Improving the Drawing Process of AHSS by Using Servo Press Technologies

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1. Background
2. Case Study 1: Drawing a non-symmetrical part
3. Case Study 2: Drawing of a round cup
4. Case Study 3: Cushion pulsation
5. Case Study 4: Attach/detach

*All the experiments were conducted in cooperation with HYSON’s Metal Forming Technology Center
Background

Challenge

Wrinkles

- Insufficient Blank Holder Force (BHF)

Splits/Fracture

- Excessive BHF
- Bad lubrication (large CoF)
- Large blank size (i.e. too large draw ratio = blank diameter / cup diameter)
A few alternatives to improve drawing...

Servo Press

1. Die
   - Punch

2. Die
   - Punch

3. Die
   - Punch

4. Die
   - Punch
   Attach/ Detach

Servo Cushion

Blank Holder Force [kN]

Forming Stroke [mm]

Variable Blank Holder Force

Blank Holder Force [kN]

Time (s)

Cushion Pulsation
Background

Test equipment*

Komatsu H2W300 Servo Press
- Press Capacity: 300 ton
- Max Ram Speed: 40 SPM
- Slide Stroke: 300 mm
- Press Curve in Appendix A

Servo Cushion Hyson MASTERform 100T
- Cushion Capacity: 100 ton
- Max Cushion Downward Velocity: 460 mm/s
- Max Cushion Upward Velocity: 104 mm/s
- Max Stroke: 125 mm
- Max BHF at contact: 90 ton
- Min BHF at contact: 8 ton

*at HYSON’s Metal Forming Technology Center
Case Study 1: Drawing of a Non-Symmetrical Part

Use of Variable Blank Holder Force (VBHF)

- CP800 / 1.4 mm
- Target draw depth: 65 mm (2.56 in)
- 23 SPM (Average forming speed ≈ 135 mm/s (5.31 in/s))
- Part size: ≈ 500 mm x 300 mm (19.7 in x 11.81 in)
- Die set provided by SHILOH
- Blank geometry used is shown in Appendix B
Case Study 1: Drawing of a Non-Symmetrical Part

BHF 400 kN Constant

Wrinkled Flange

BHF 500 kN Constant Press stopped at about 25 mm before BDC

No picture
**Wrinkling and VBHF Criterion**

- In this case, max wrinkle height allowed in FE simulation was 5% of the sheet thickness. ($h_{wrinkle} < 0.05t$)
- Every time wrinkling is observed, the BHF was increased.
Case Study 1: Drawing of a Non-Symmetrical Part

Final result

Press over tonnage was avoided while reducing the wrinkles observed on the flange.

VBHF (slide 8)

Flange
Case Study 2: Drawing of a Round Cup

Cushion pulsation, attach/detach and variable blank holder force to increase material draw-in

- 152.4 mm (6 in) diameter cup
- 304.8 mm (12 in) initial blank diameter
- Target draw depth: 76.2 mm (3 in)
- Die set provided by IRMCO

DP980/1.2 mm
Case Study 2: Drawing of a Round Cup

Ram stroke and velocity - 20 SPM (Average forming speed ≈ 138 mm/s (≈5.45 in/s))

Ram Stroke

Press Ram Stroke [mm]

Ram Velocity

Press Ram Velocity [mm/s]

Slow down before die touches blank

Forming Stage

Time [s]
Case Study 2: Drawing of a Round Cup

Approaches

Constant and Variable Blank Holder Force (BHF)

Attach/Detach (constant 200 kN BHF)

Cushion Pulsation (5Hz)

Blank Holder Force vs. Stroke

- Variable BHF
- Constant BHF

35 mm
5 mm
76 mm

Blank Holder Force vs. Time

- Actual BHF
- Target BHF
Case Study 2: Drawing of a Round Cup

Results

Blank size-Dia. 304.8 mm (12 in), Material-DP980/ 1.2 mm

In this case, variation in BHF did not affect significantly friction in the flange.
Case Study 3: Cushion Pulsation

Blank Geometry

Significant thinning reduction by optimizing blank shape
Case Study 3: Cushion Pulsation

Blank Geometry

- Geometries applicable to Steel 1008/1.0 mm
- All samples fractured at about 35 mm stroke for geometry A.
- Geometry B formed successfully up to 60 mm stroke.

*Units are in mm*
Case Study 3: Cushion Pulsation

- Steel A1008/1.0 mm
- Target draw depth: 60 mm (≈2.35 in)
- Ram Speed: 11 SPM (Average forming speed ≈ 90 mm/s (≈3.54 in/s))
- Part size ≈ 80 mm x 100 mm (≈3.15 in x 3.94 in)
- Ram motion: Slow down before die contacts blank
- Die set provided by Hyson Metal Forming Solutions

Successfully formed at using pulsating BHF=85 kN to 20 kN (5 pulses/s)

Fracture using constant BHF=85 kN Fracture at about 35 mm stroke
Case Study 3: Cushion Pulsation

- Al 6205/1.0 mm
- Target draw depth: 50 mm (1.97 in)
- Ram Speed: 11 SPM (Average forming speed ≈ 66 mm/s (≈2.6 in))
- Part size ≈ 80 mm x 100 mm (≈3.15 in x 3.94 in)
- Ram motion: Slow down before die contacts blank

Fractured at stroke around 39 mm (≈ 1.53 in)
Fractured at stroke around 32 mm stroke (≈ 1.26 in)

Pulsating BHF=5 kN to 1 kN (15 pulses/sec)
Fracture using constant BHF=5 kN

Depending on the material and other forming conditions, such as blank holder force or ram speed, cushion pulsation may help to improve drawability.

- Geometry used
- Units are in mm

No pictures available
Case Study 4: Attach/Detach

Attach/Detach

- Initial blank size: 190 mm (≈7.5 in) diameter circle
  - Stroke at crack not measured

Speed: 19 SPM
Average forming speed ≈ 115 mm/s (4.53 in/s)

Speed: 12 SPM
Average forming speed ≈ 72 mm/s (2.83 in/s)

Different fracture location

- SS304/1.0 mm
- Target draw depth: 70 mm (2.76 in)
- Blank Holder Force: 140 kN (constant)
- Part size ≈ 80 mm x 100 mm (≈3.15 in x 3.94 in)
- Ram motion: Slow down before die contacts blank.
Case Study 4: Attach/Detach

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Set up 1</th>
<th>Set up 2</th>
<th>Set up 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ram Speed [SPM]</td>
<td>12</td>
<td>12</td>
<td>19</td>
</tr>
<tr>
<td>Attached/Detach</td>
<td>NO</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>

In this case, attached/detach and increasing forming speed helped to improve the drawability of the material.

BHF 100 kN (constant)
SS304/1.0 mm

*Stroke at crack not measured
Conclusions

• **Variable blank holder** force can be used not only to prevent material fracture or to reduce springback but also to reduce significantly the tonnage required to form the part.

• **Attach/detach** can improve, for some cases, the material draw-in. However, further studies are required to determine the physics behind it and is the method cost effective. Material relaxation and a different contact point during the “second” stroke are some hypotheses.

• **Cushion pulsation** seems to reduce friction on the flange. Therefore, it can improve drawability. However, more studies are required to evaluate whether this method is cost-effective.
Effect of blanking speed and die/punch clearance upon edge quality

TRIP1180/1. 42 mm
Ram Speed at tool/blank contact ≈ 195 mm/s

≈10% nominal punch/clearance
≈20% nominal punch/clearance

Press and tools provided by AIDA America
SZL = Shear Zone Length

50 SPM (195 mm/s)

5 SPM (19.5 mm/s)
Future Work

Using a Servo Hydraulic Cushion, to explore:

• Cushion pre-acceleration

• Blanking using counter punch (activated by a hydraulic system)
Acknowledgements

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Tonnage Curve

Komatsu H2W300 Servo Press
- Press Capacity: 300 ton
- Max Ram Speed: 40 SPM
- Slide Stroke: 300 mm

Provided by HYSON
Blank geometry used in experiments with Shiloh tooling.
Cushion Pulsation Accuracy

11 SPM
15 pulses /sec

Start of forming

End of forming

11 SPM
5 pulses /sec

Start of forming

End of forming