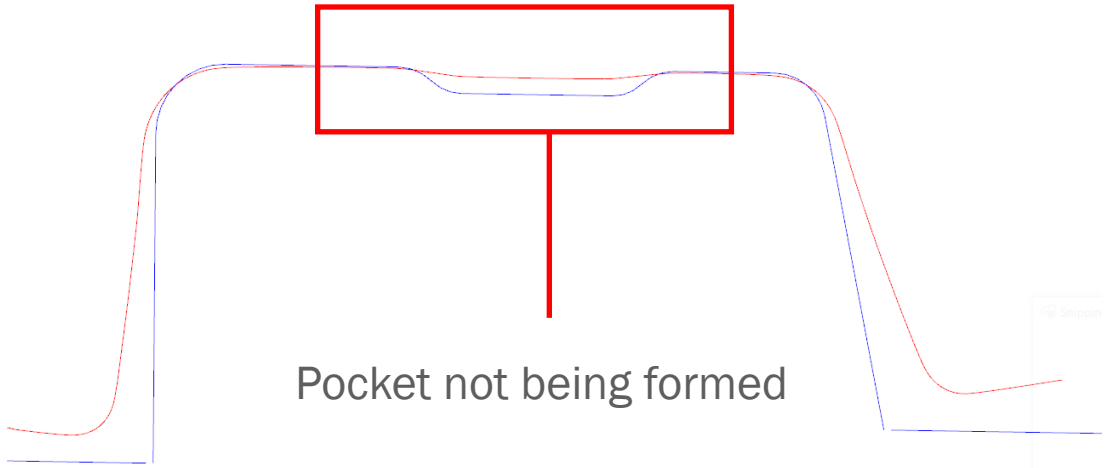
There were still issues present when trying to stamp the higher strength materials, even with the smaller blanks. As you can see on the left, many of the blanks split at the ends of the hybrid beads. These splits greatly reduced the effectiveness of the hybrid beads on reducing springback and side wall curl.

The tonnage was insufficient to completely form the panel for the higher strength materials. An example of this can be seen below on the right.

AUTODIE

CR1000Y1180-RA-SE-GI	
Lot	165
Sample #	2
Ram Tonage	558
Binder Tonnage	400
Sheet size	1/2
Bead engagement	7mm
Material Thickness	1.45
Result	Fracture

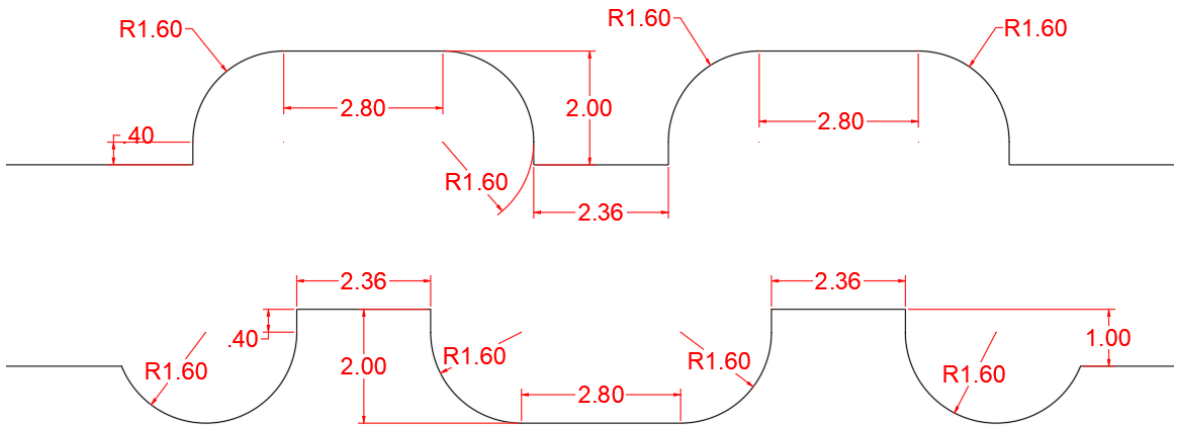




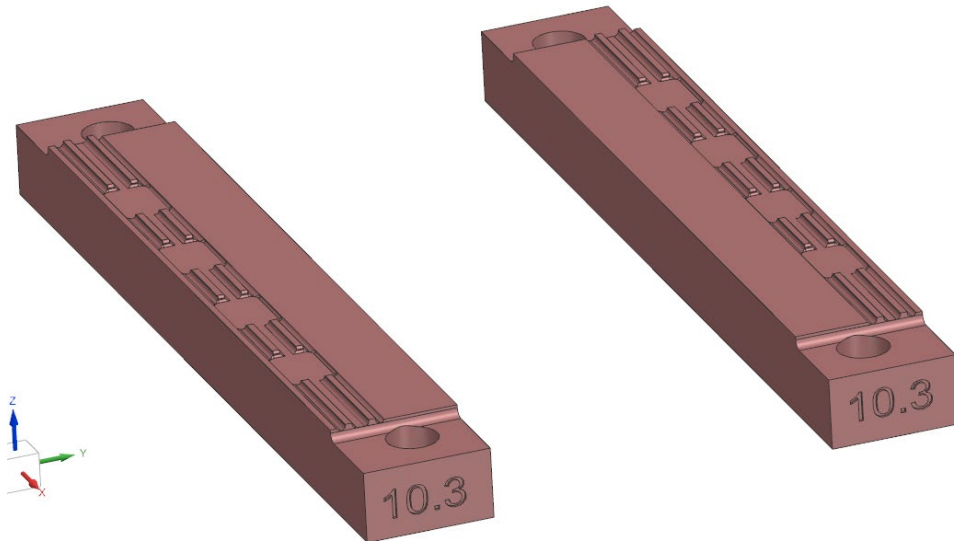
Blue: Section through CAD tools
Red: Section through M165 (CR1000Y 1180T-RA-SE-GI)

PROJECT RESULTS

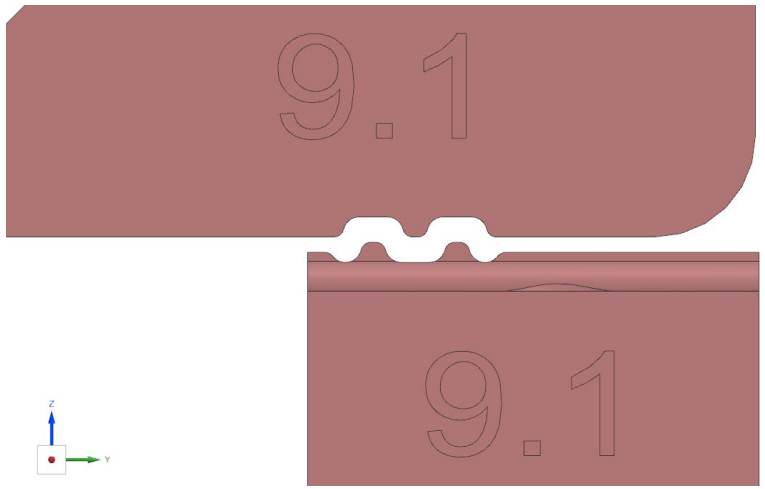
Version #9.0



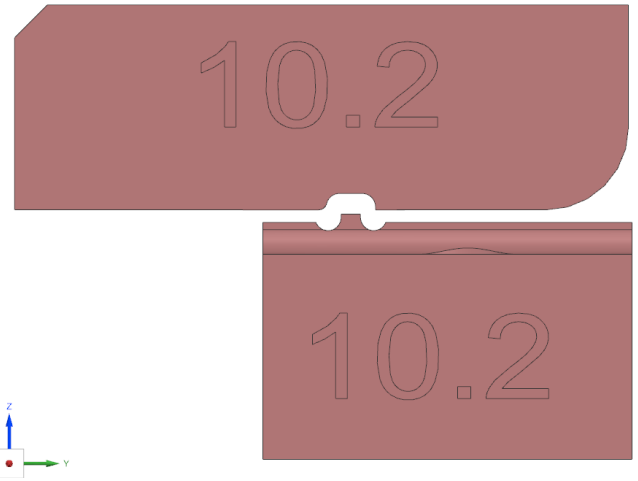
Version #10.3



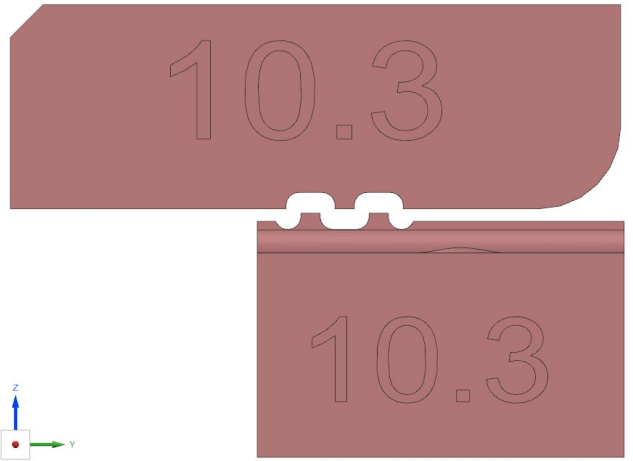
Version #9.1



Version #10.2



Version #10.3

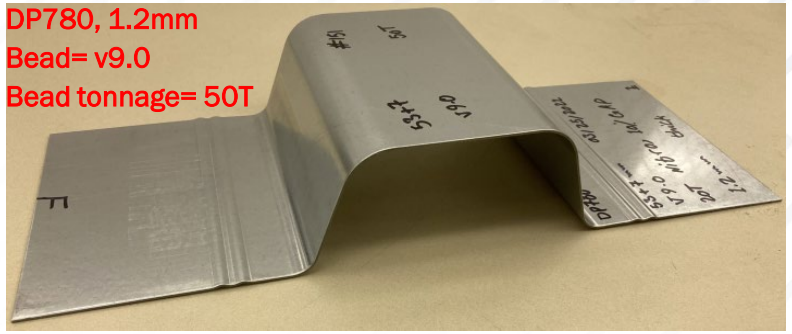


PROJECT RESULTS

Simulation Results for Hybrid Bead Versions 9.0, 9.1, 10.2 & 10.3

Material	Bead Version	Predicted Tonnage (Upper Die)	Draw-in after Beads Engaged	Springback Prediction
CR980T-600Y HE1 RA t=1.2	9.0	178	0.27mm	-1/2.3
CR980T-600Y HE1 RA t=1.2	9.1	137	0.85mm	-1/2.2
CR980T-600Y HE1 RA t=1.2	10.2	144	1.44mm	-1.2/3.3
CR980T-600Y HE1 RA t=1.2	10.3	127	1.01mm	-1.3/3
780/420Y DP t=1.5	9.0	190	0.37mm	-0.7/1.3
780/420Y DP t=1.5	9.1	159	0.62mm	-0.68/1.3
780/420Y DP t=1.5	10.2	150	1.3mm	-0.67/1.8
780/420Y DP t=1.5	10.3	137	0.74mm	-0.66/1.6

PROJECT RESULTS



Results of Lab Scale Stamping Trial

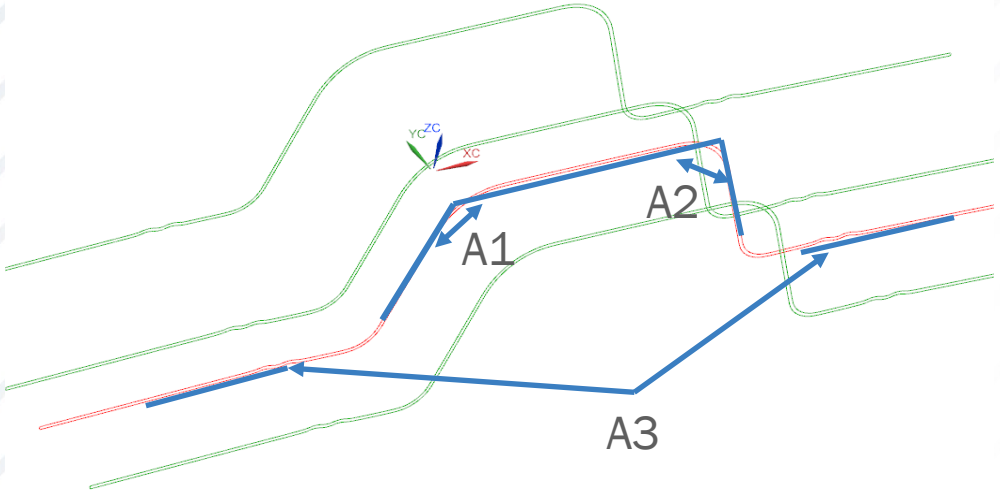
A) Stamped panels with hybrid bead versions #9.0, #9.1, #10.2, and #10.3

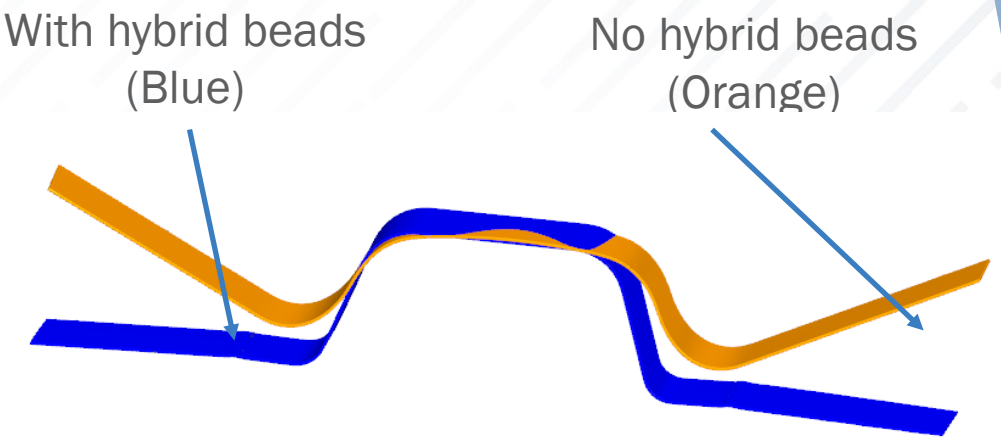
B) Varied the press forming force to determine minimum force to eliminate slippage through each set of hybrid beads

C) All panels stamped were a DP780 grade (t=1.2mm)

Hybrid Bead Version	#9.0	#9.1	#10.2	#10.3
Forming Force (Tons)	45	40	25	30

PROJECT RESULTS





Springback measurements and their corresponding measured press tonnage (Lab Scale Trial)

	Bead Version	Tonnage	A1	A2	A3
Baseline (#1)	None	20 Tons	118.5	118.5	129
Component #2	9.0	45 Tons	71.5	70.8	4.56
Component #3	9.1	40 Tons	69.9	70.0	3.51
Component #4	10.2	25 Tons	70.3	70.7	2.22
Component #5	10.3	30 Tons	70.5	71.1	3.0
Component #6	9.0	40 Tons	71.4	71.1	4.65
Component #7	9.1	35 Tons	69.9	70.1	3.0
Component #8	10.2	20 Tons	70.2	69.7	3.9

PROJECT CONCLUSIONS

Version #2 Hybrid Bead Design:
- Laboratory-Scale Hybrid Bead Die
  - Effective in springback reduction for all steels tested through AHSS
- Production-Scale Hybrid Bead Die
  - Not sufficiently robust, fractured in early testing

Version #9 Hybrid Bead Design:
- Laboratory-Scale Hybrid Bead Die
  - Effective in springback reduction for all steels tested through AHSS
  - No issues observed with insufficient die forces to form beads in stamping trial
- Production-Scale Hybrid Bead Die
  - Effective in springback reduction for HSLA420 but not effective for AHSS
  - Robust design, able to withstand high stress
  - Required too much cushion force to fully engage beads for AHSS

Versions #9.1,#10.2 & #10.3 Hybrid Bead Designs:
- Laboratory-Scale Hybrid Bead Die
  - Effective in springback reduction for DP780 Material
  - Significantly less die forces required to form beads compared to Version #9.0
  - All three bead versions showed similar amounts of springback compared to each other regardless of forming force

PROS AND CONS

Pros	Cons
Hybrid Beads can be effective in reducing springback	Hybrid beads can significantly increase the required forming forces
They can save material compared to Stake Beads	They can be difficult to machine and their long-term robustness isn't known
	They may be a relatively high maintenance item in a production environment
	Hybrid beads require a more complex die set-up than a traditional 3-piece draw die
	Results may be applicable for relatively flat binder shapes due to their shallow depth. It's unknown how they would perform with a more complex binder shape

NEXT STEPS

Scrap Free Stamping Demonstration with Hybrid Bead

(1) stamping with segmented hybrid bead;

(2) spot welding between two segmented hybrid beads.

Investigate other possible shapes to restrain the panel requiring less forming force

FOR MORE INFORMATION

Chris Roman
General Motors
chris.roman@gm.com

Eric McCarty
Auto/Steel Partnership
emccarty@a-sp.org

A/SP Stamping Team Members

- N. Goan, General Motors
- L. Huang, General Motors
- D. Qin, General Motors
- JP Singh, General Motors
- T. Stoughton, General Motors
- W. Wu, General Motors
- J. Bigelow, Gestamp
- W. Lengyel, Gestamp
- V. Millioto, Martinrea
- D. Kanelos, Nucor
- I. Viera, Nucor
- W. Sun, Nucor
- J. Ha, POSCO America
- D.J. Zhou, Stellantis
- Y. Zhou, Stellantis
- J. Luis Galaviz, Ternium
- O. Garcia, Ternium
- S. Rafael David Mercado, Ternium
- J. Pablo Pedraza, Ternium
- E. Rodriquez, Ternium
- N. Wang, Toyota

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