EWI Project No. 20381CSQ – Final Report rev 1

6-in. Diameter Cup Draw Testing on 0.9-mm DP780 with Four Lubricants

PREPARED FOR: Brit Capizzano Chemcoaters

EWI CONTACT: Laura Zoller Engineering Group Leader Materials Forming Group 614.688.5283 Izoller@ewi.org

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Introduction



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Scope of project

- Chemcoaters approached EWI to evaluate four lubricants with 0.9-mm DP780 using EWI's 6-in. diameter, deep draw cup tooling in EWI's 300-ton servo press at a forming speed of 15 shots per minute (SPM).
 - Lubricants:
 - CG-DFL 150-200mg
 - Advanced Polymer DFL
 - CG-DFL 400-500mg
 - Unnamed Wet Lubricant
- The lubricants were evaluated based on the following cup testing criteria:
 - Maximum drawing force
 - Flange perimeter measurements
 - Blank Holding Force to avoid wrinkling and fracture



Objective

• Evaluate the effectiveness of each lubricant with DP780 steel using a 6-in. diameter cup drawing tooling



- The following forming criteria means the better lubrication condition:
 - Lower maximum drawing force
 - Higher blank holder force without fracture
 - Smaller flange perimeter



Deliverables

• Flange perimeter measurements at different blank holder forces

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- Load-displacement curves at different blank holder forces
- Tested samples (will be shipped upon completion of the project)



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Testing procedure





Primary details

- Chemcoaters provided the material to EWI at the beginning of the project.
 - The three DFL lubricants were applied by Chemcoaters, while wet lubricant was applied by EWI.
- EWI waterjet cut 12-in. diameter blanks for testing
- Initial blank diameter: 12 in.
- Punch diameter: 6 in.
- Forming Speed: 15 SPM
- Maximum Forming Stroke: 82 mm (3.22 in.)
- Servo press: 300-ton with 250 kN blank holder force capacity



Testing approach

- 1. Set up testing to determine the appropriate blank holder forces (BHF) without wrinkling or cracking
 - Same BHF was used for all lubricants.
- 2. Determine test matrix
- 3. Apply the wet lubricant to the DP780 samples prior to testing
- 4. Complete test matrix
 - Tooling cleaned after each lubricant type was tested.
- 5. Plot load-displacement data
- 6. Measure perimeter of formed cups



6 in. cup test tooling

Blanks with four different lubricants



Cup Drawing Tooling





Set Up Experiments





Experimental parameters

- Four different BHF were tested: 100 kN, 150 kN, 200 kN, and 250 kN.
- All BHFs were tested on all four lubricants.
- Maximum and minimum BHF were found, through which wrinkling and failure are prevented in all four lubricants.
- The three DFLs arrived to EWI in the ready to test condition.
- The wet lubricant was applied prior to testing with a saturated rag.
- The wet lubricant was in the neat condition.





CG-DFL – 150-200mg lubricant





- 100 kN: wrinkles
- 150 kN: good
- 200 kN: good
- 250 kN: good



Advanced Polymer DFL lubricant



- 100 kN: wrinkles
- 150 kN: good
- 200 kN: good
- 250 kN: good



CG-DFL – 400-500mg lubricant



- 100 kN: wrinkles
- 150 kN: good
- 200 kN: good
- 250 kN: good

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Wet lubricant





- 150 kN: good
- 200 kN: good
- 250 kN: good



Test Matrix

- The setup experiments led to following results:
 - Wrinkling was observed in 100 kN BHF.
 - Minimum BHF: 150 kN to prevent wrinkles
 - Maximum BHF: 250 kN (maximum of servo press, no cracking)
- Test matrix is created at follows:
 - Forming stroke: 82 mm (max stroke)
 - Forming speed: 15 SPM
 - BHF: 150 kN, 200 kN, and 250 kN

	Results			
BHF (kN)	CG-DFL 150-200mg	Advanced Polymer DFL	CG-DFL 400-500mg	Wet
100	Wrinkles	Wrinkles	Wrinkles	Wrinkles
150	Good	Good	Good	Good
200	Good	Good	Good	Good
250	Good	Good	Good	Good



Cup drawing results





Test samples for CG-DFL – 150-200mg lubricant











Test samples for Advanced Polymer DFL lubricant











Test samples for CG-DFL – 400-500mg lubricant











Test samples for wet lubricant















Load-displacement curves for BHF=200 kN





Load-displacement curves for BHF=250 kN





Comparison of Max Drawing Force

- <u>150kN:</u>
 - 1. Advanced Polymer DFL
 - 2. Wet
 - 3. CG-DFL 400-500mg
 - 4. CG-DFL 150-200mg
- <u>200kN</u>:
 - 1. Advanced Polymer DFL
 - 2. Wet
 - 3. CG-DFL 400-500mg
 - 4. CG-DFL 150-200mg
- <u>250kN</u>:
 - 1. Wet
 - 3. Advanced Polymer DFL
 - 2. CG-DFL 400-500mg
 - 3. CG-DFL 150-200mg





Perimeter Measurements

Perimeter

Lower perimeter = better lubricant





Perimeter Measurements

- <u>150kN:</u>
 - 1. Advanced Polymer DFL
 - 2. Wet and CG-DFL 400-500mg
 - 3. CG-DFL 150-200mg

• <u>200kN</u>:

- 1. Advanced Polymer DFL
- 2. Wet
- 3. CG-DFL 400-500mg
- 4. CG-DFL 150-200mg
- <u>250kN</u>:
 - 1. Wet
 - 2. Advanced Polymer DFL
 - 3. CG-DFL 400-500mg
 - 4. CG-DFL 150-200mg





Conclusions





Perimeter Measurements

- All 4 lubricants were able to fully draw parts to the 82-mm maximum stroke without cracking.
- At both 150 kN and 200 kN, the Advanced Polymer DFL coated samples showed both lower drawing forces and perimeter measurements compared to CG-DFL – 400-500mg, wet and CG-DFL – 150-200mg.
- At 250 kN, wet and Advanced Polymer DFL samples showed similar performance.
- Based on the lubricant evaluation criteria, EWI's findings on lubrication performance is as follows:
 - 1. Advanced Polymer DFL
 - 2. Wet
 - **3**. CG-DFL 400-500mg and CG-DFL 150-200mg



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Columbus, Ohio EWI (Headquarters) 1250 Arthur E. Adams Drive Columbus, OH 43221 614.688.5000 info@ewi.org

Buffalo, New York

Buffalo Manufacturing Works 683 Northland Ave. Buffalo, NY 14211 716.710.5500 info@BuffaloManufacturingWorks.com

Loveland, Colorado

Rocky Mountain Center for Innovation & Technology 815 14th Street SW, Ste. D190 Loveland, CO 80537 970.635.5100 info@ewi.org

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Laura Zoller Engineering Group Leader Materials Forming Group 614.688.5283 Izoller@ewi.org



