Improving the Drawing Process of AHSS by Using Servo Press Technologies

David Diaz-Infante

Center for Precision Forming/The Ohio State University

Outline

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

Challenge

Wrinkles

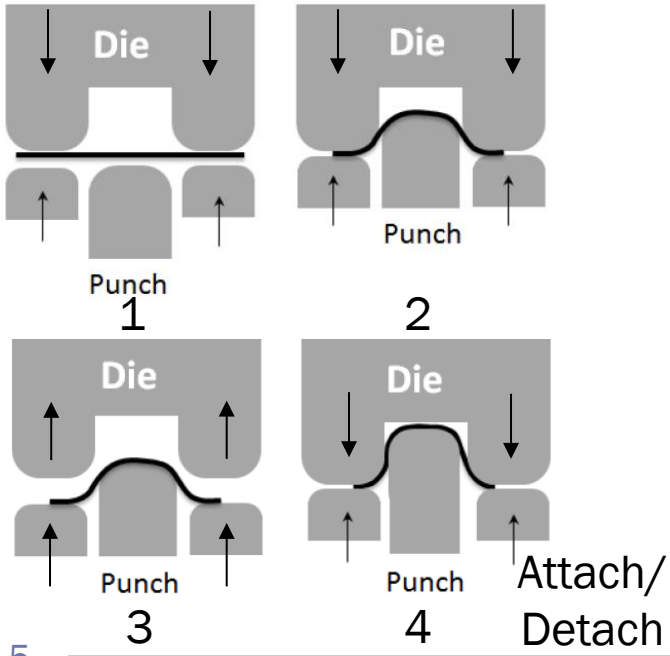
- Insufficient Blank Holder Force (BHF)

Splits/Fracture

- Excessive BHF
- Bad lubrication (large CoF)
- Large blank size (i.e. too large draw ratio= blank diameter/ cup diameter)

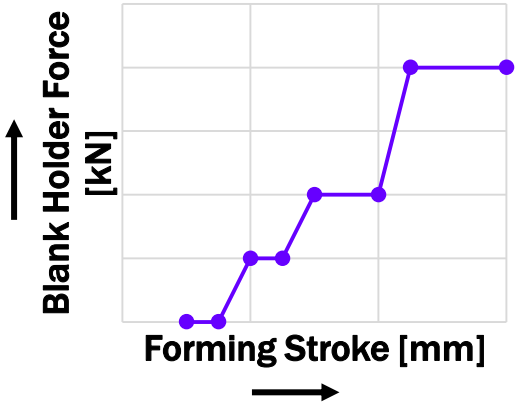
A few alternatives to improve drawing…

Servo Press

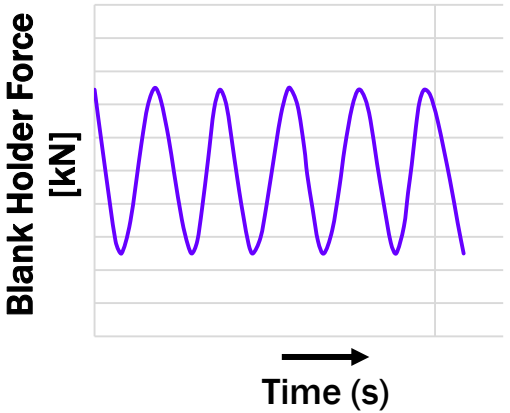


Attach/
Detach

Servo Cushion



Variable Blank
Holder Force



Cushion
Pulsation

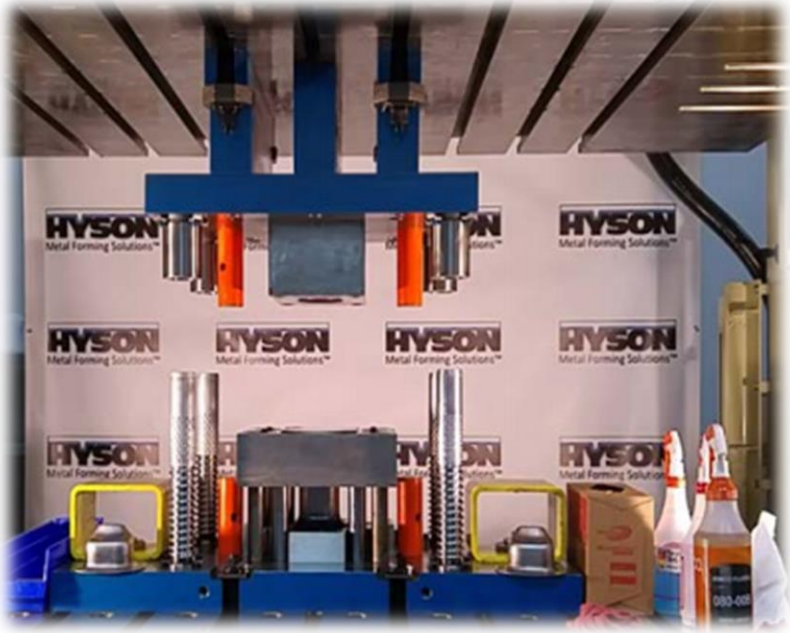
Test equipment*

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

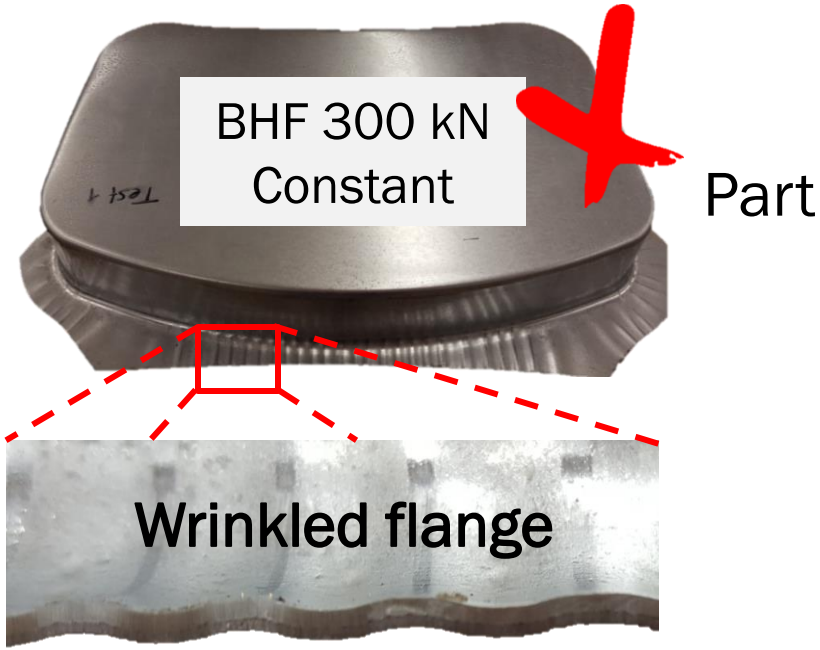


*at HYSON's Metal Forming Technology Center

Case Study 1: Drawing of a Non-Symmetrical Part

Use of Variable Blank Holder Force (VBHF)

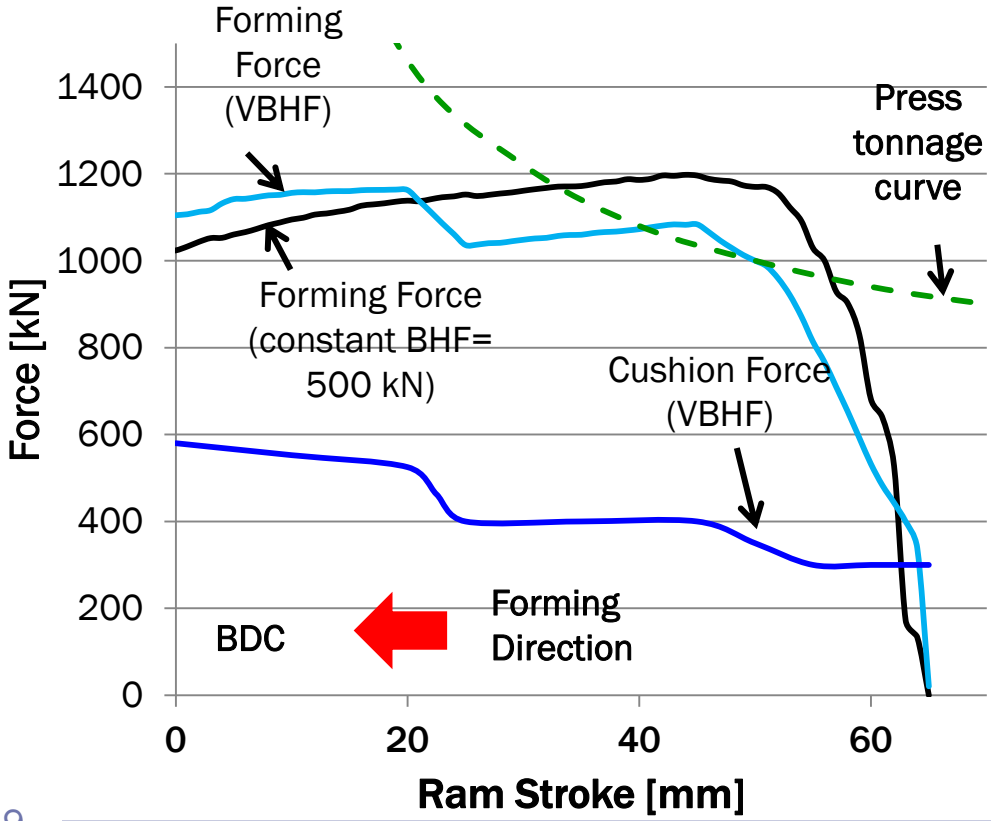
- **CP800 / 1.4 mm**
- Target draw depth: 65 mm (2.56 in)
- 23 SPM (Average forming speed ≈ 135 mm/s (5.31 in/s)
- Part size: ≈ 500 mm x 300 mm (19.7 in x 11.81 in)
- Die set provided by SHILOH
- Blank geometry used is shown in Appendix B



Case Study 1: Drawing of a Non-Symmetrical Part

No picture

Case Study 1: Drawing of a Non-Symmetrical

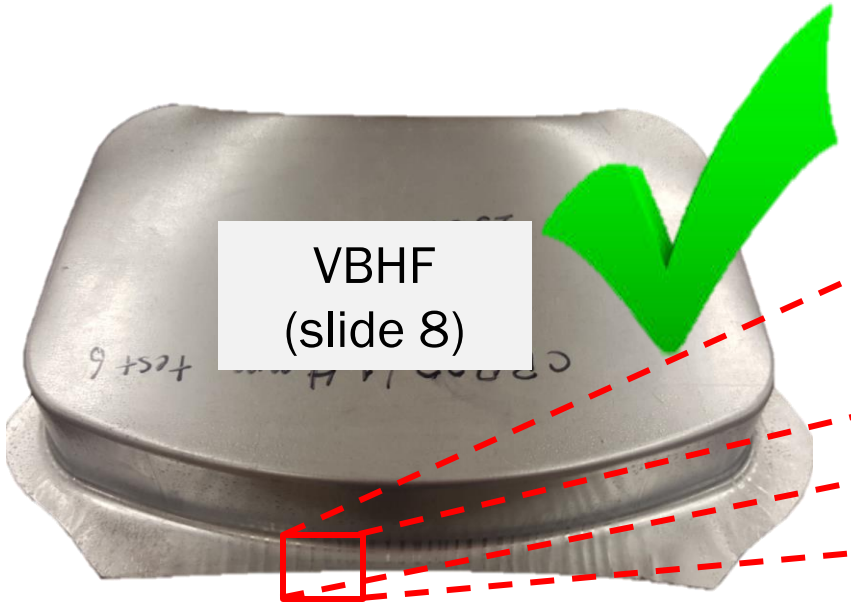


Wrinkling and VBHF Criterion

- In this case, max wrinkle height allowed in FE simulation was 5% of the sheet thickness. ($h_{wrinke} < 0.05t$)
- Every time wrinkling is observed, the BHF was increased

Case Study 1: Drawing of a Non-Symmetrical Part

Final result

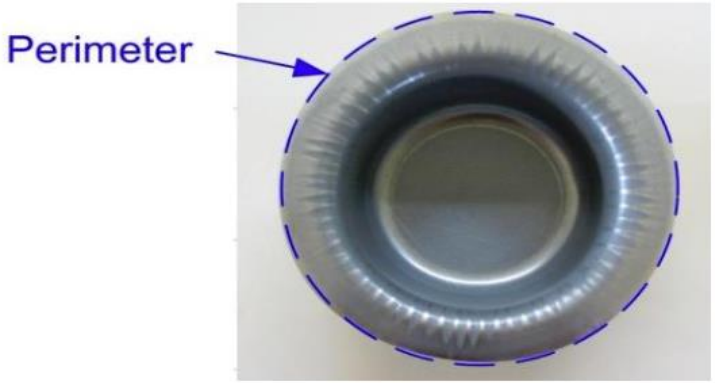


Press over tonnage was avoided while reducing the wrinkles observed on the flange.

Case Study 2: Drawing of a Round Cup

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

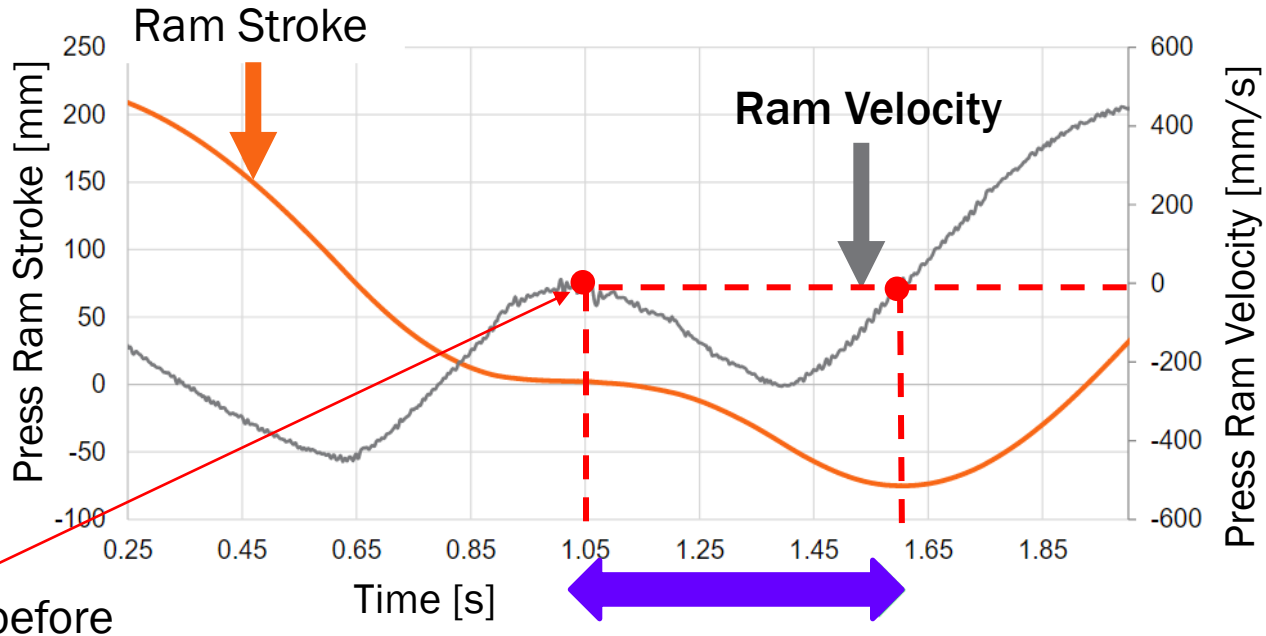
DP980/1.2 mm



- 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

Case Study 2: Drawing of a Round Cup

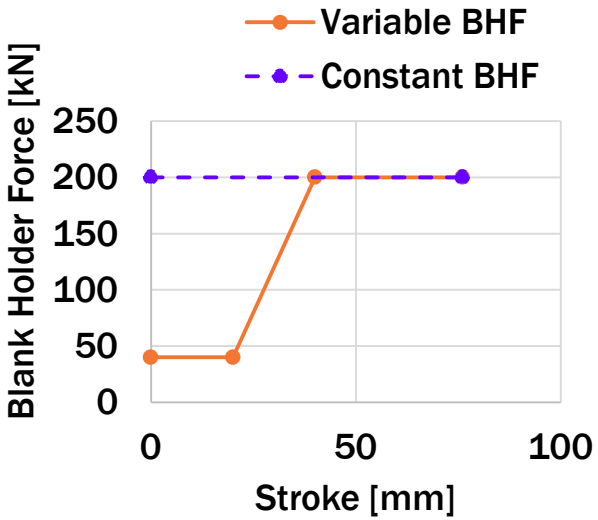
Ram stroke and velocity- 20 SPM (Average forming speed ≈ 138 mm/s (≈5.45 in/s)



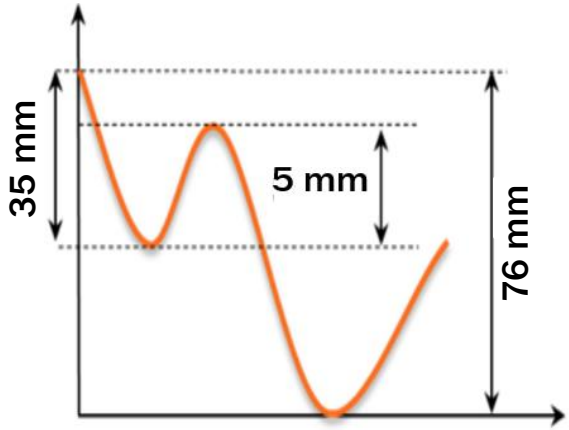
Case Study 2: Drawing of a Round Cup

Approaches

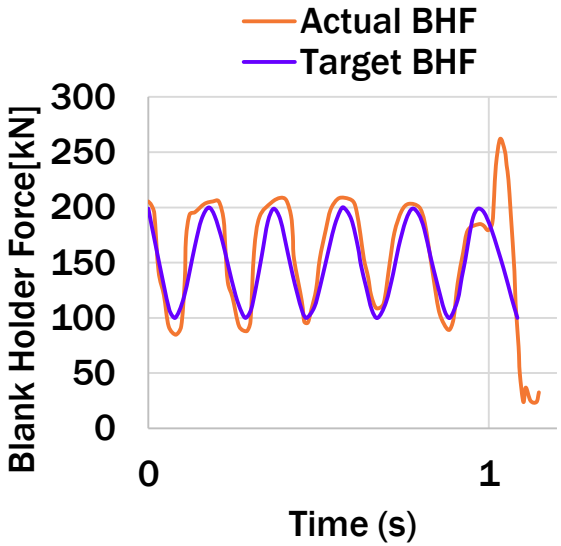
Constant and Variable Blank Holder Force (BHF)



Attach/Detach (constant 200 kN BHF)



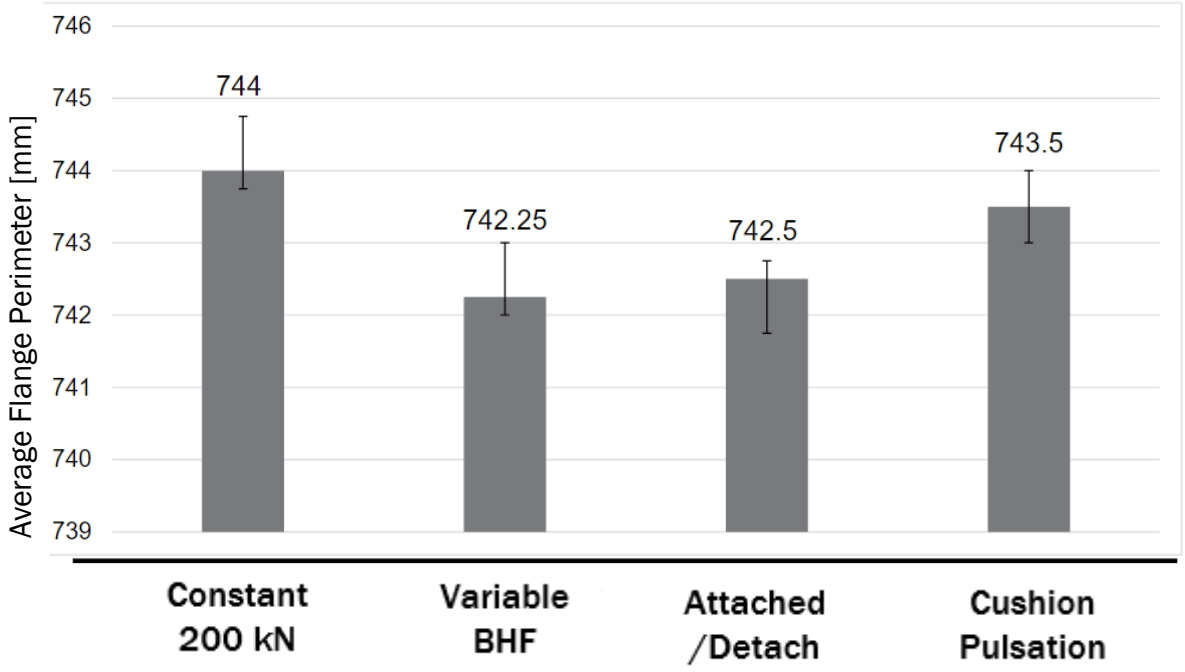
Cushion Pulsation (5Hz)



Case Study 2: Drawing of a Round Cup

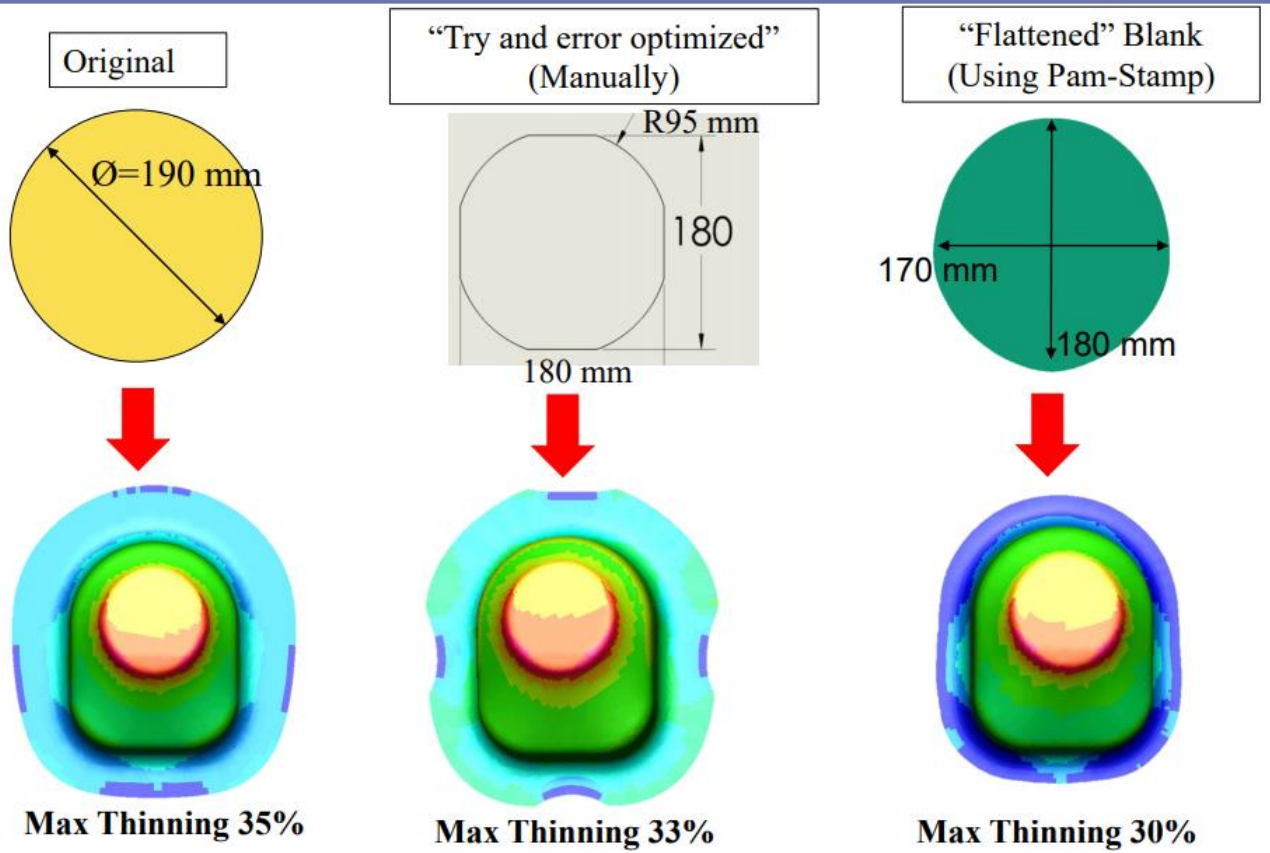
Results

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

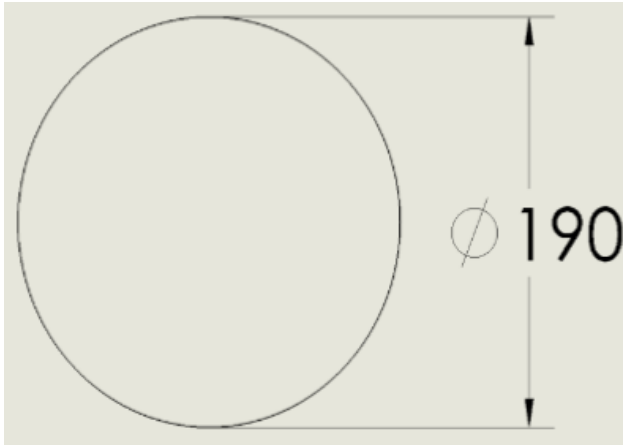
Significant thinning reduction by optimizing blank shape

Case Study 3: Cushion Pulsation

Blank Geometry

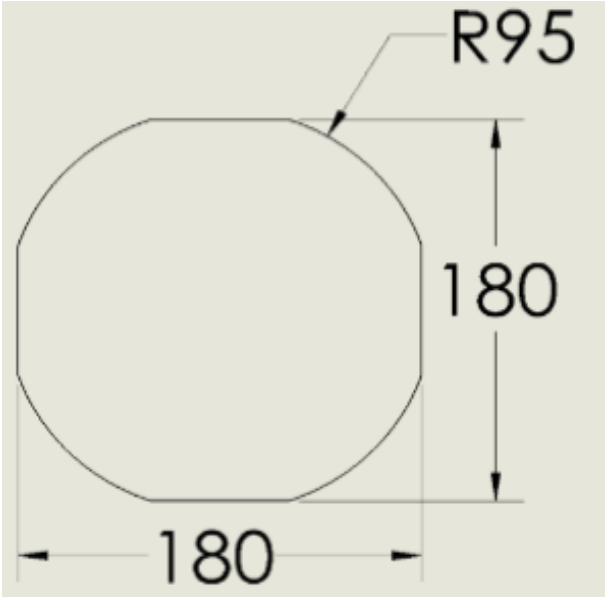
- Geometries applicable to Steel 1008/1.0 mm
- All samples fractured at about 35 mm stroke for geometry A.
- Geometry B formed successfully up to 60 mm stroke.

Geometry A



*Units are in mm

Geometry B



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

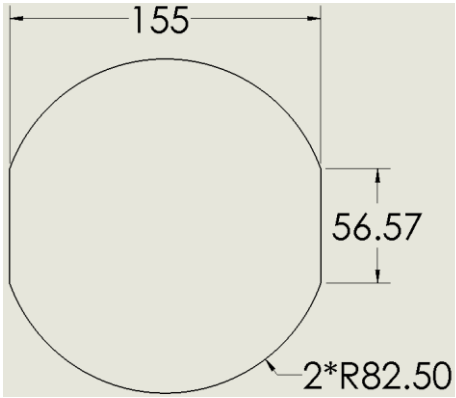
Fractured at stroke around 39 mm (≈ 1.53 in)

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

No pictures available

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

Fracture using constant BHF=5 kN



- Geometry used
- Units are in mm

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

Case Study 4: Attach/Detach

Attach/Detach

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

- 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.

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

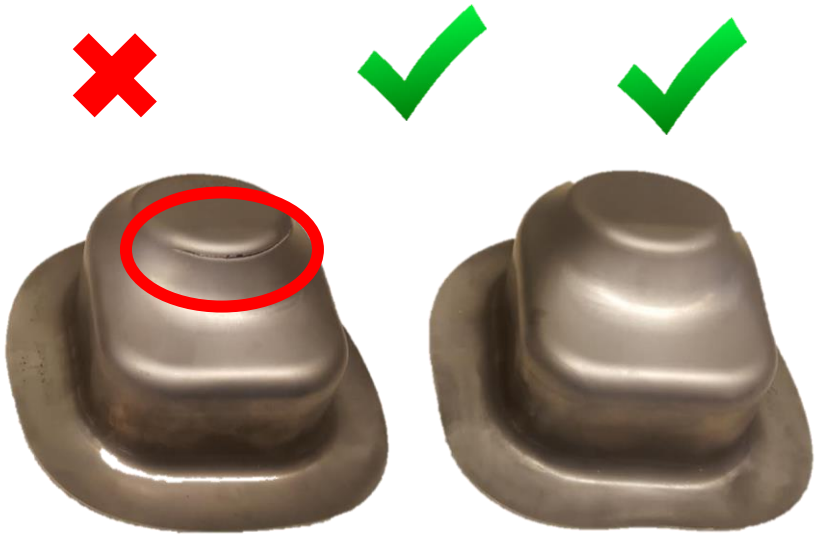
Different fracture location

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

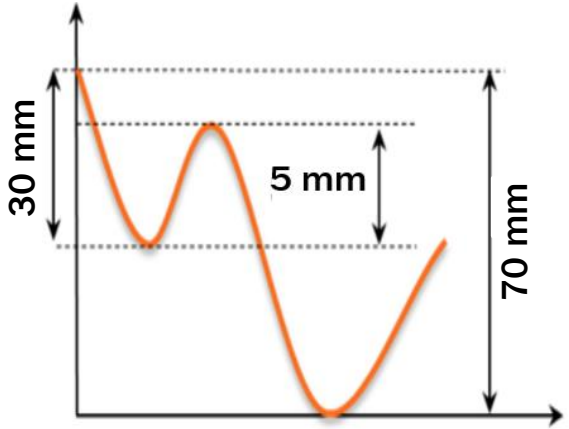
Case Study 4: Attach/Detach

Parameter	Set up 1	Set up 2	Set up 3
Ram Speed [SPM]	12	12	19
Attached/Detach	NO	YES	NO

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.

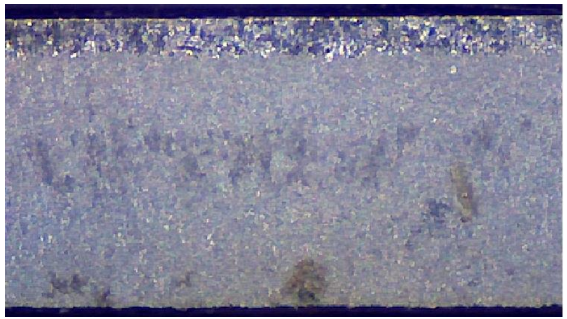
- **Cushion pulsation** seems to reduce friction on the flange. Therefore, it can improve drawability. However, more studies are required to evaluate whether this method is cost-effective.

Work in Progress

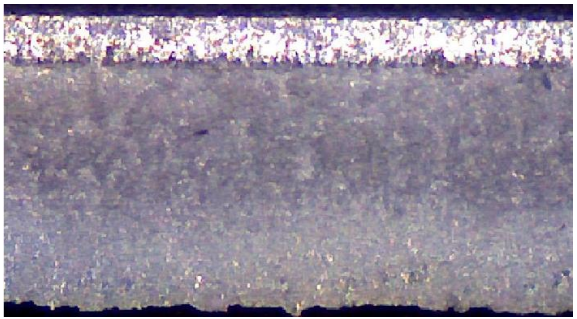
Effect of blanking speed and die/punch clearance upon edge quality

TRIP1180/1. 42 mm

Ram Speed at tool/blank contact ≈ 195 mm/s



≈10% nominal punch/clearance



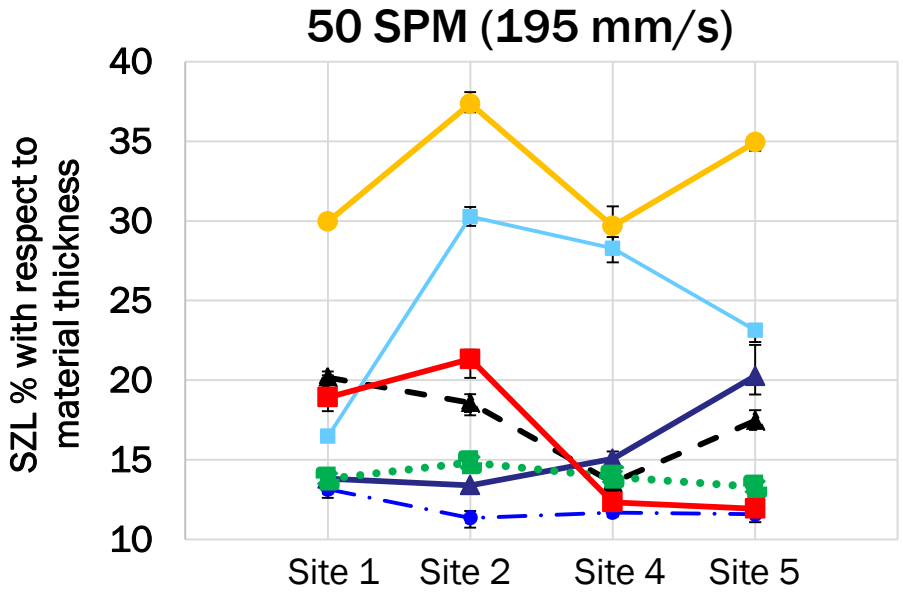
≈20% nominal punch/clearance

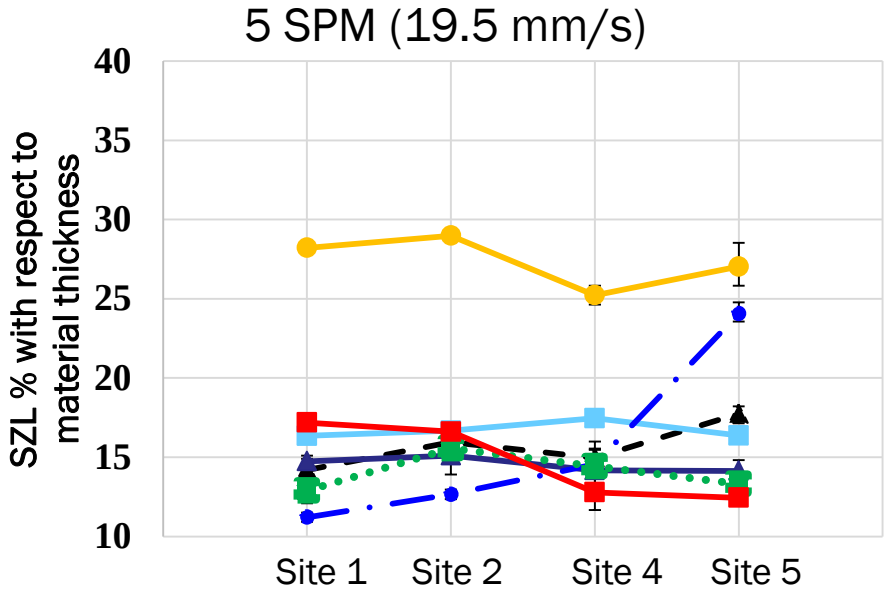
Press and tools provided by AIDA America

Work in Progress

SZL= Shear Zone Length

DP1180/1.21 mm
DP980/1.5 mm
TRIP1180/1.21 mm
TRIP 1180/1.42 mm
DP780/1.52 mm
DP590/1.38 mm
Al5182-O/1.21 mm





Future Work

Using a Servo Hydraulic Cushion, to explore:

- Cushion pre-acceleration
- Blanking using counter punch (activated by a hydraulic system)

Acknowledgements

- The experiments presented were conducted in collaboration with HYSON Metal Forming Solutions, SHILOH Industries, Inc., AIDA America and IRMCO.

- Special thanks to Cliff Hoschouer (SHILOH), Ethan McLaughlin (HYSON), Shrinivas Patil (AIDA), Frank Kenny (IRMCO) and Ali Fallahiarezoodar (CPF).

For More Information

David Diaz-Infante

Center for Precision Forming/The Ohio State University

614.747.5998

diazinfantehernandez.1@osu.edu

Taylan Altan

Center for Precision Forming/The Ohio State University

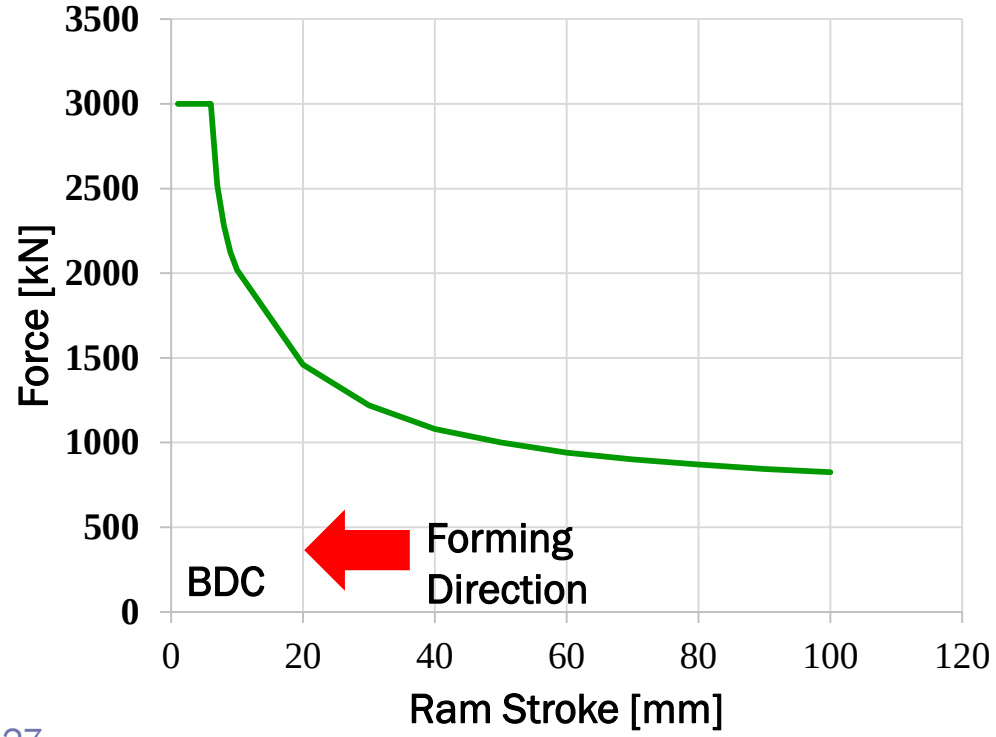
614.292.50.63

altan.1@osu.edu

https://ercnsm.osu.edu

Appendix A

Tonnage Curve

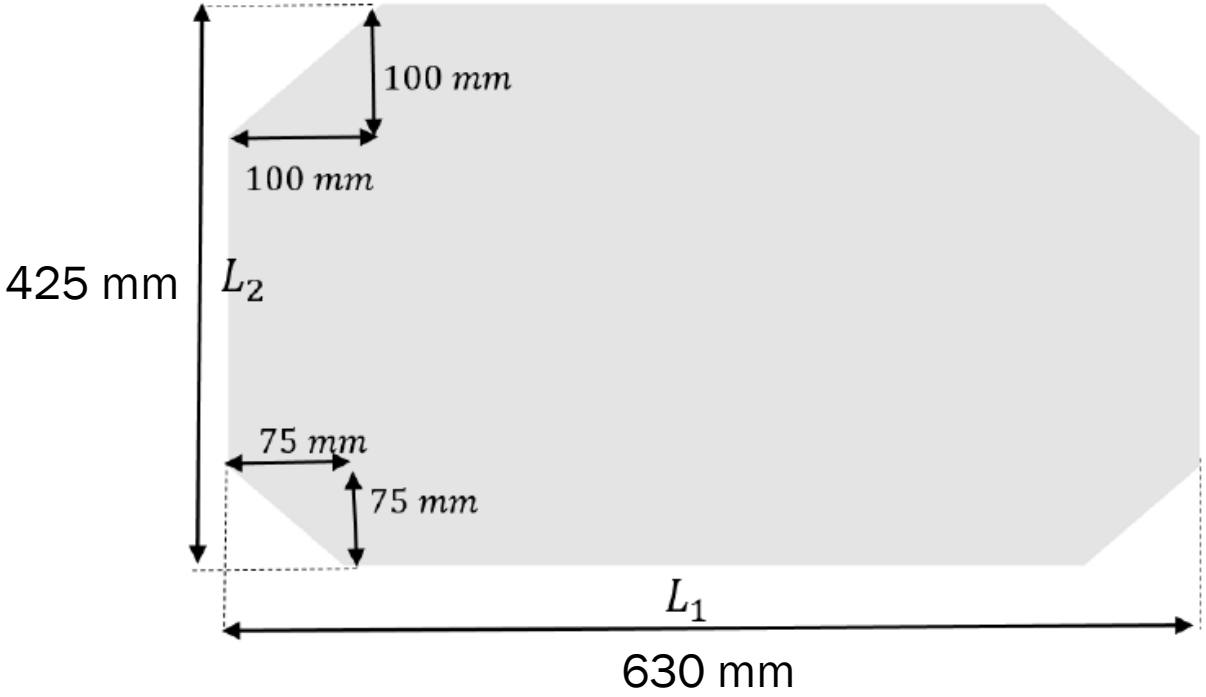


Komatsu H2W300 Servo Press

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

Provided by
HYSON

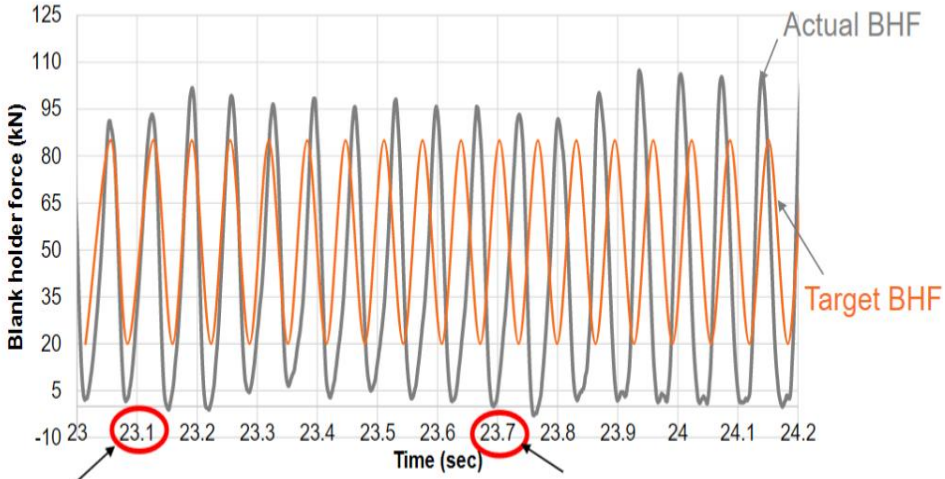
Appendix B



Blank geometry used in experiments with Shiloh tooling

Appendix C

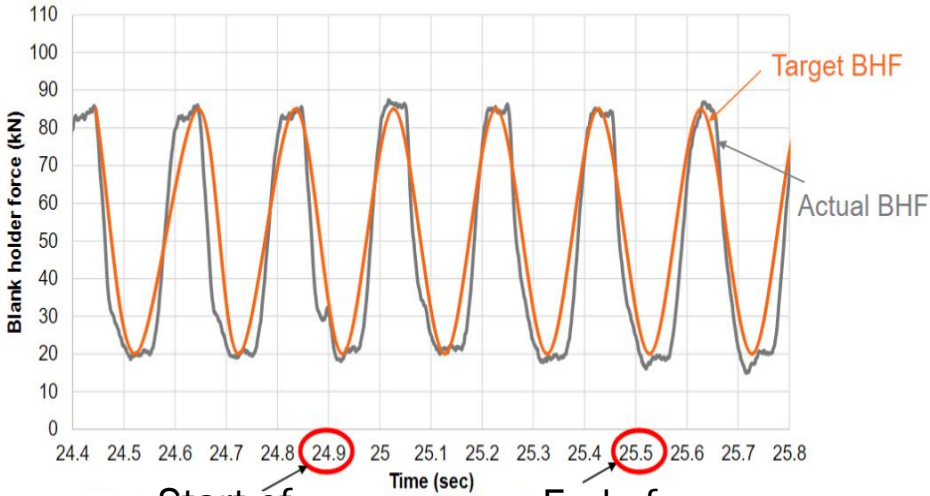
Cushion Pulsation Accuracy



Start of forming

End of forming

11 SPM
15 pulses /sec



Start of forming

End of forming

11 SPM
5 pulses /sec