AUTODESK UNIVERSITY

Moldflow Research and Development Update - 2021

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Research Director

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New Features and Capabilities

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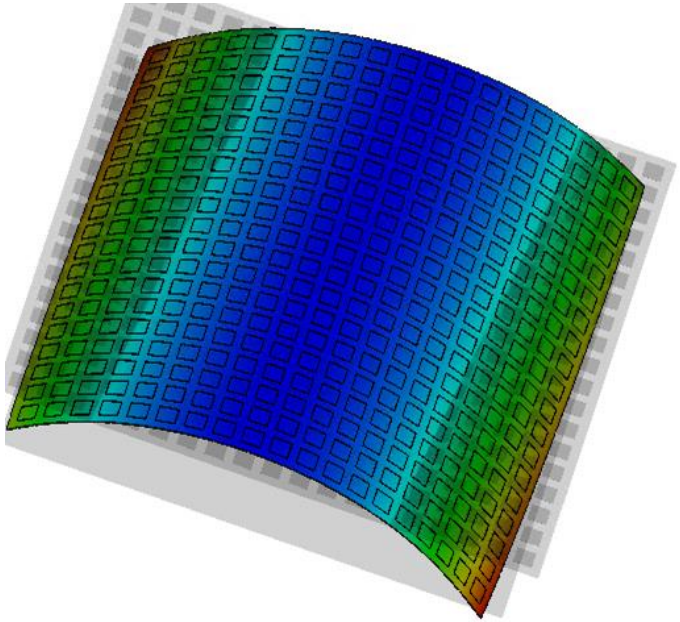
Accuracy Enhancements

- Warp & Flow Accuracy

External Research Collaborations



Moldflow 2021 Accuracy Improvements

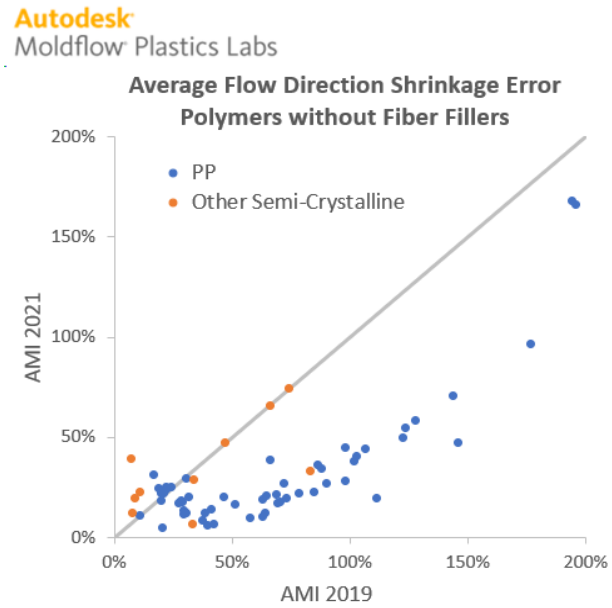
MF 2021 Solver accuracy validation report

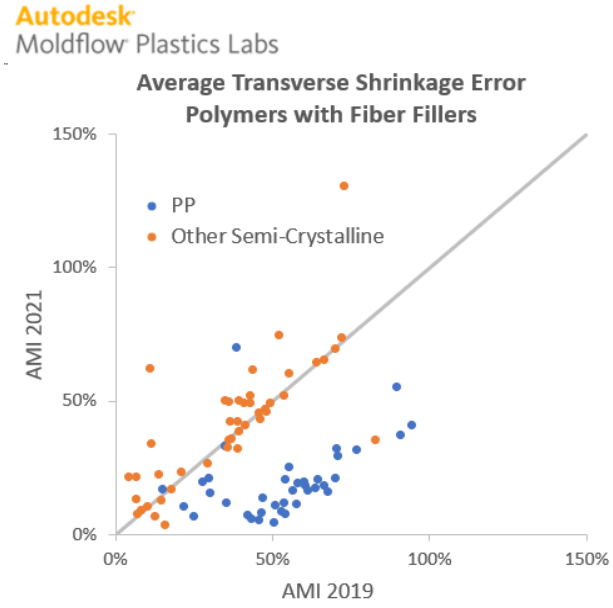
Report published on: www.autodesk.com/industry/manufacturing/simulation-hub/resources

Highlighted the improvement of 3D Warp for Semi-crystalline materials

Compare Warp prediction error from measurement:

AMI 2021 v.s. AMI 2019



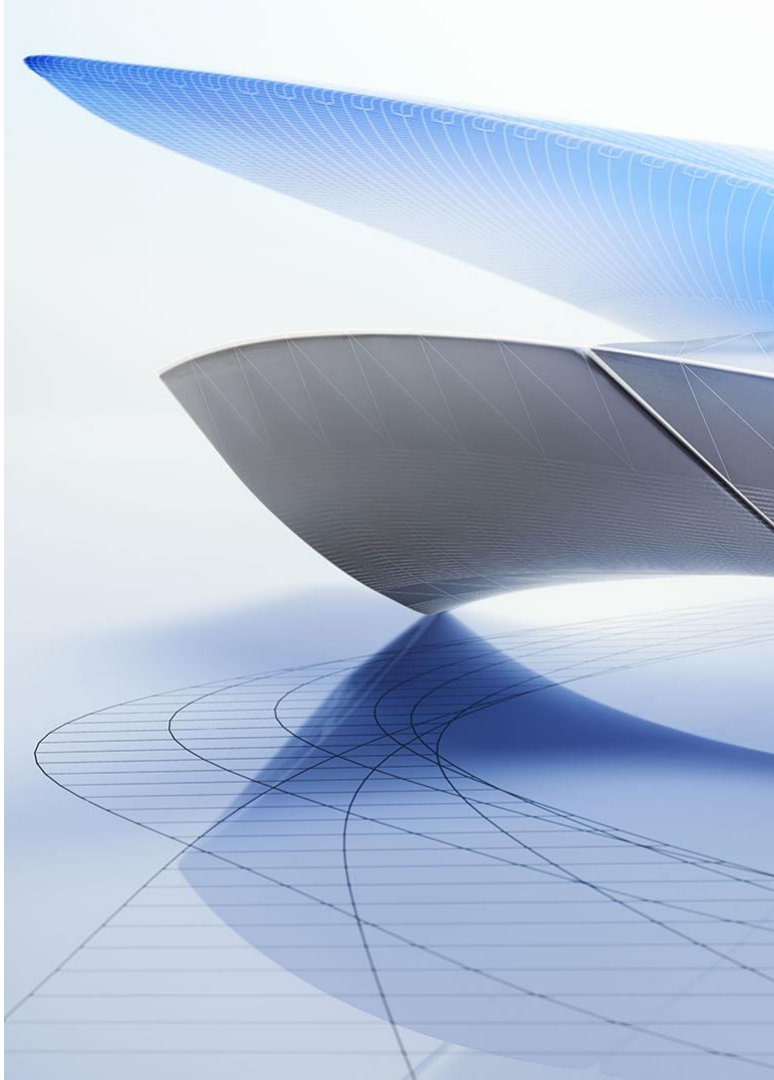


New Features and Capabilities

Research disclaimer

We may make statements regarding planned or future development efforts for our existing or new products and services. These statements are not intended to be a promise or guarantee of future delivery of products, services or features but merely reflect our current plans, which may change. Purchasing decisions should not be made based upon reliance on these statements.

The Company assumes no obligation to update these forward-looking statements to reflect events that occur or circumstances that exist or change after the date on which they were made.



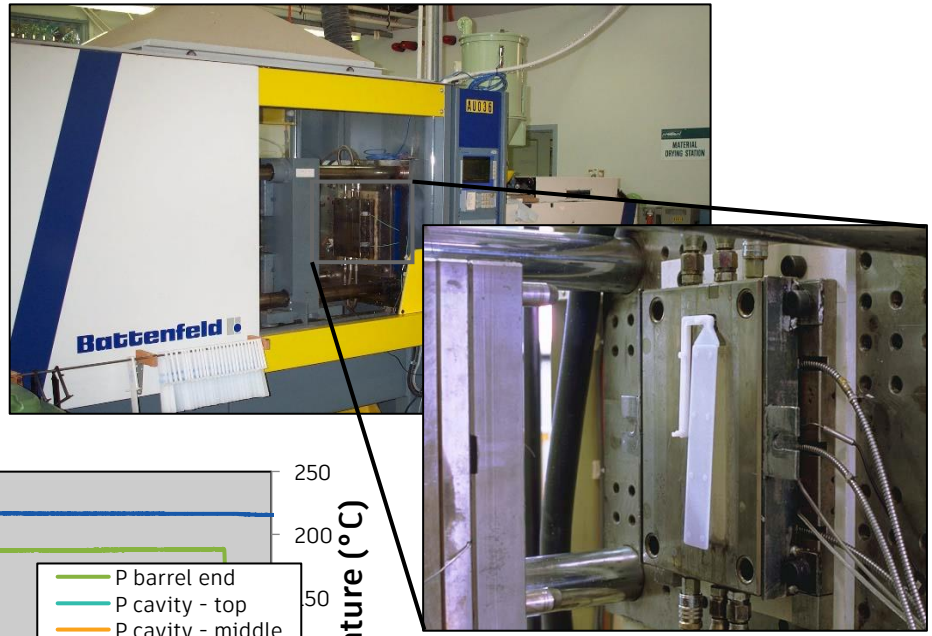
Use Shrinkage Correction Data in 3D analysis

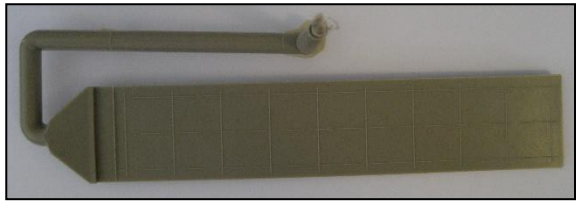
Shrinkage measurement

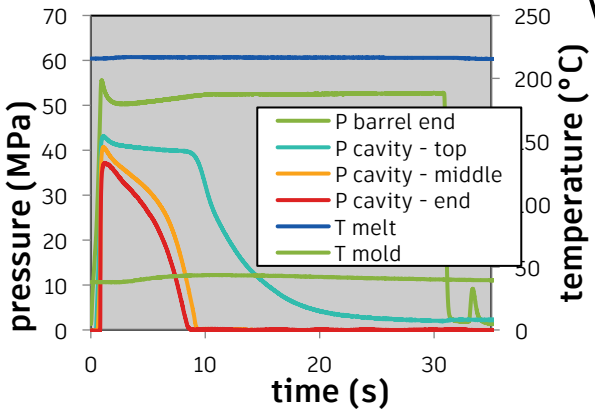
Material Characterization Service in Autodesk Plastic Laboratories

Using existing measured shrinkage data:

- 25 Molding conditions:
- thickness tag
- injection speed
- melt temperature
- mold temperature
- packing pressure
- packing time
- cooling time



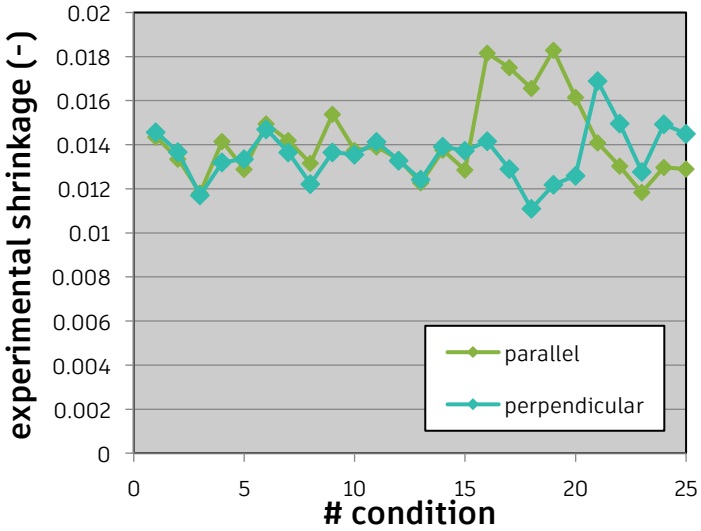




Shrinkage measurement process

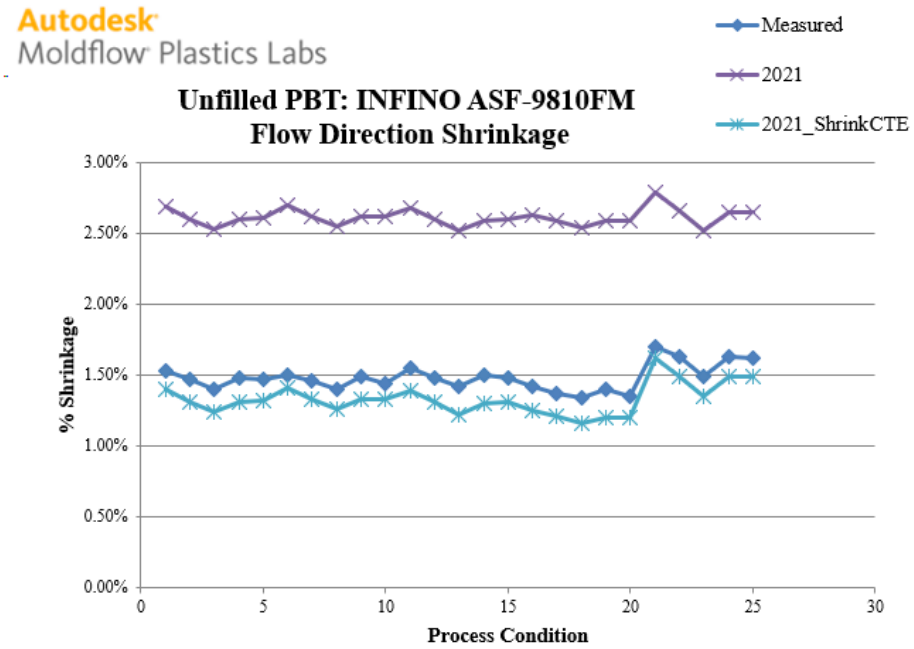
Measure tag grid dimensions (x25)

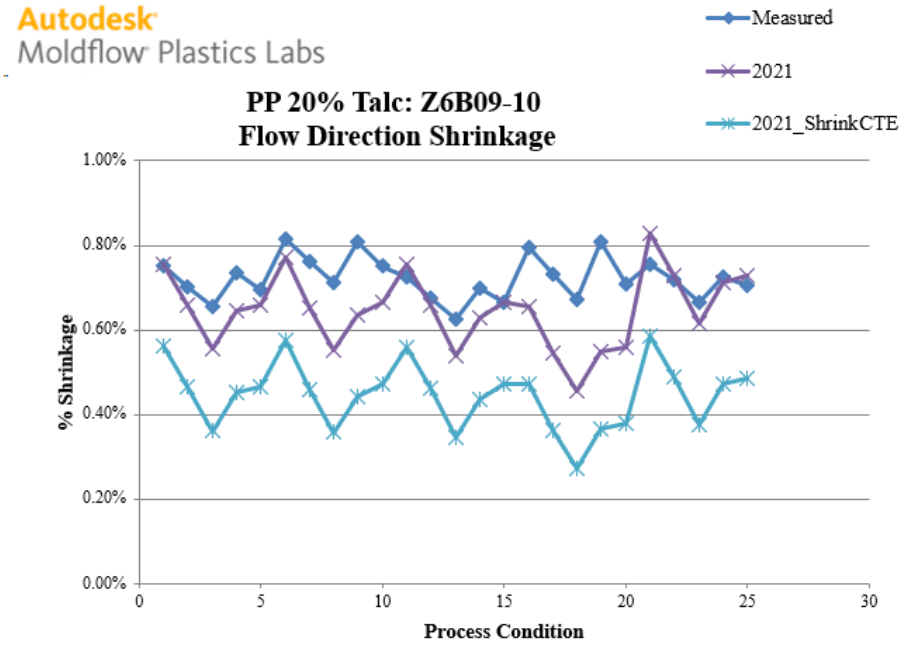
7 days @ 23°C
& 50% RH



Shrinkage correction in 3D

Calibrated CTE (Scandium TP): Non-fiber polymer grades



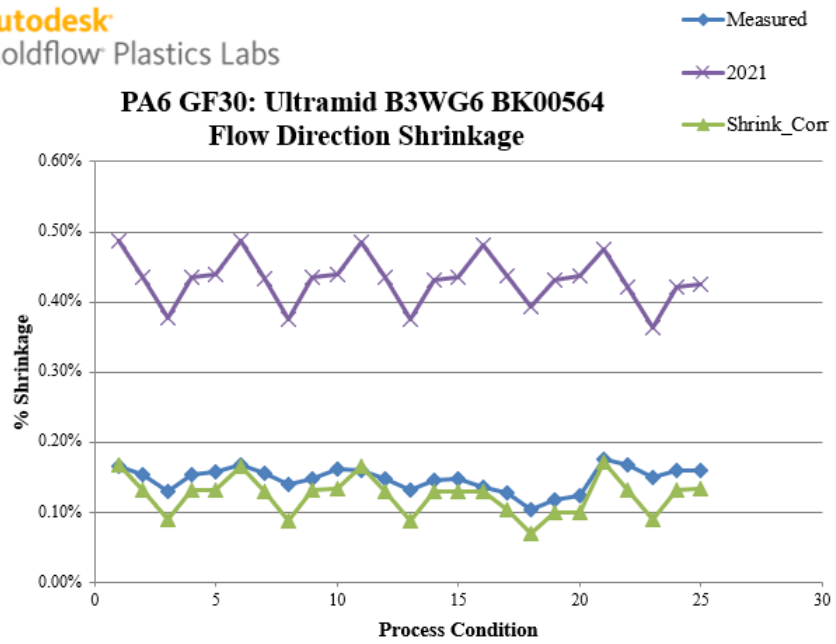


Shrinkage Tag moldings of 2.0, 1.5 & 3.0 mm

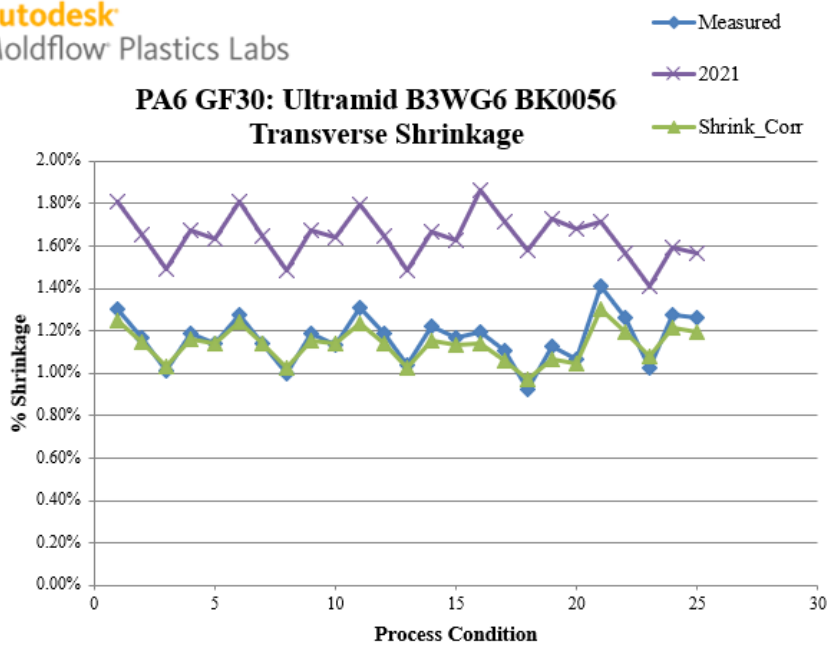
Shrinkage correction in 3D

Development for fiber filled polymer material grades

Autodesk Moldflow Plastics Labs



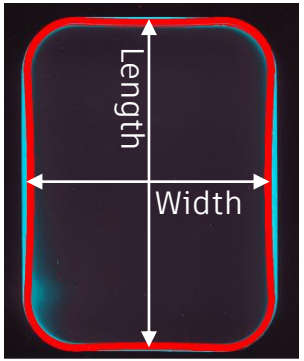
Autodesk Moldflow Plastics Labs

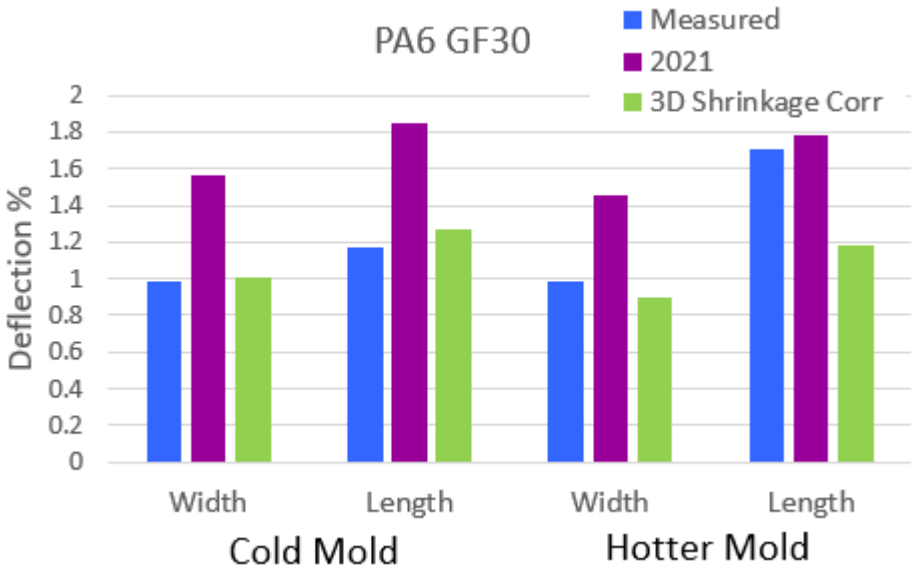


Shrinkage Tag moldings of 2.0, 1.5 & 3.0 mm

Shrinkage correction in 3D

Validation molding: PA6 30% glass fiber filled

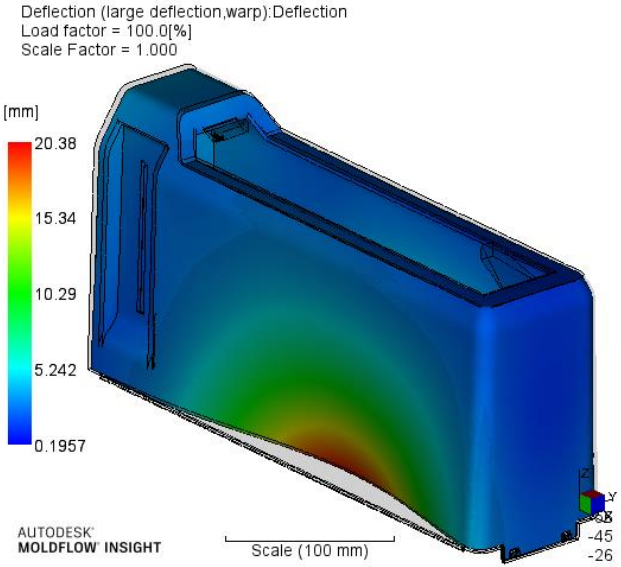


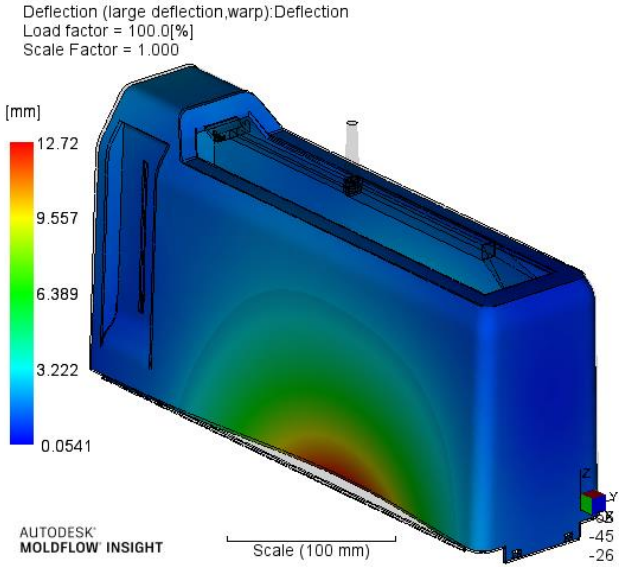


Validation moldings from Autodesk Plastics Lab

Shrinkage correction in 3D

Validation molding: PBT 20% glass fiber filled





Data published by Bayer/Covestro and Carl Hanser Verlag

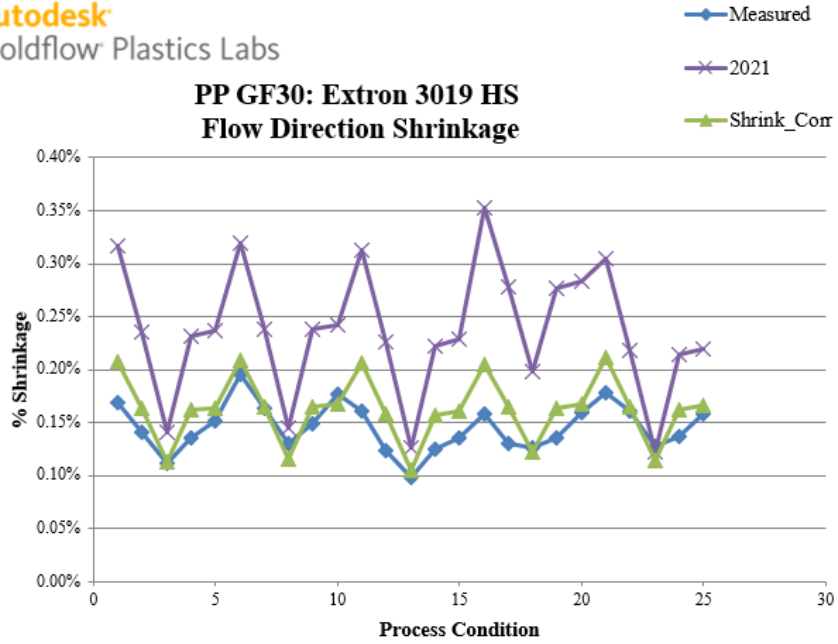
AMI 2021

3D Shrinkage Correction

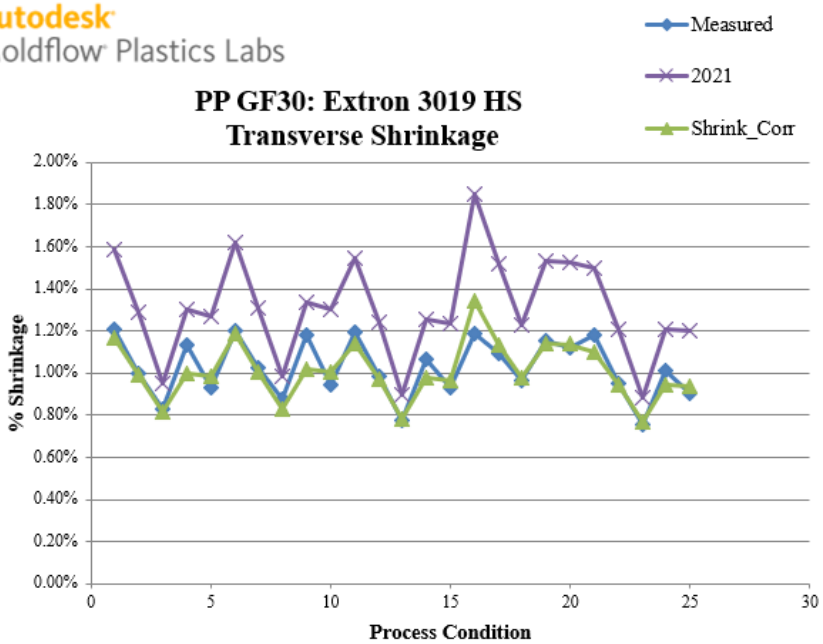
Shrinkage correction in 3D

Development for fiber filled polymer grades: Problems to investigate

Autodesk Moldflow Plastics Labs



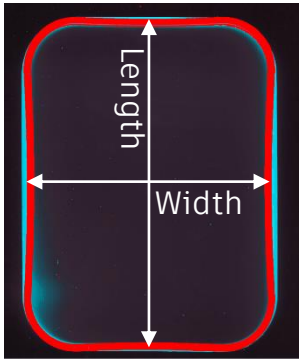
Autodesk Moldflow Plastics Labs

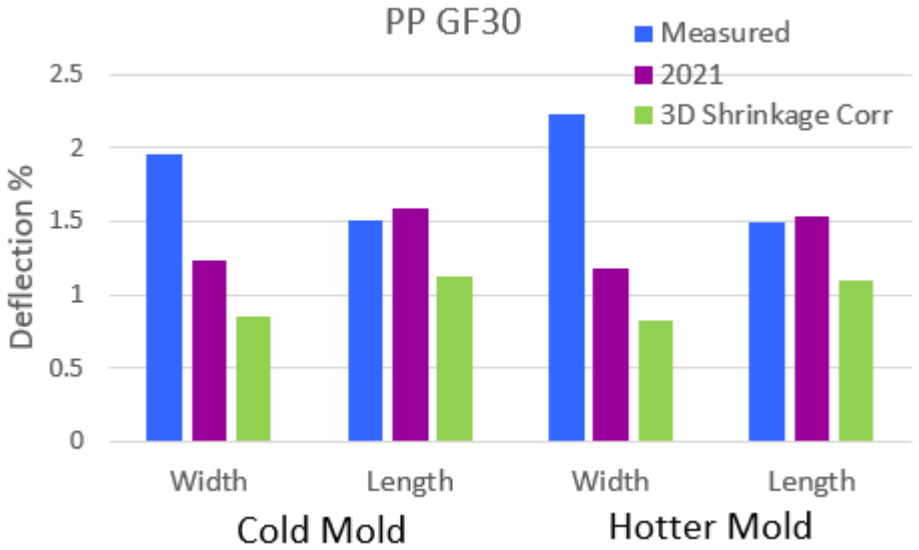


Shrinkage Tag moldings of 2.0, 1.5 & 3.0 mm

Shrinkage correction in 3D

Validation molding: PP 30% glass fiber filled



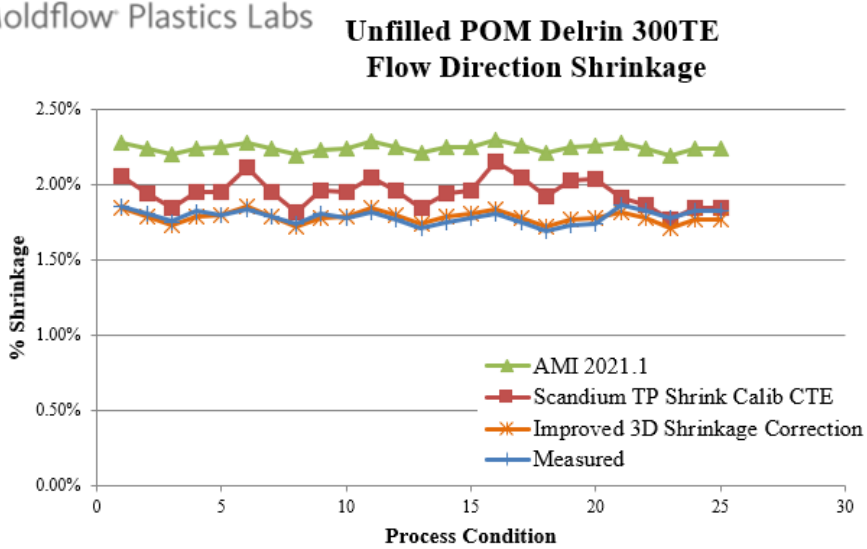


Validation moldings from Autodesk Plastics Lab

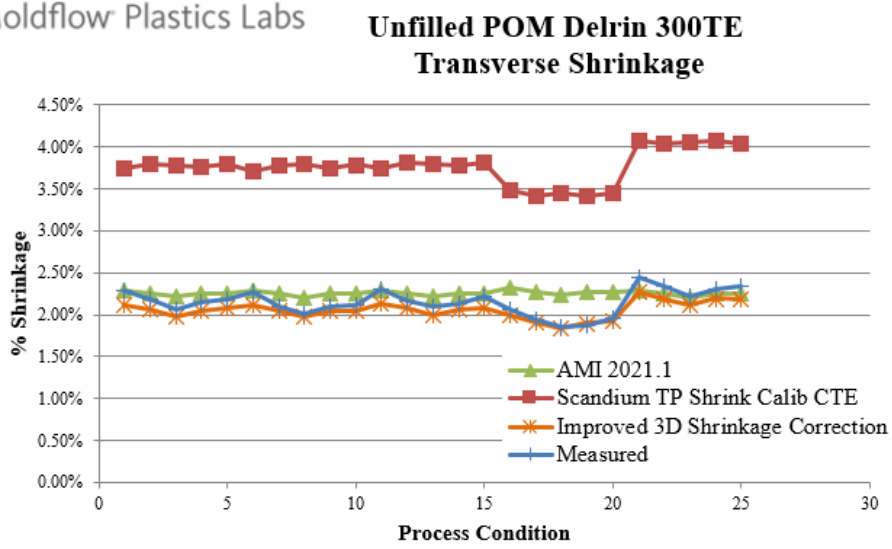
Shrinkage correction in 3D

Improved Shrinkage Calibration: Non-fiber polymer grades

Autodesk Moldflow Plastics Labs



Autodesk Moldflow Plastics Labs



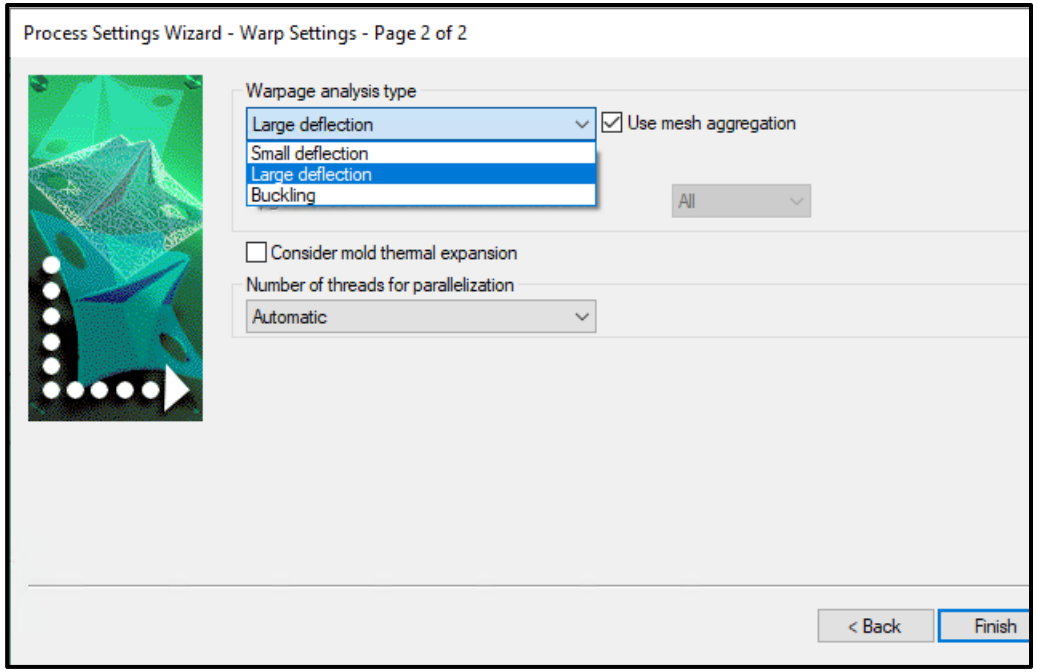
Shrinkage Tag moldings of 2.0, 1.5 & 3.0 mm

3D Large Deflection (with Mesh Aggregation)

Mesh Aggregation for 3D Large Deflection

3D Warp analysis

- Improvement the convergence behavior of 3D Large Deflection analysis
- Enable Mesh Aggregation option



Large Deflection analysis

Geometric Non-linearity

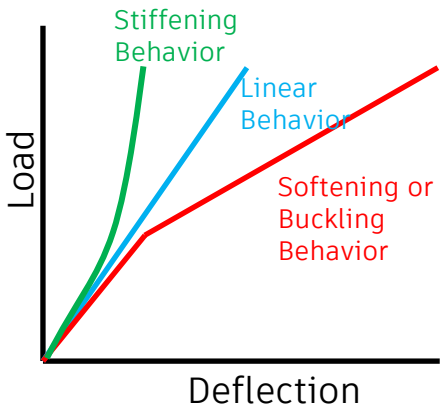
Linear deformation analysis

“Small deflection” analysis

Assumes linear relationship between applied load & deflection

- Single step calculation

Good representation for most warpage cases



Non-linear deformation analysis

“Large deflection” analysis

Apply the load incrementally

- Calculate a deflected shape

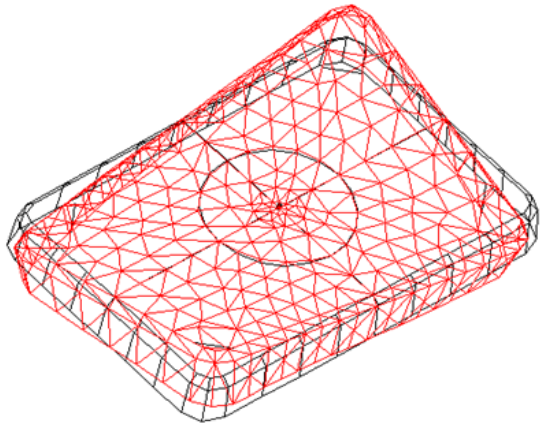
Recalculate the stress balance according to this deflected shape

Large Deflection analysis

Geometric Non-linearity

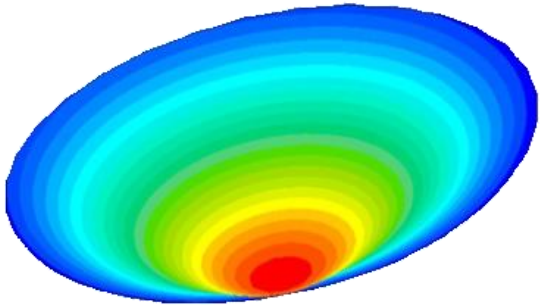
Components buckle under the in-mold residual stress and a post-buckling response is required

- A linear analysis will under predict the deflection in this case



Displacements and rotations of components become large enough that the stiffness of the part changes as more load is applied

- A linear analysis would over predict the deflection in this case



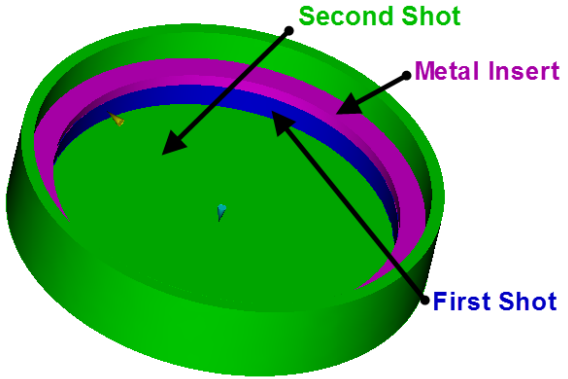
Z. Fan, ANTEC 2011

Large Deflection analysis

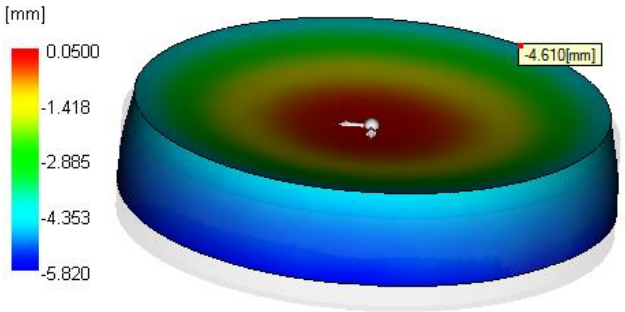
Geometric Non-linearity

Small deflection (linear) over-estimates the warpage

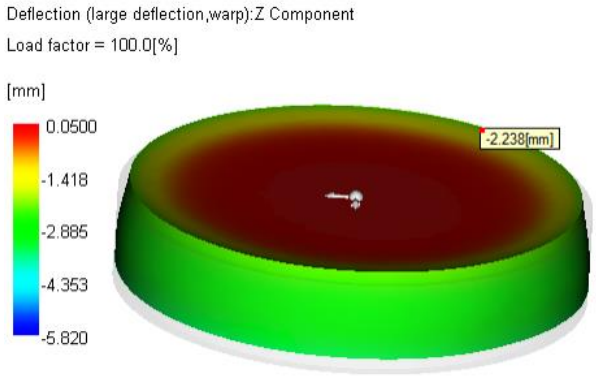
As the top of the part domes a little the structure stiffens lowering the total deflection



Small Deflection (Linear) Analysis Result



Large Deflection (Non-Linear) Analysis Result



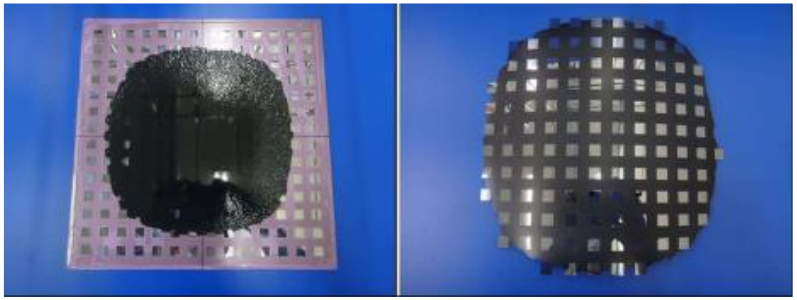
Z. Fan, ANTEC 2011

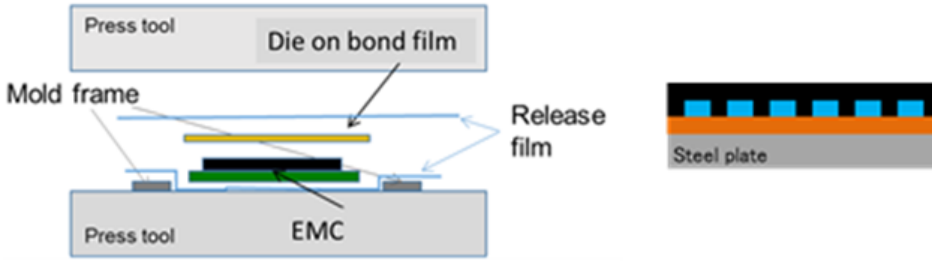
Microchip Panel Encapsulation

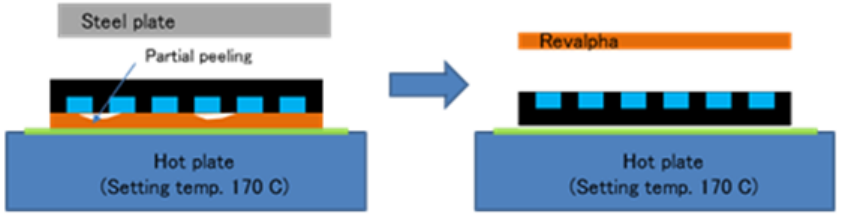
Process Case-Study

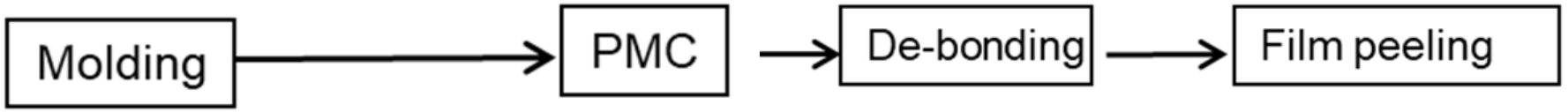
- Molding
- Post-mold curing (PMC)
- De-bonding
- Film peeling

EMC & test vehicle provided by ShinEtsu



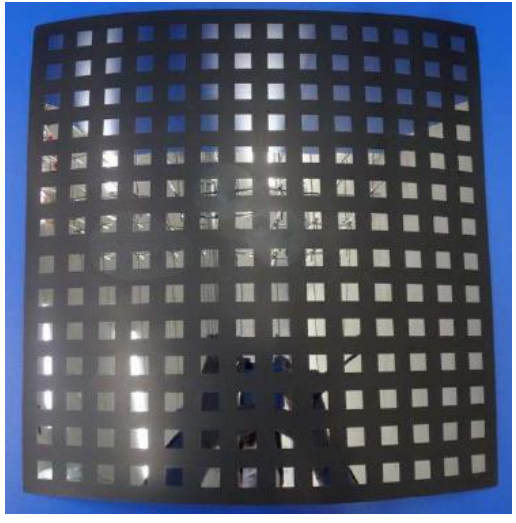






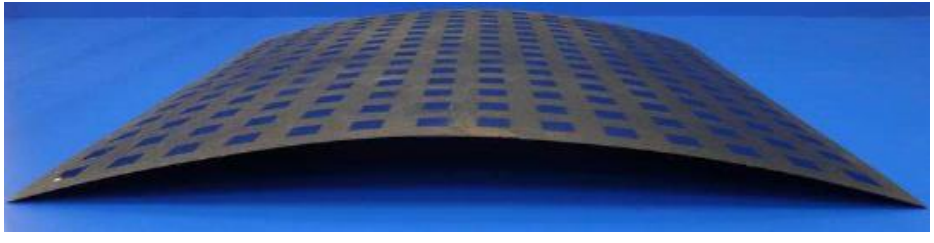
Microchip Panel Encapsulation

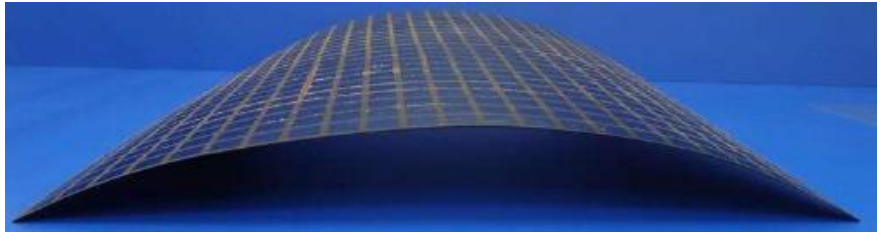
Warp Observation



Dimensions: 300 x 300 x 0.5 mm

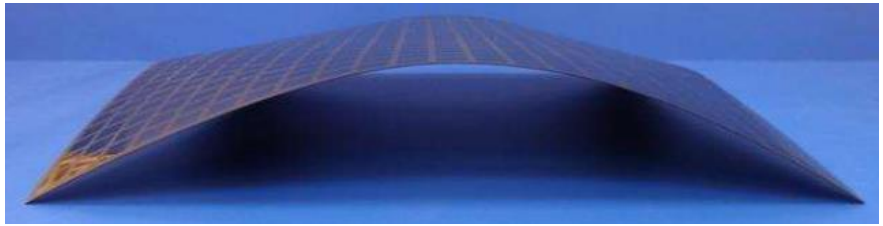
Majority of the panel exhibits a cylindrical or tunnel shape warpage



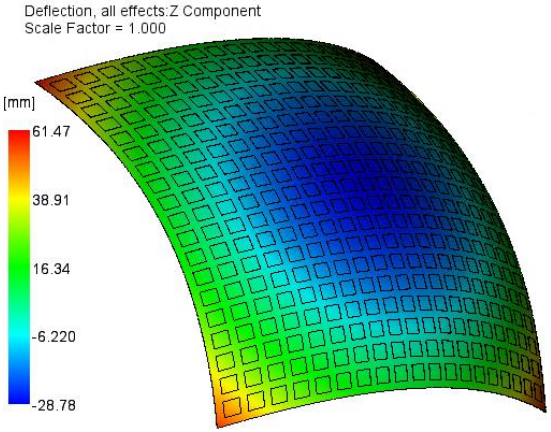


Microchip Panel Encapsulation

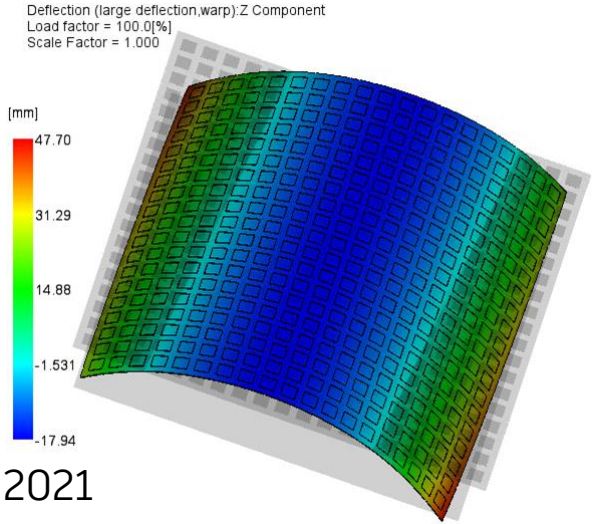
Deflection prediction



Small Deflection Analysis
(Linear Analysis)



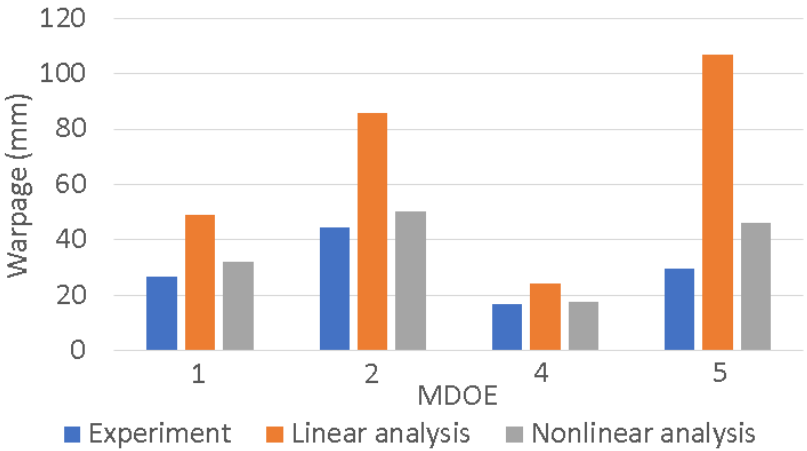
Large Deflection (non-linear) Analysis



S. Han, SPE-ANTEC 2021

Microchip Panel Encapsulation

Deflection prediction & performance



Four different panel molding cases

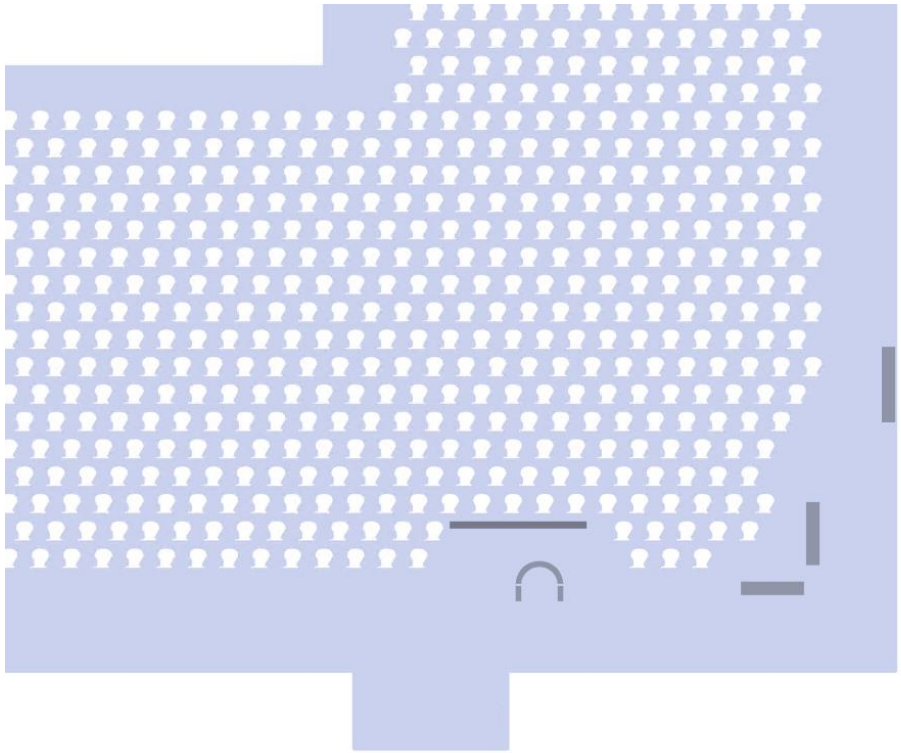
- Original Large Deflection analyses had convergence problems
  - No progress after running for 6 weeks
- With convergence behavior improved & using mesh aggregation enabled
  - Required between 14 to 25 days for each Large Deflection analysis
- These ultra thin panels are an extreme case!

Additional Results and Capabilities

Remove memory limit for 3D Warp

Model size limit

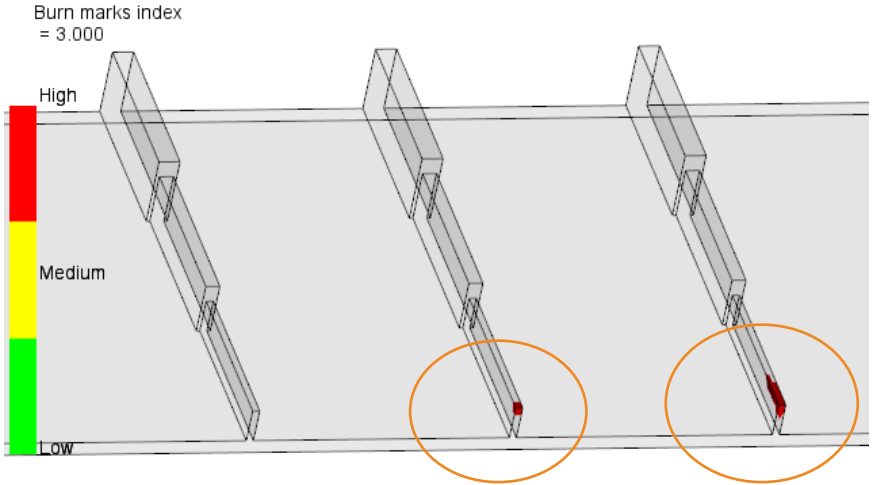
- Previous limits:
  - Without Mesh Aggregation: ~8 million
  - With Mesh Aggregation: ~ 16 million
- 3D Warp code now restructured to remove this memory limit
- Still limited by the memory on your computer



Burn mark prediction

Due to air compression and heating as part of an air-trap in a venting analysis

Not all air-traps will result in burn marks

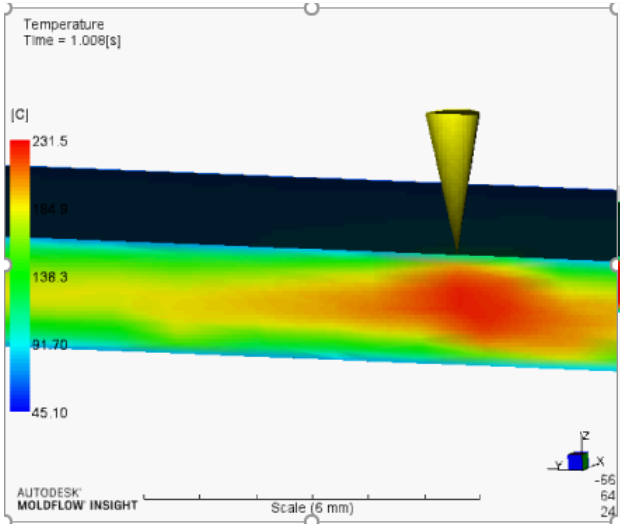


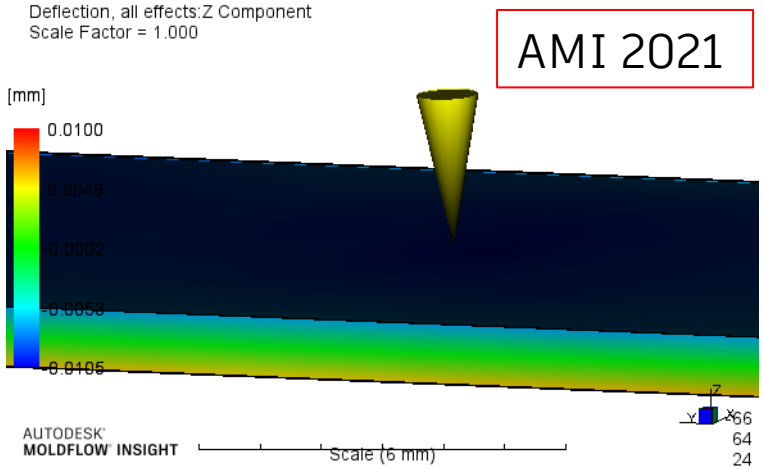
Visual warp deflection with mold opening

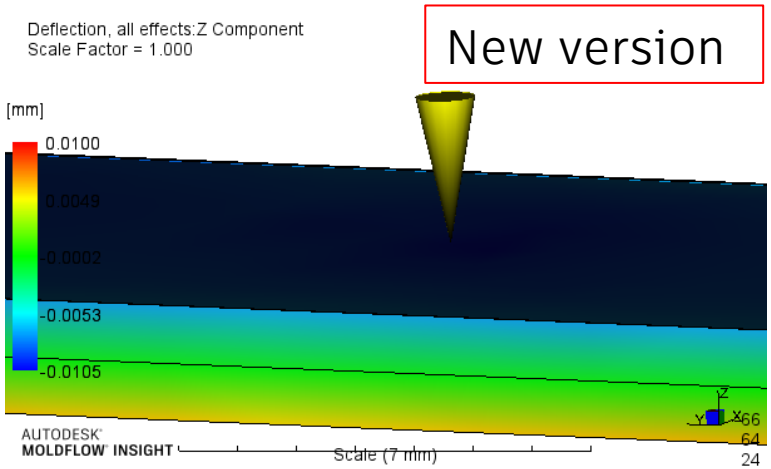
Microcellular Foaming with Core-back (mold opening)

Visualize the true part geometry

Warp deflection was previously displayed on the original geometry only



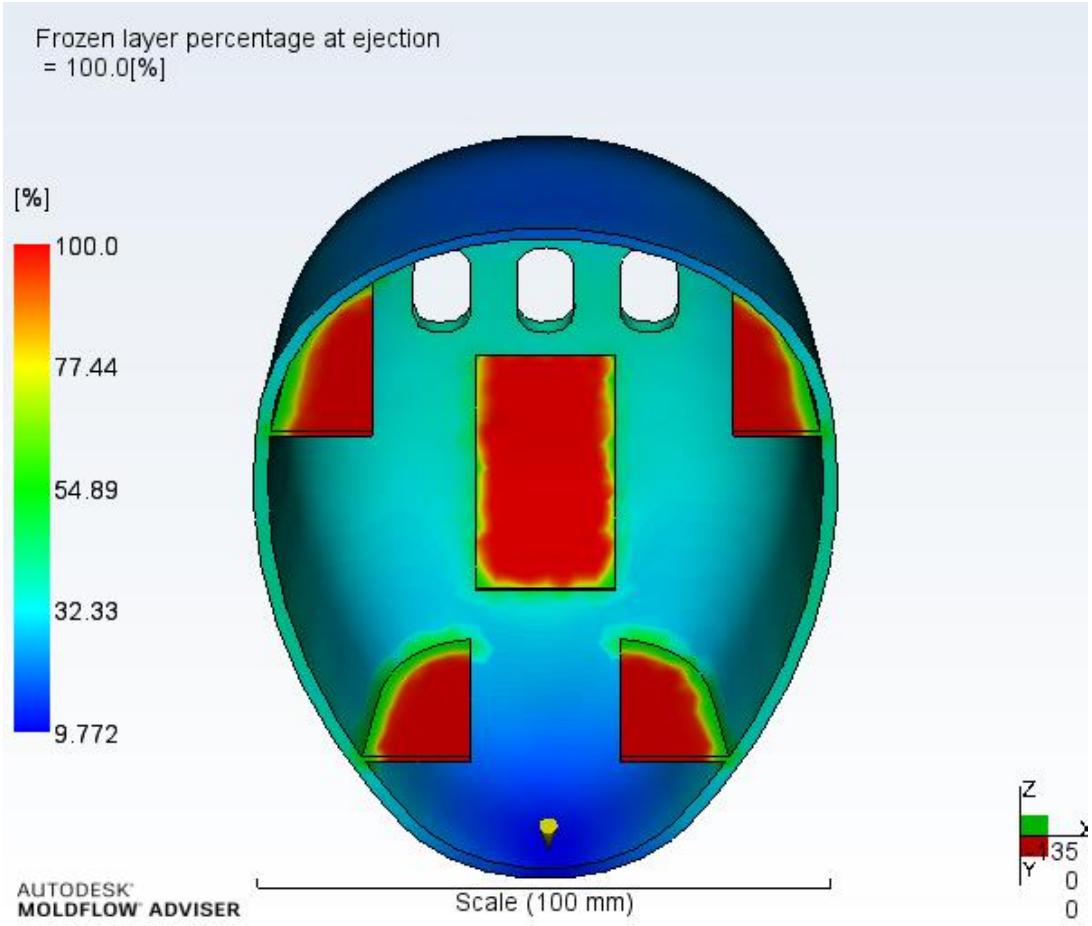




Frozen Layer at Ejection for Moldflow Adviser

Thinner sections freeze earlier

Frozen Layer result already available in Moldflow Insight/Synergy



Warp Accuracy Enhancements (in progress)

Corner effects

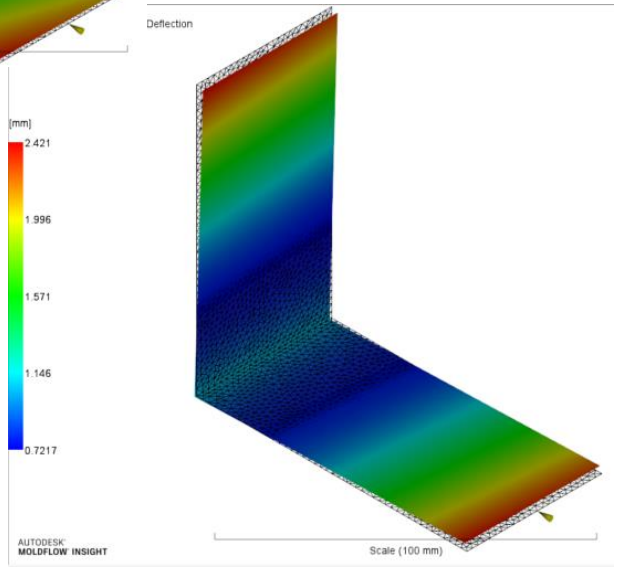
Midplane and Dual-domain warp

Improved handling of corner effect for anisotropic materials

- Includes when the anisotropy comes from CRIMS shrinkage measurement

AMI 2021
False twisting observed in the deflection result

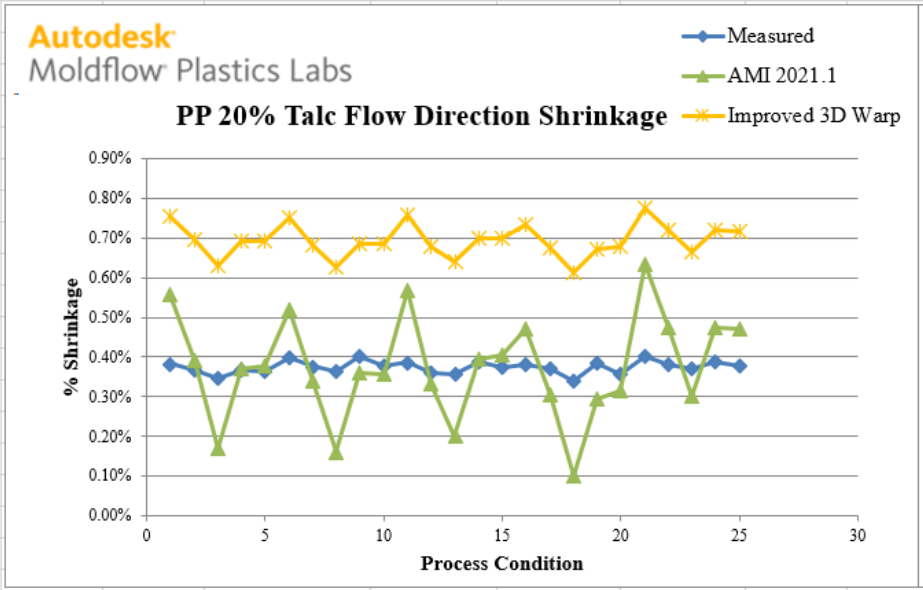
New result:
Deflection is symmetric (no twisting)

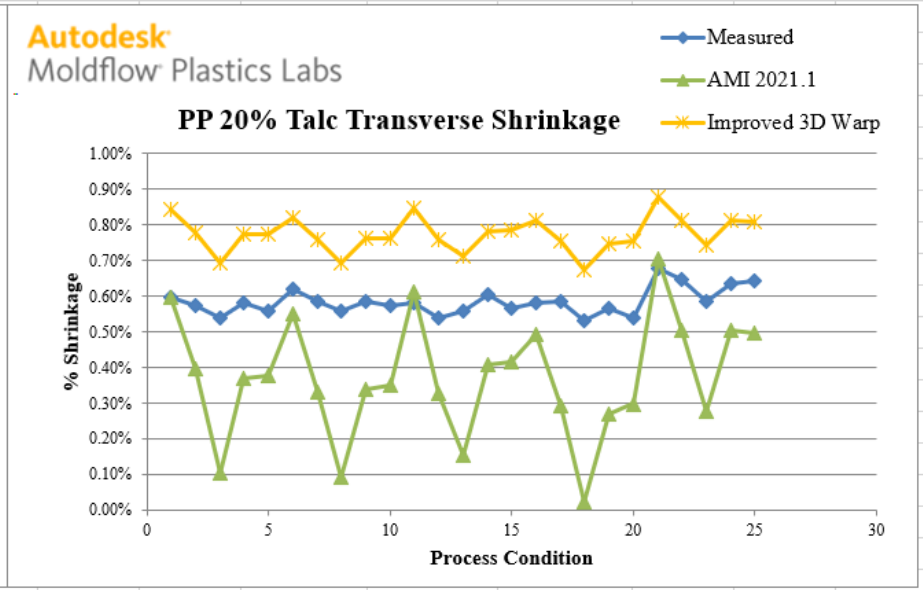


Improve 3D Warp for low stiffness polymers

Example: PP with Talc

- 3D Residual Stress Model in AMI 2021 is too sensitive to packing pressure variation
- Improve 3D Residual Stress model improves pressure sensitivity
  - This improvement does not rely on the use of measured Shrinkage Correction data

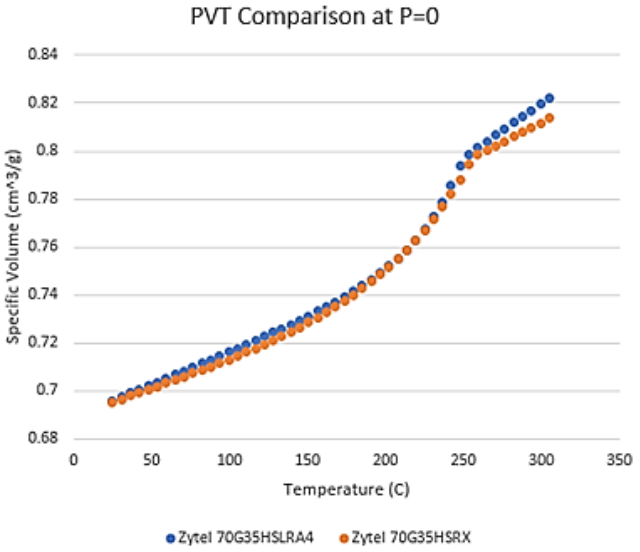




Other Warp investigations

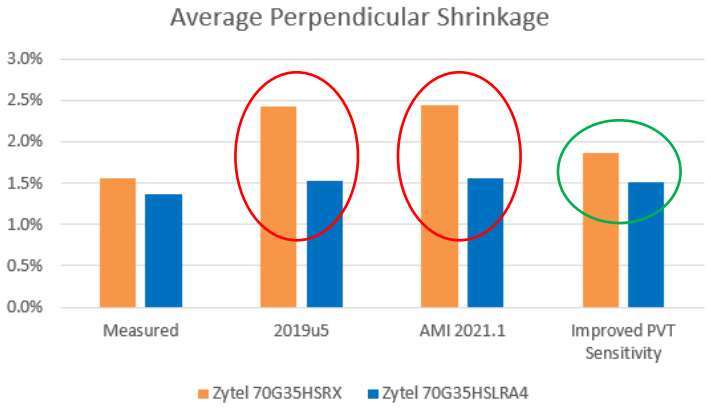
Sensitivity to PVT solid phase curvature:

- PVT magnitude very similar for 2 materials
- 3D Residual Stress Model results up to 25% difference



Some warp results (Midplane/DD/3D) are unsymmetric due to lack of convergence

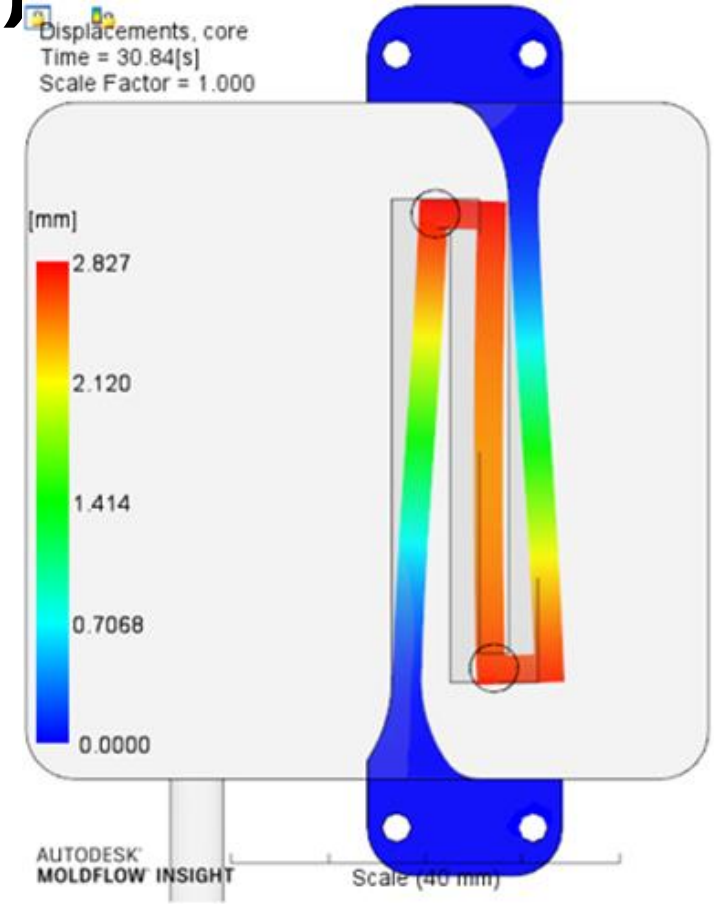
- Related to the selection of automatic constraints



Flow Accuracy Enhancements

Consider shear stress (drag) in Core-Shift

Previously only normal forces (pressure) were acting on the core



Other 3D Flow Solver Changes

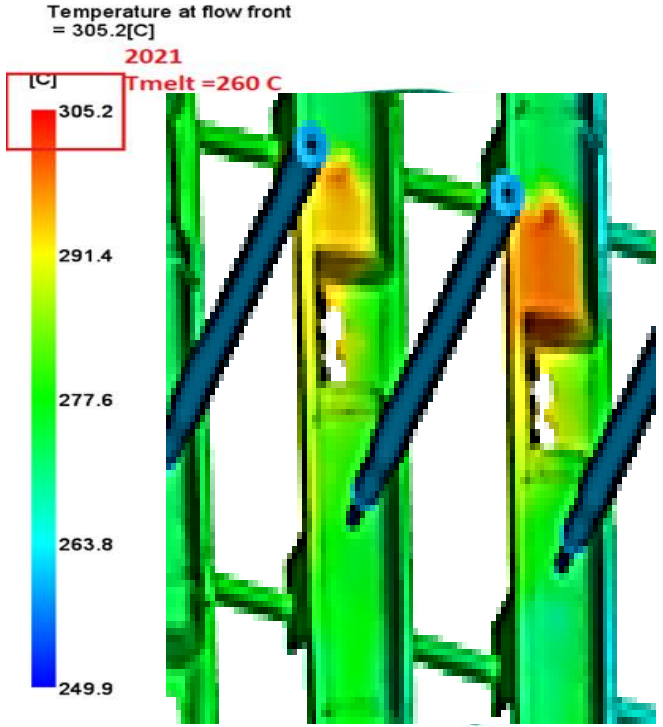
(In development)

Improved time-steps when valve-gates open

- Less spurious Flow Front Temperature hot-spots

Display actual surface temperature of polymer

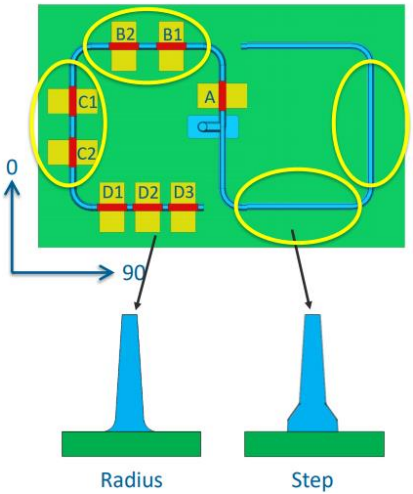
- Previously displayed the mold surface temperature on part surface



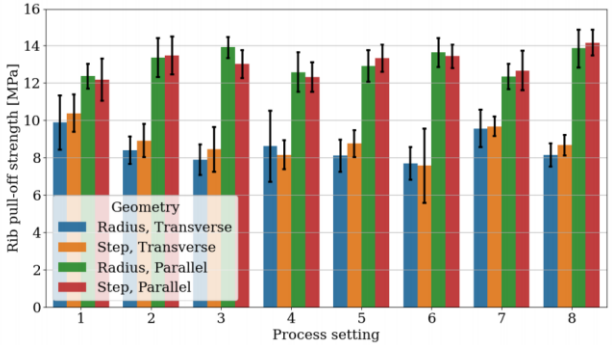
External Research Collaborations

Composites Overmolding

TPRC (Netherlands) + Aniform + Industry Partners



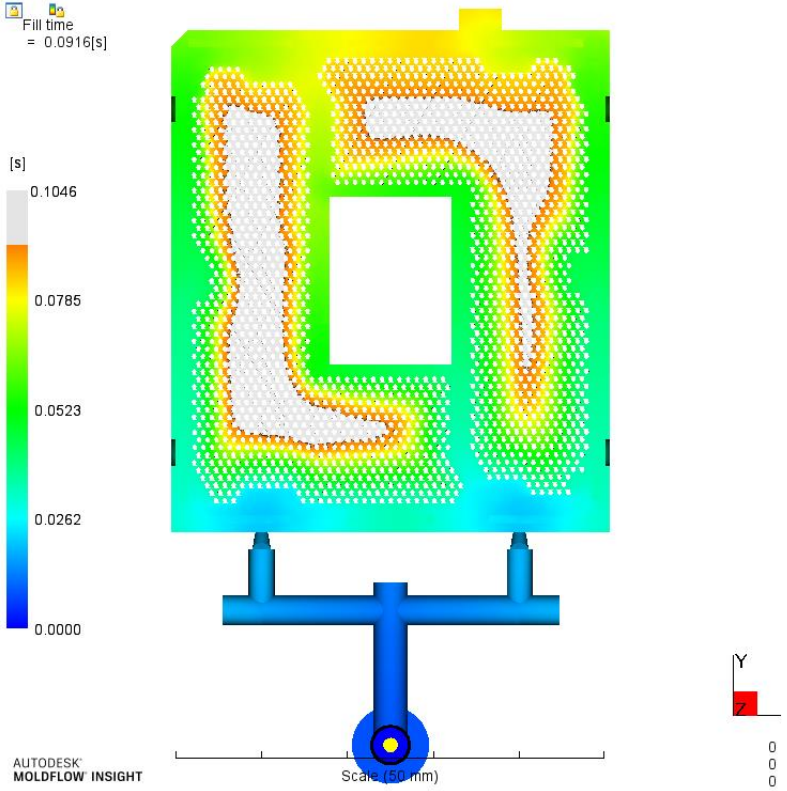
Gathering bond strength data for injection over-molding of continuous fiber composites



"Enlighten": New large scale publicly funded research project

LCP Socket Moldings

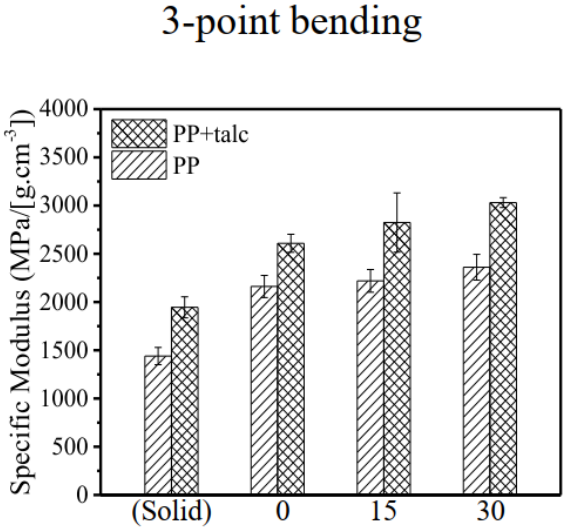
- Partnership with INEMI, Intel, Celanese, Foxconn, Lotes, ….
- Validating Flow and Warpage Predictions
- Developing a simplification approach for accelerated simulation



Microcellular Foaming

(University of Toronto)

- Visualizing Bubble Coalescence
- Implemented a LBM foaming + fiber analysis
- Relate properties to void fraction
  - (MO: mold-opening)

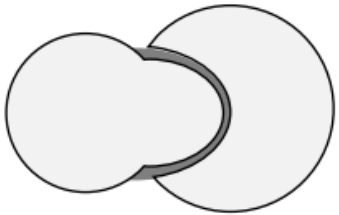


Images: University of Toronto

Microcellular Foaming

(University of Toronto)

Visualizing Bubble Coalescence



Mode 2: Differential bubble pressure
(Proussevitch, 1993b)

Video: University of Toronto

CONTENT

Moldflow 2021 Accuracy Improvement

- 3D Warp for Semi-Crystalline Materials

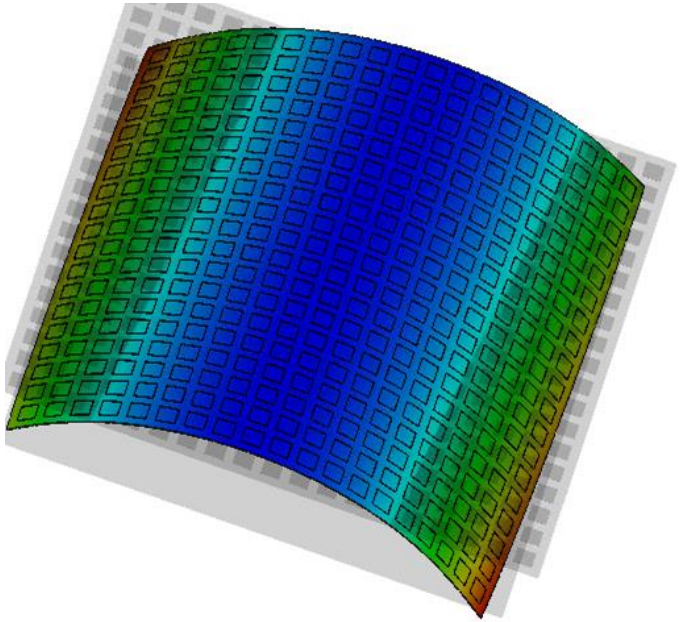
New Features and Capabilities

- Shrinkage Correction in 3D
- 3D Large Deflection analysis
- 3D Warp model size limit
- Additional Results

Accuracy Enhancements

- Warp & Flow Accuracy

External Research Collaborations



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