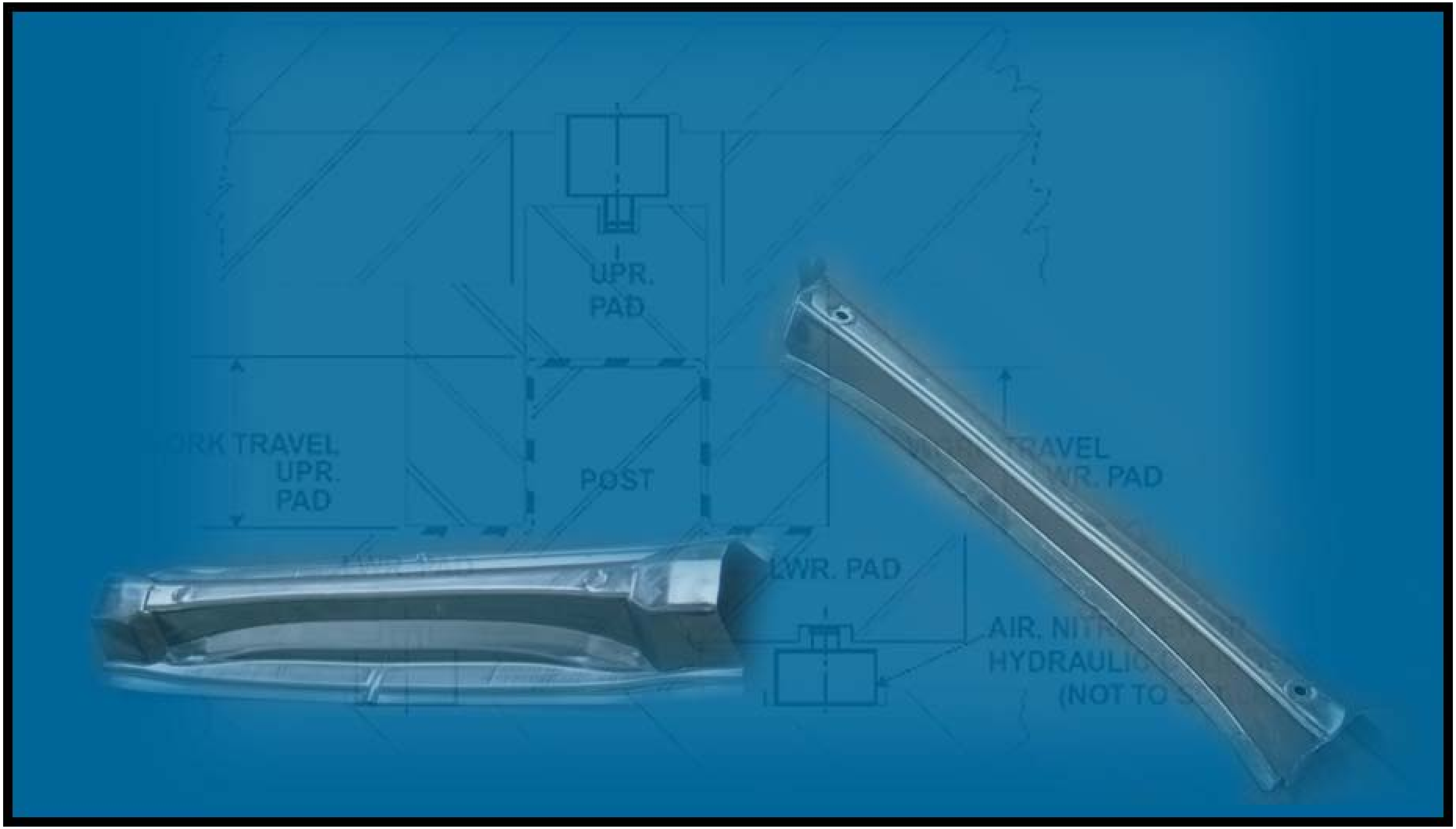


Cross Cowl Member Stamping Trials

Auto/Steel
Partnership
www.a-sp.org

AHSS PROJECT TEAM MEMBERS

Co-Chairs: Jim Fekete and Changqing Du

A/SP Project Management: Mike Bzdok

Car Company Members:

Changqing Du	DaimlerChrysler
Steve Kernosky	Ford
Feng Ren	Ford
Jim Fekete	General Motors
Gary Telleck	General Motors
Ken Schmid	General Motors

Mentor

Ron Traficante	DaimlerChrysler

Steel Company Members:

Tim Lim	Dofasco
Mai Huang	Mittal Steel
S. Sadagopan	Mittal Steel
Weiping Sun	Nucor
Tony Chang	Severstal NA
Ming Chen	U.S. Steel
A. Konieczny	U.S. Steel

Suppliers/Consultants:

Ronart Industries

Generalety, LLC

Troy Design & Mfg.

PROJECT GOALS

This work with the Cross Cowl Member is part of the umbrella project featuring the A/SP Master Shoe.

The project is examining die (forming) processes and material grades for their effect on;

- Dimensional accuracy/part quality
- Press force/energy requirements.

Overall, the goal is to develop product/process design guidelines for AHSS.

PROJECT APPROACH

1. Select parts based on;
   A. size
   B. shape
   C. application
2. Identify processing variables/parameters
3. Design and build tools
4. Select and procure materials for trials
5. Conduct trials
6. Scan stamped parts
7. Trim parts
8. Re-scan parts
9. Conduct data analysis

Overview of Part Stamping Trials

Four materials (1.9 mm);

- **HSLA 350**
- **DP 600**
- **DP 780**
- **DP 980**

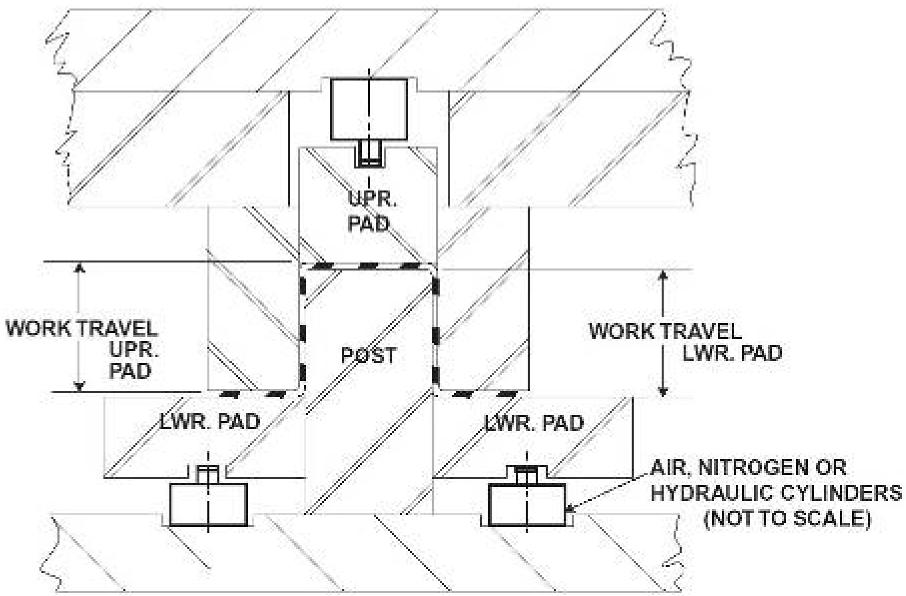
Three stamping configurations;

- **Cushion Draw with 340 mm wide blank.**
- **Crash Form with 340 mm wide blank.**
- **Crash Form with 280 mm wide blank.**

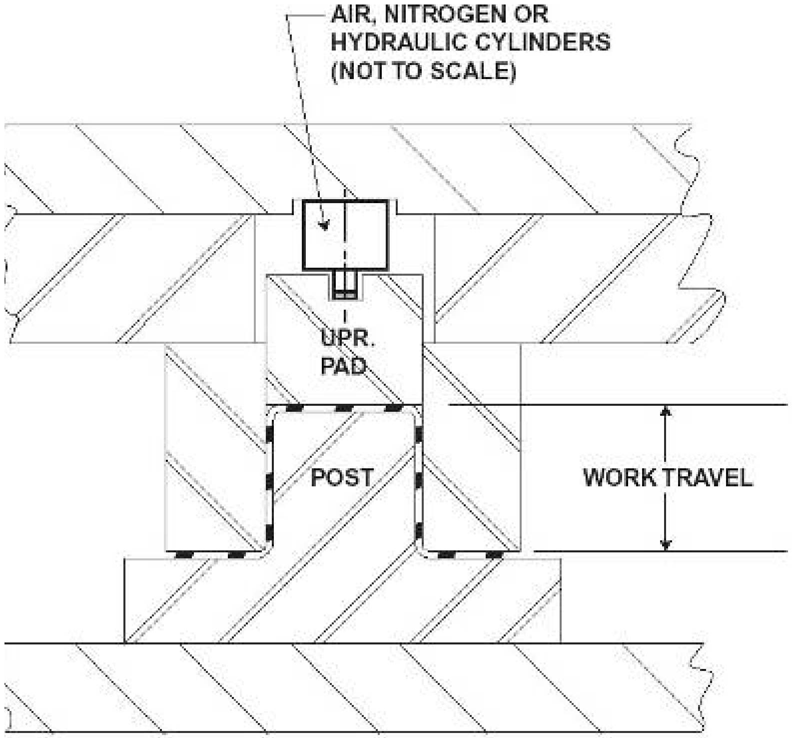
Production part is 1.9 mm DP 600

Production process is toggle draw

Process Descriptions



Draw Action (Upper and Lower Pad)

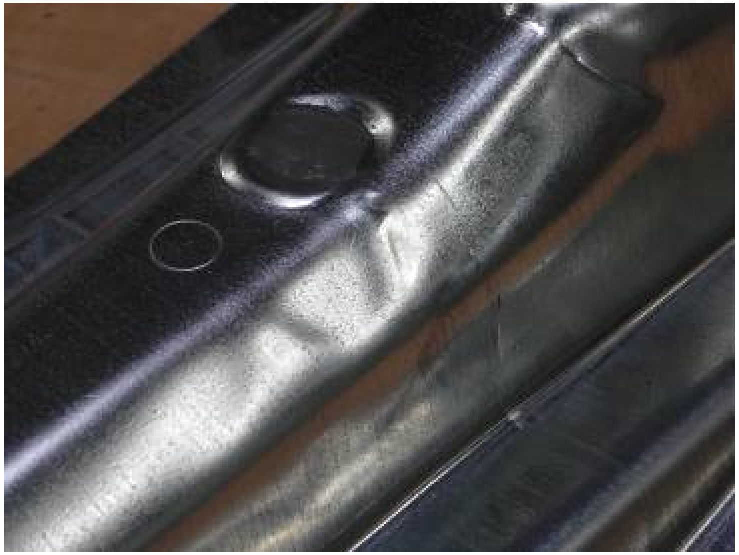


Form Die with Upper Pad (a.k.a Crash Form)

Binder force and pad force determined experimentally prior to conducting organized trials.

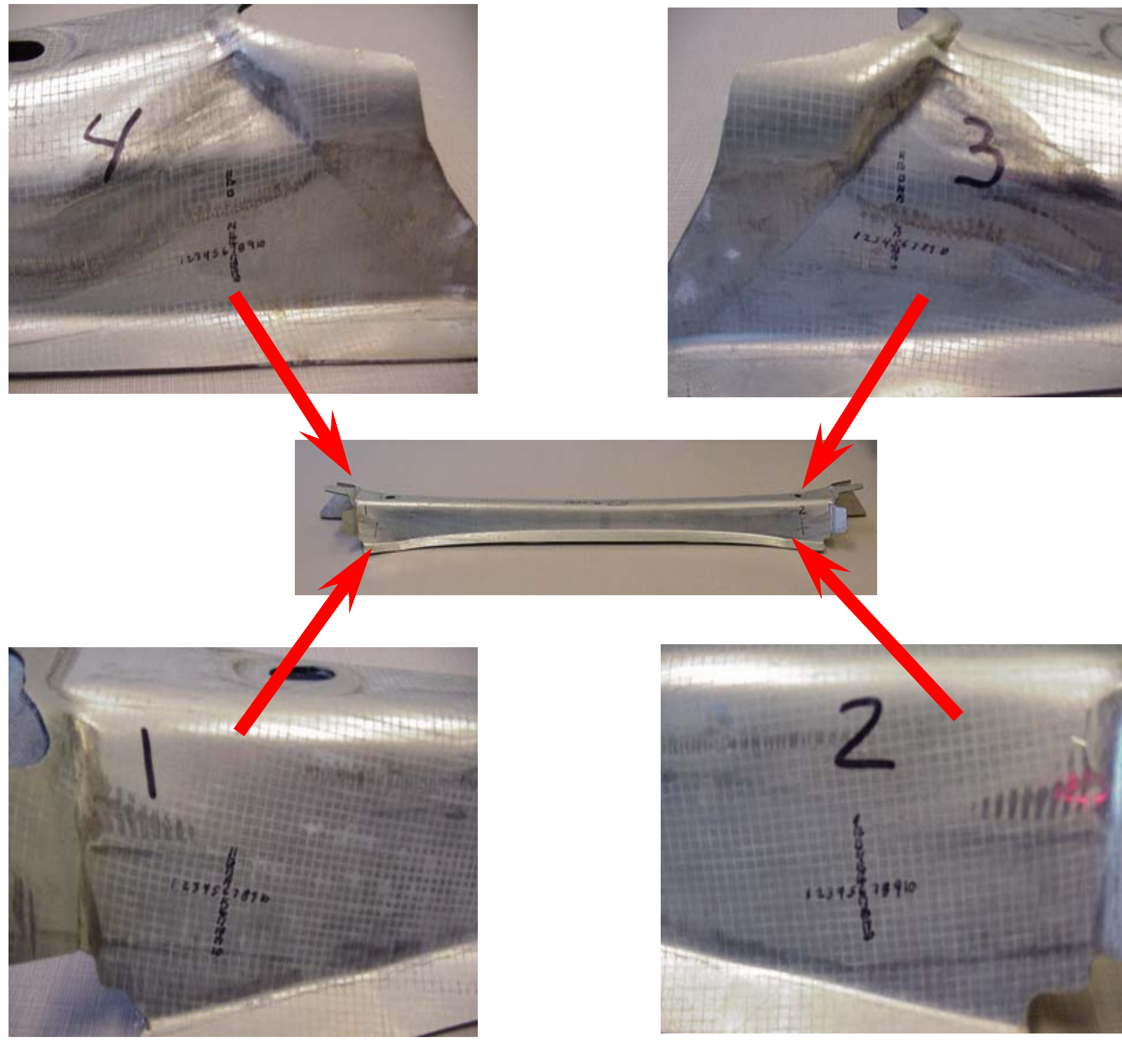
Overall, satisfactory parts were stamped from all four materials and the three forming processes.

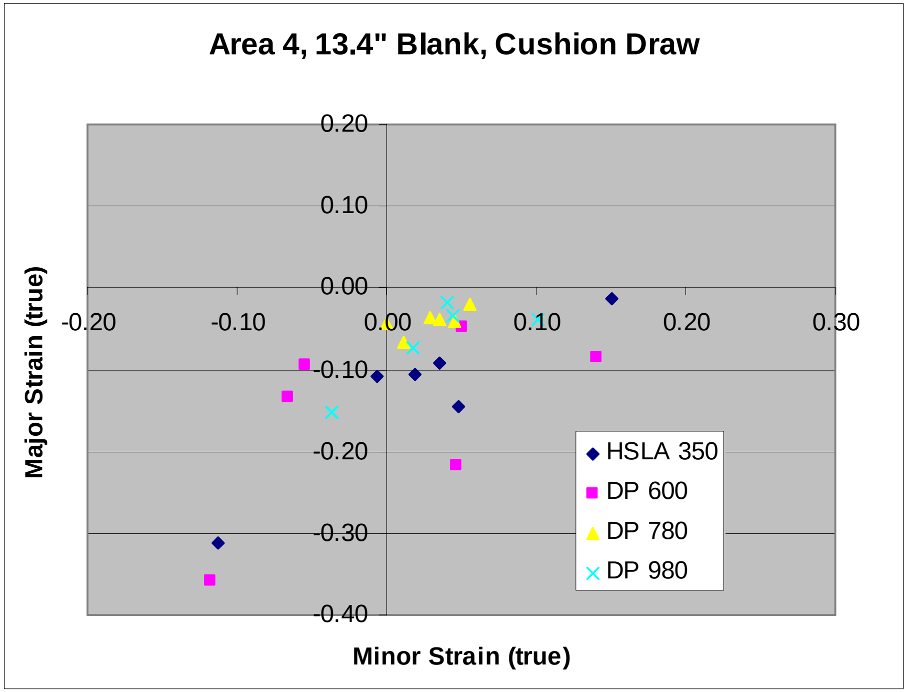
Two areas were prone to wrinkles the surfaces near each end of the part. The production parts exhibited this same tendency.

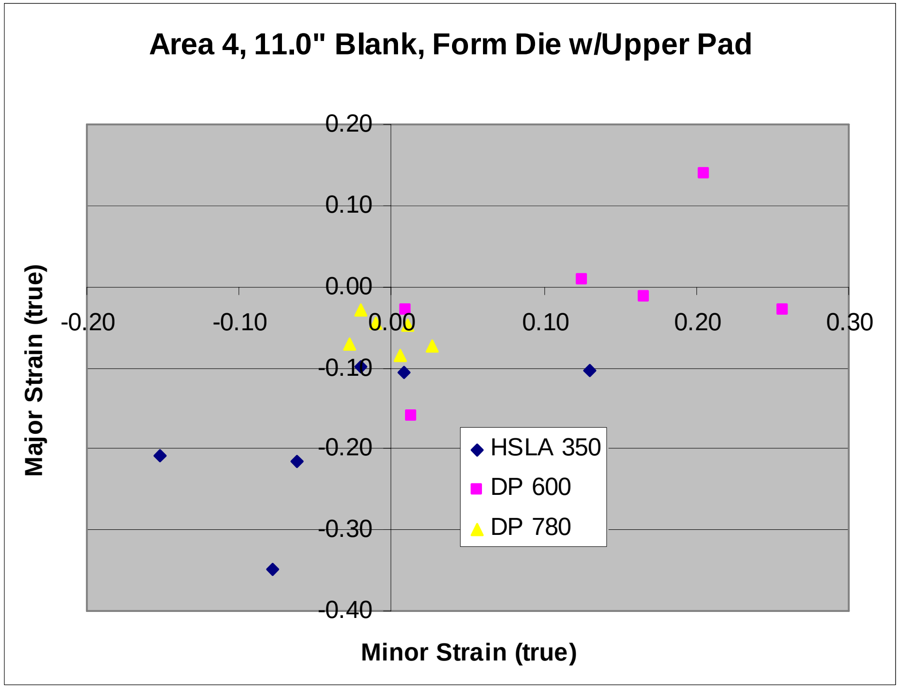


Splits did occur with DP 980 but they were confined to an area off-part and could have been induced by holes laser cut for locating the blank.

Strain Analyses



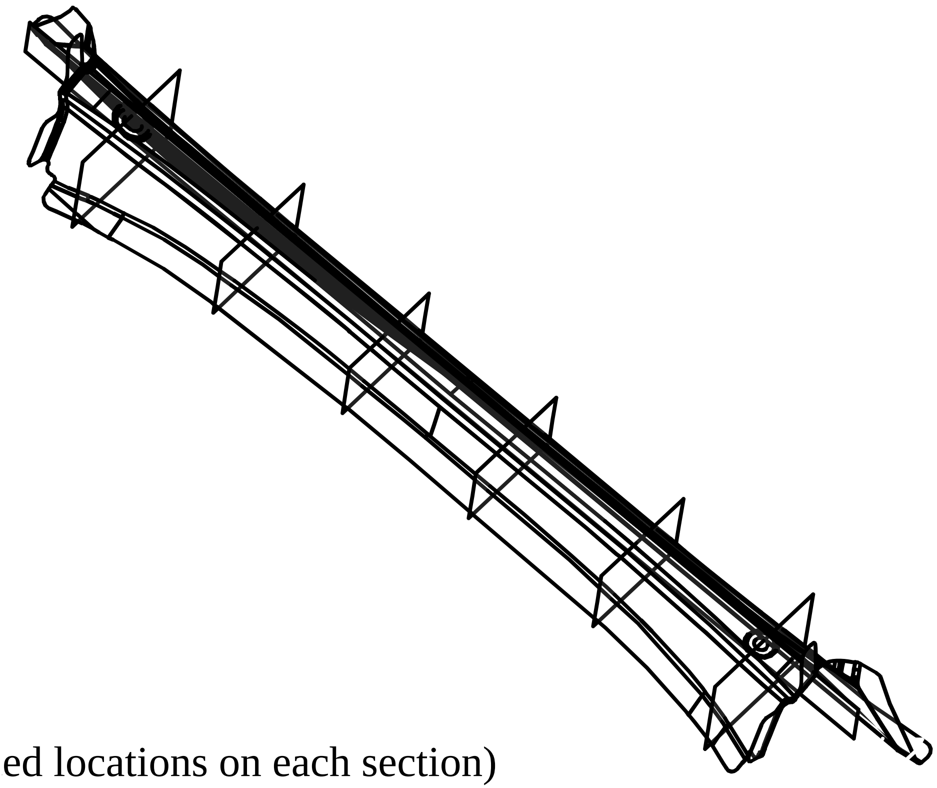




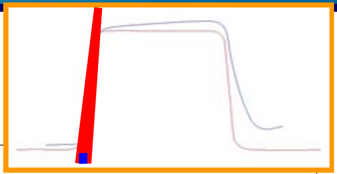
For the areas measured, major and minor strain levels for DP 780 and DP 980 appear to be more uniform than HSLA 350 and DP 600.

Dimensional Analyses

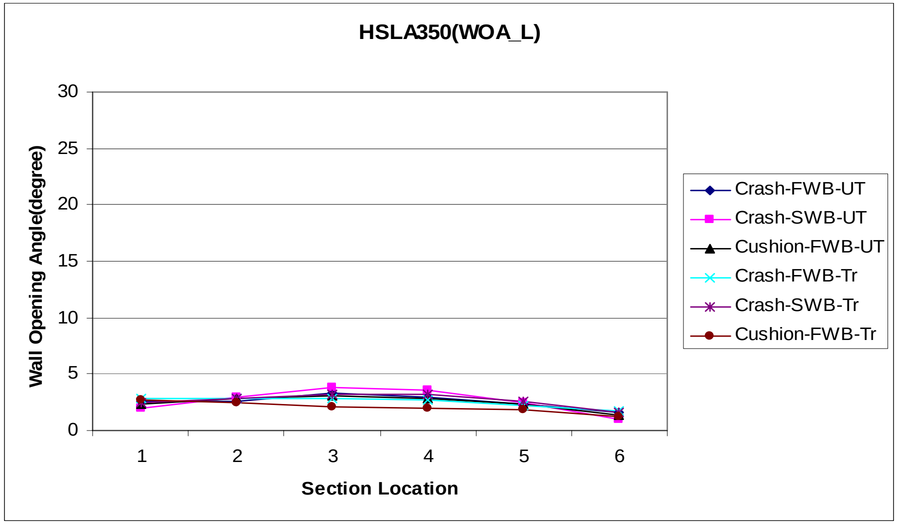
Six transverse sections and one longitudinal section.

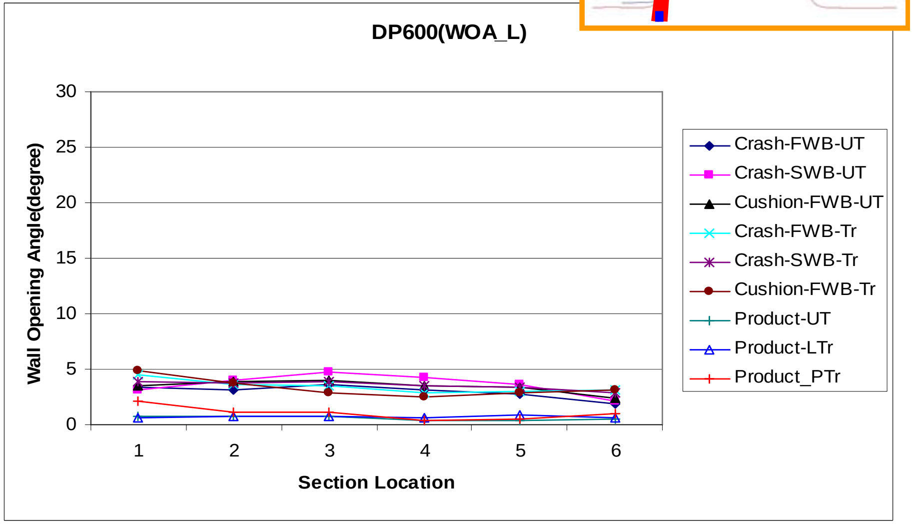


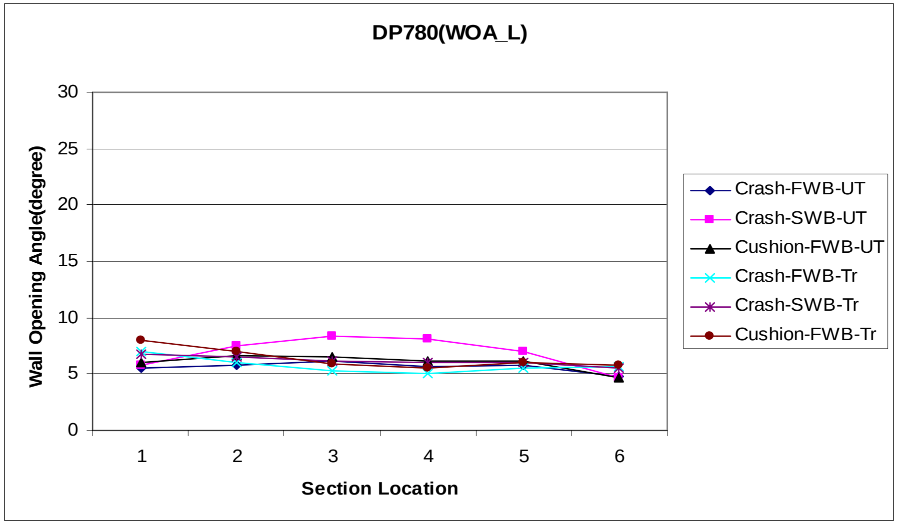
- For each Section the following measurements were evaluated:
  - AOT (Angle of Twist)
  - T-Angle (Top Angle)
  - WOA (Total Wall Opening Angle)
  - WOA-L (Wall Opening Angle - Left)
  - WOA-R (Wall Opening Angle - Right)
  - SWC-L (Side Wall Curl - Left)
  - SWC-R (Side Wall Curl - Right)
  - Average Deviation (Average at five selected locations on each section)
  - F-Deviation-L (X Deviation on Left Flange)
  - F-Deviation-R (X Deviation on Right Flange)
  - Top-Sag (Top Surface Sagging in the longitudinal sections)

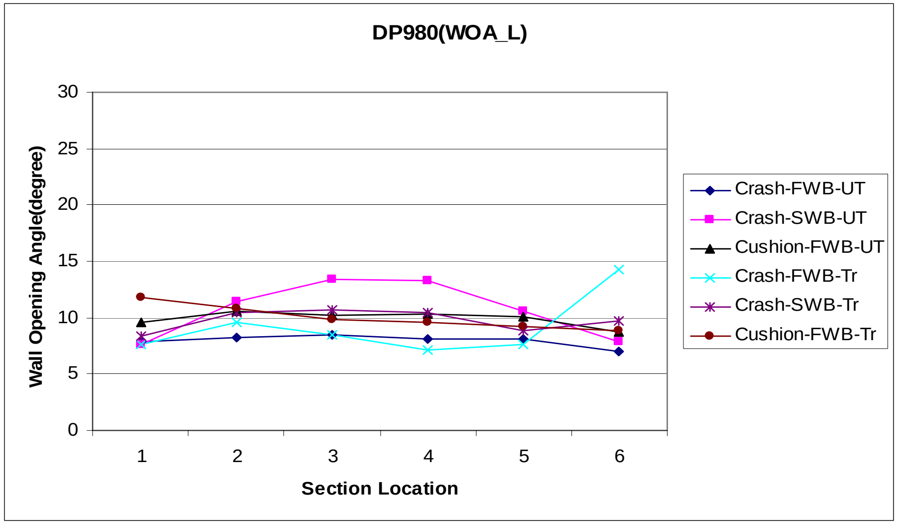


Wall Opening Angle (left side)



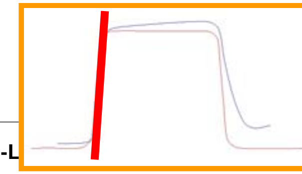


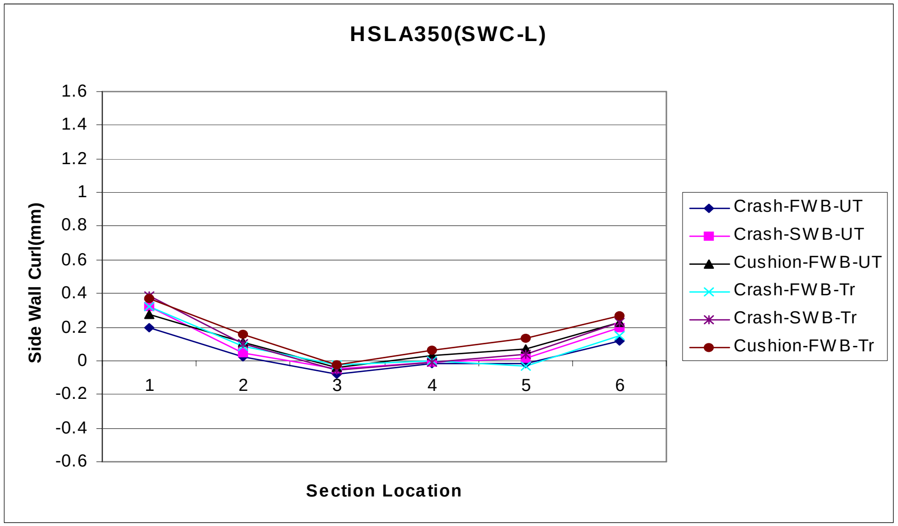


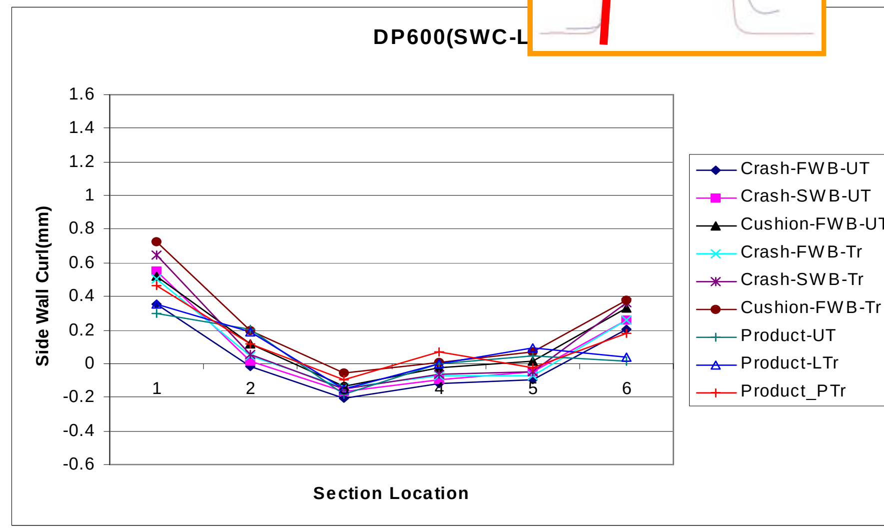


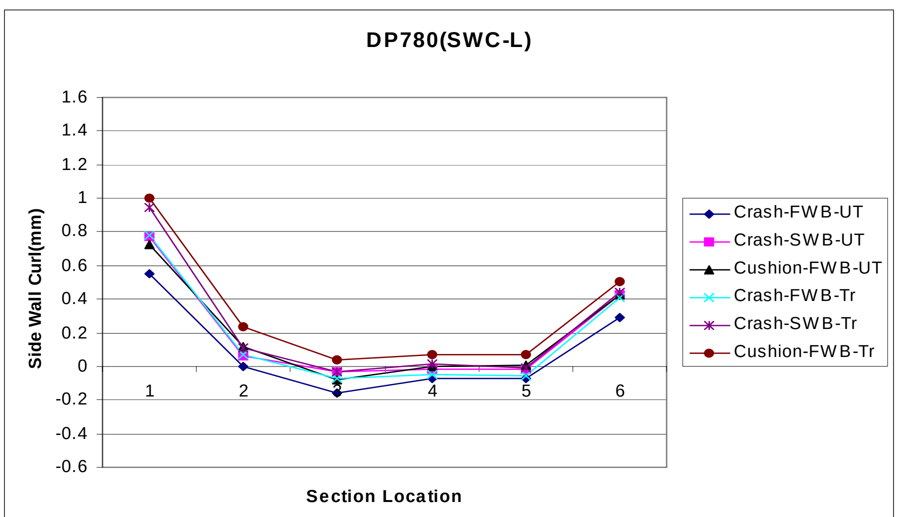
Dimensional Analyses (cont.)

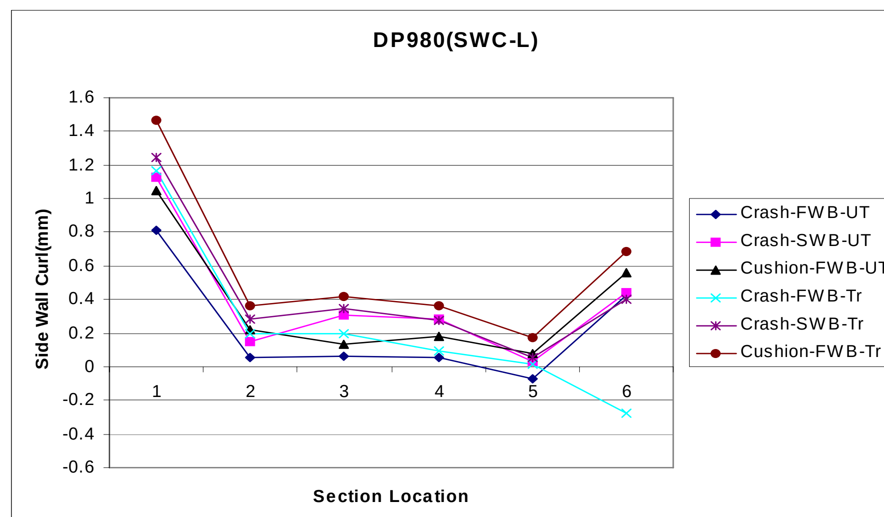
Sidewall curl











The left side exhibited more sidewall curl than the right side. Curl increased at the ends.

However, the left side had less opening angle than the right side.

As might be expected, deformation was essentially symmetric.

Opening angle tended to be greater at the center area.

Dimensional Analyses (cont.)

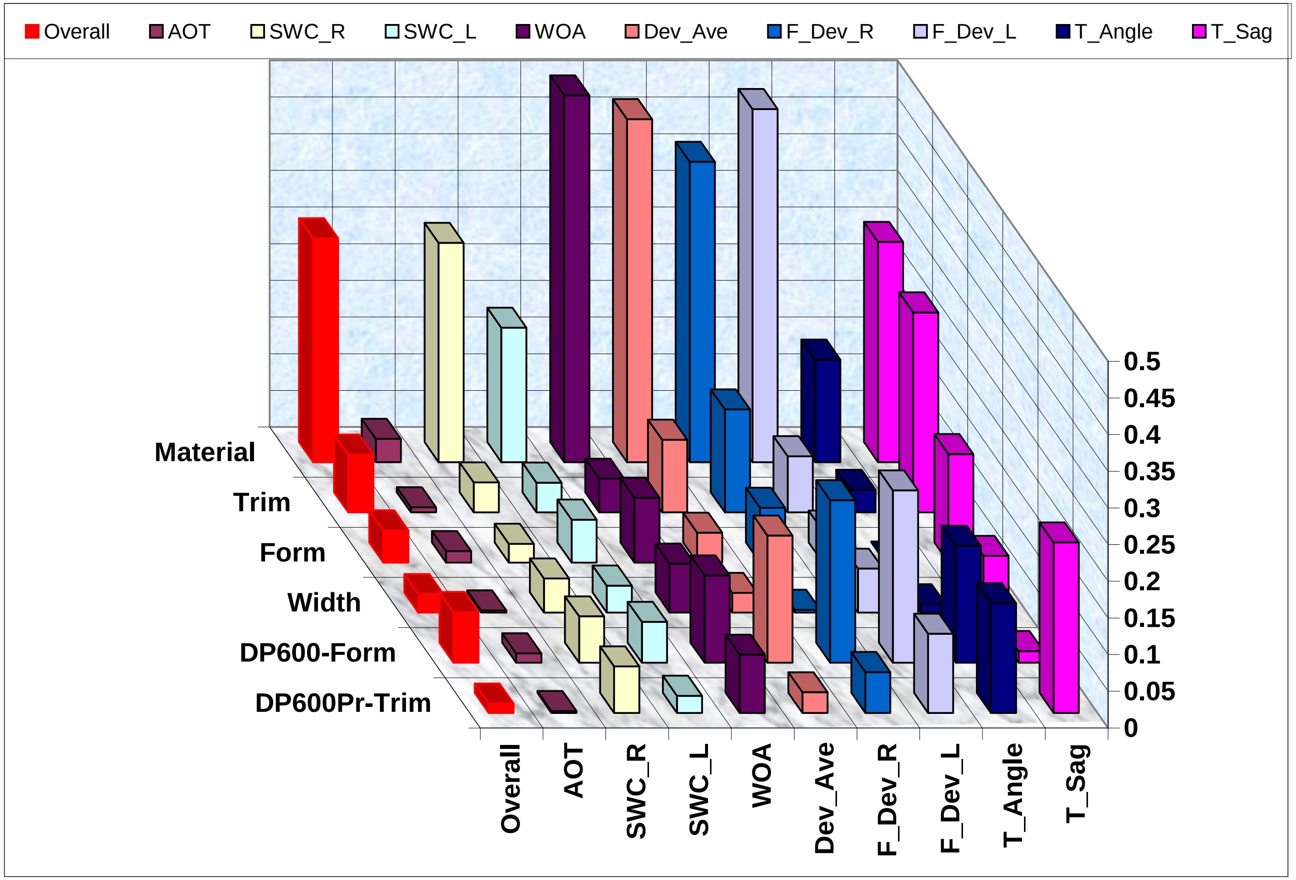
Assessment of Springback

- In order to obtain a general trend of amount of springback for different materials and processes, dimensionless springback is evaluated using the equations below:
  - Dimensionless WOA-L = WOA-L / Max(ABS(WOA-L of all the test data))
  - Dimensionless WOA-R = WOA-R / Max(ABS(WOA-R of all the test data))
- The equations scale the dimensionless springback to the range of 0.0 to 1.0 while 1 unit equals the maximum value in the category. The Average Dimensionless Springback is then evaluated using the following equation:
  - Average Dimensionless Springback = Sum(Dimensionless Springback in all sections) / Number of sections.

PROJECT RESULTS

1 unit = 1.0 for all the dimensionless springback factors. The heights of the bars indicate the maximum difference in dimensionless springback among three levels of each factor.

	Level I	Level II	Level III	Level IV
Material	HSLA350	DP600	DP780	DP980
Form	Form	Draw		
Trim	Untrimmed	Trimmed		
Width	Full	Reduced		
DP600-Form	Form	Draw	Toggle	
DP600Pr-Trim	Pr-Untrim	Pr-PTrim	Pr-LTrim	



AOT-Angle of Twist

SWC-Sidewall Curl

WOA-Wall Opening Angle

F_Dev-Flange Deviation

T-Sag-Top Sag

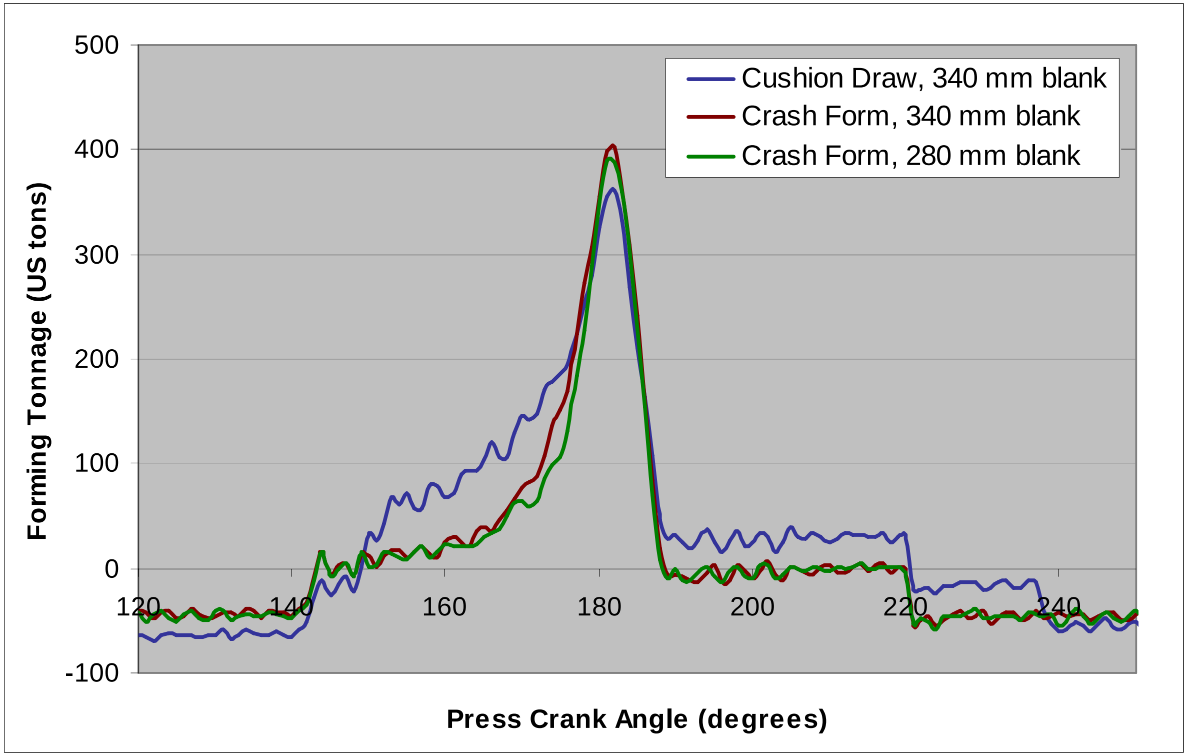
Springback is observed at two stages; directly from the draw/form process and after trimming (the removal of offal reduces stiffness/reinforcement of the formed part).

- The majority of springback is material related. The amount of springback increased parabolically with the material strength.
- Trimming had the second largest effect on overall springback followed by forming process and blank width. Trimming caused springback to increase by approx. 30%.
- DP980 had <u>three times</u> the springback of DP600.
- Drawing produced about <u>20%</u> more springback than crash form.
- Springback increased about <u>10%</u> with the reduced blank size (crash form process).

Forming Forces/Press Tonnage Analyses

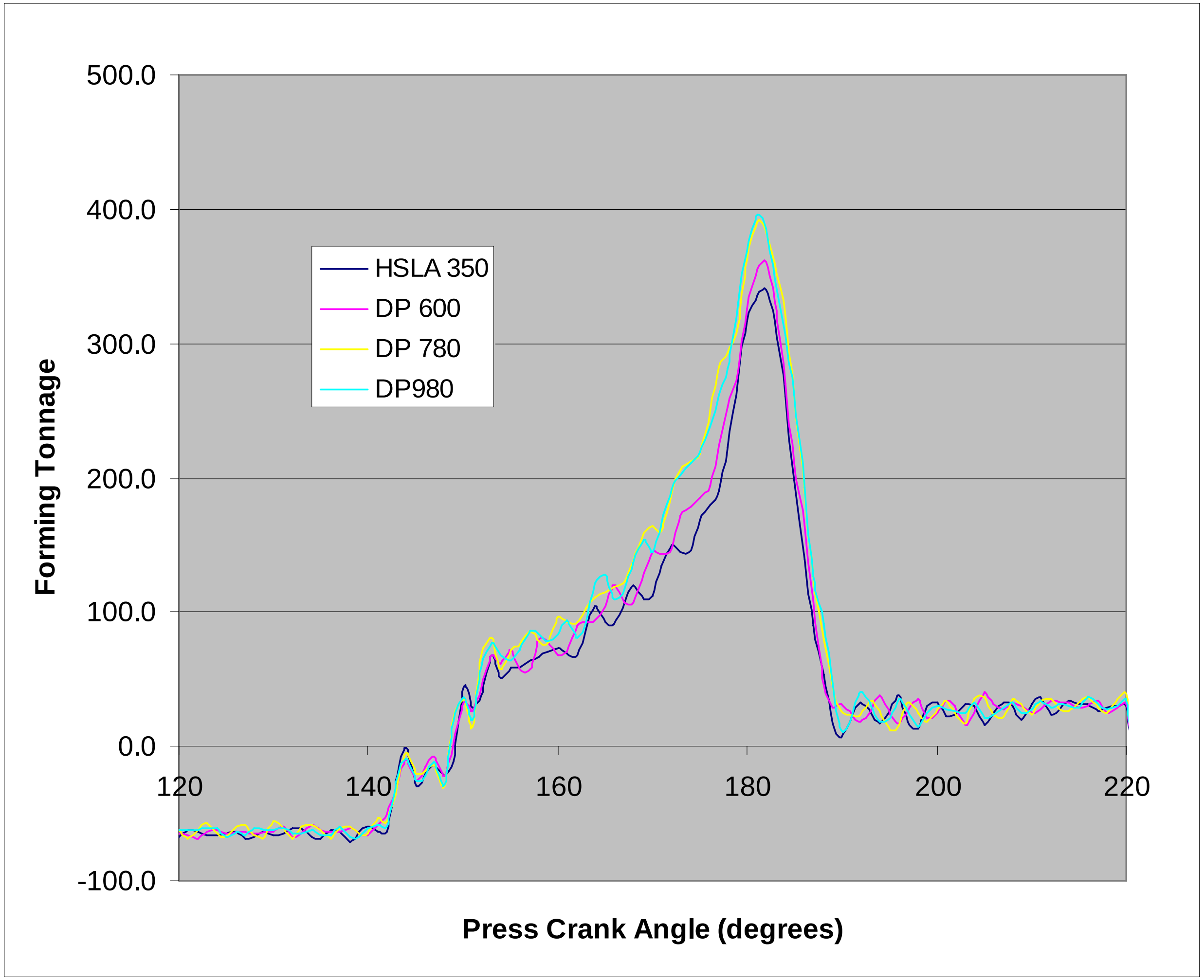
-Helm Instruments Co. model SCM-4800-TSM

-2750 Ton Ravne Press (Ronart Industries)



Press tonnage profiles for forming 1.9 mm DP 600. The curves are forming tonnage only; binder and pad force have been removed. Curves for the three other materials are very similar.

Forming Tonnage Analyses (cont.)



Forming tonnage profiles for cushion draw process (binder and pad forces have been removed).

Overall Observations

- At 175^{o} press crank angle and for a specific forming process the increase in forming tonnage between any two material grades was much less than the increase in either yield or tensile strength. A typical increase in forming tonnage due to material grade was less than half the increase in tensile strength.
- For any of the three forming process, material grade did not affect forming tonnage until approximately 170 degrees press crank angle.

Overall Observations (cont.)

Crash Form specific

- Over the materials tested, the forming tonnage observed at 175o press crank angle for the 340mm wide blank was 22-29% greater than the 280 mm wide blank which essentially follows the increase in width (21%).

FUTURE WORK

Use the dimensional analyses results to predict a die configuration that will produce a part at nominal (CAD) dimensions (compensate for material’s and trimming’s contributions to springback).

Re-cut/modify existing die accordingly

Conduct second iteration stamping trials to determine success of prediction/re-cut effort.

FOR MORE INFORMATION

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