Moldex3D | Live Webinar

Moldex3D at Ethicon
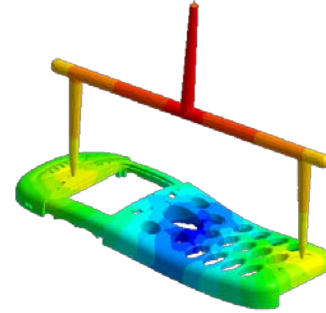
SRIKAR VALLURY
Engineering Manager

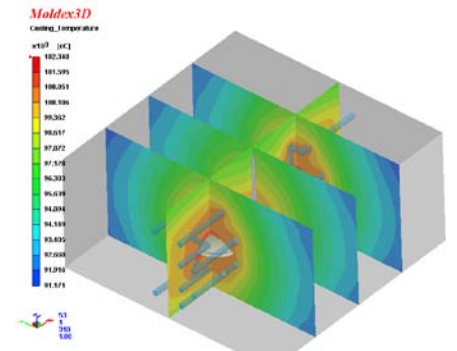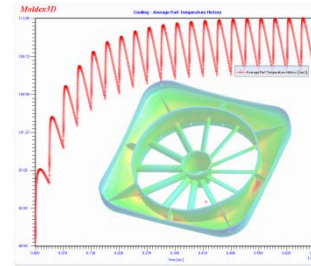**August 17th, 2022**

Why Injection Molding Simulation?

> ## Aesthetics and Dimensional Concerns

  – **Weld line, air trap, flow mark**

  – **Flow balance and part weight**

  – **Shrinkage and warpage control**
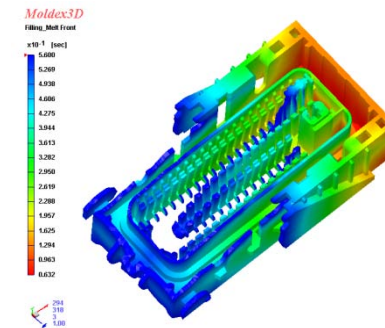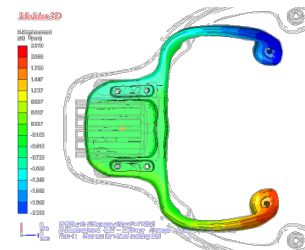
  – **Fiber orientation prediction**

> ## To Help You Be More Competitive

  – **Cycle time reduction**

  – **Improve overall quality**

  – **Reduce mold trial & tooling cost**

  – **Optimize material selection**

> ## Smarter Manufacturing

  – **Process optimization before mfg**

  – **Clamping force reduction**

  – **Efficient machine utilization**

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Why Injection Molding Simulations?

> Common Issues in medical components

> > Dimensions

> > Inability to fill

> > Pressures

Software	Development Weakness
• Product Design • Mold Development • Production Issues	• Molding Defects • Warpage • Structure Analysis

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Inputs Needed for Successful Simulations

> **CAD**

> > **Part CAD, Tool CAD**

> **Material**

> > **Viscosity, PVT, Thermal Properties, Mechanical Properties**

> **Process**

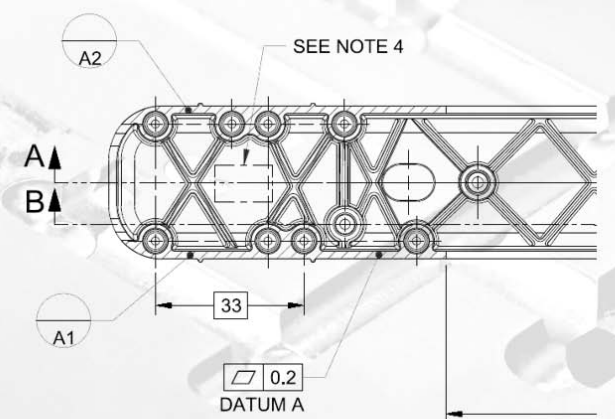> > **Times, Temperatures, Pressures, V/P Transfer Point etc.**

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Material Data

> **Material**

> > **Thermoplastics (PP, PA6/6…)**

> > **Thermosets (LSR…)**
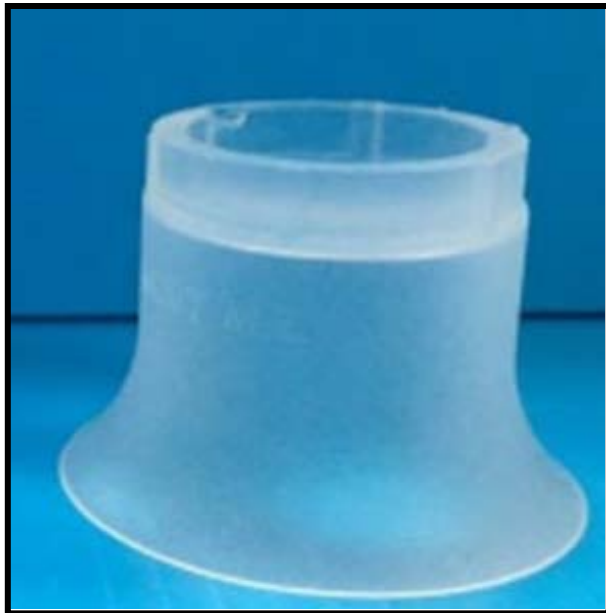
Introduction to Medical Bracket

Rev 04.25.2019

- **Material** = Ultramid A3WG6 (30% glass filled PA6/6)
  - Semi-crystalline material (impacts warpage)

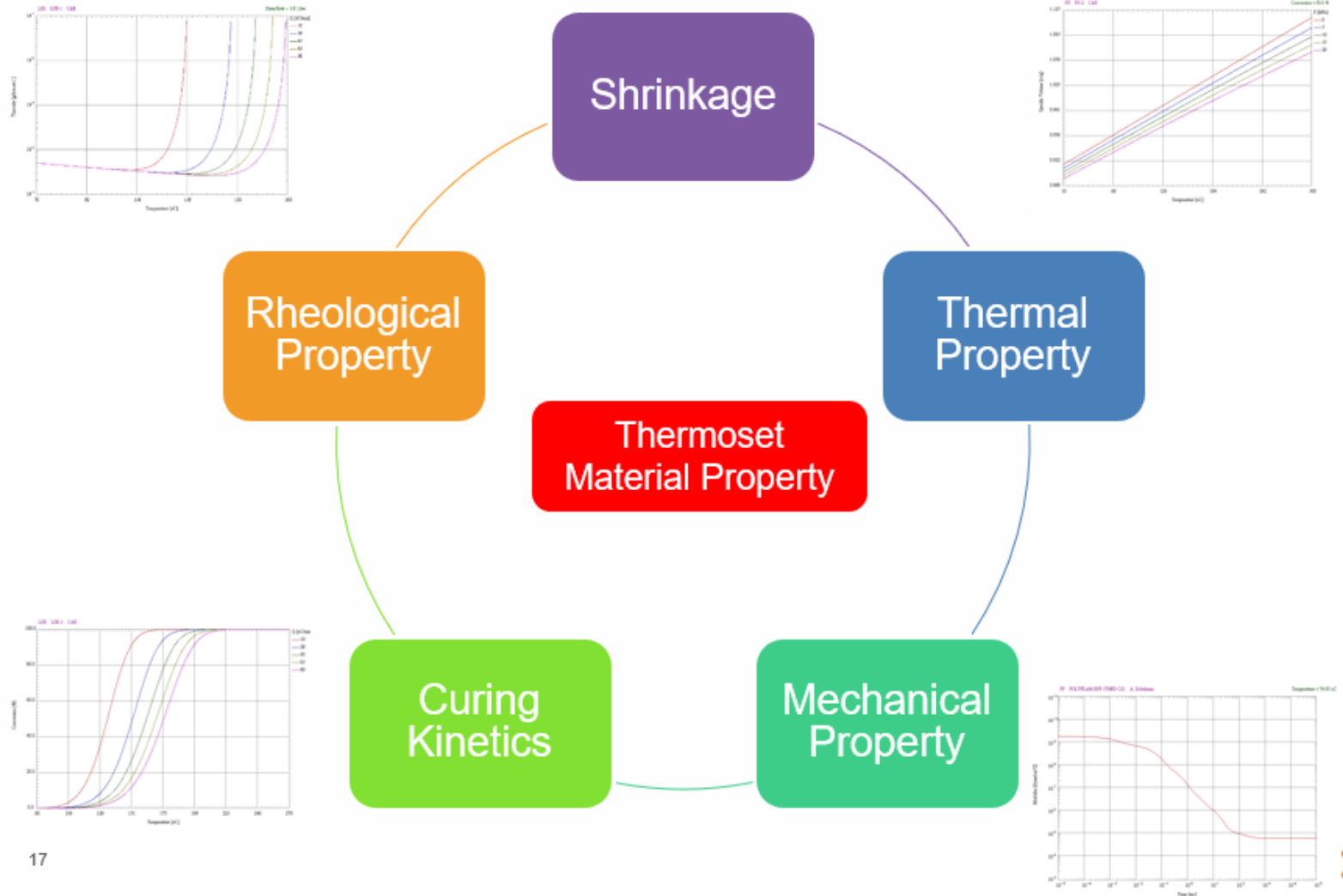- **Flatness Spec** = 0.2mm (.008") – Datum A

A2

SEE NOTE 4

A

B
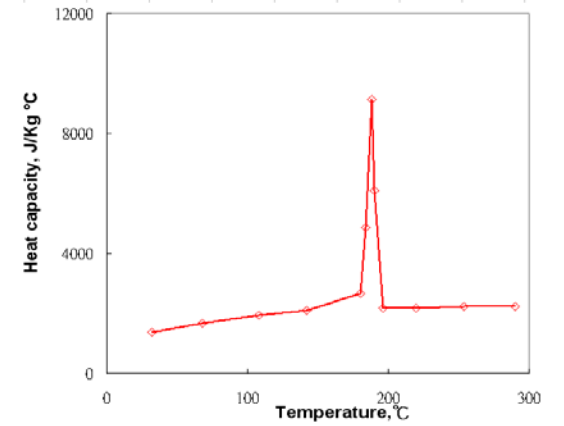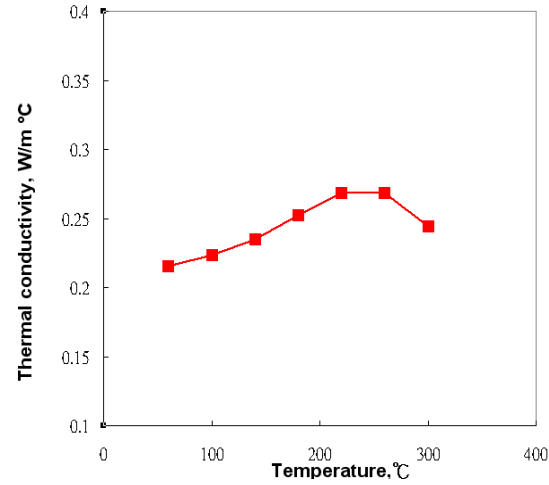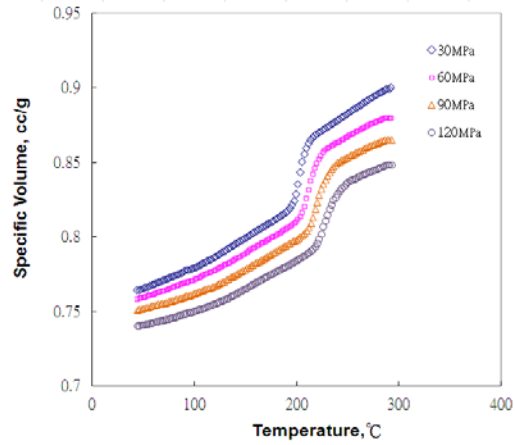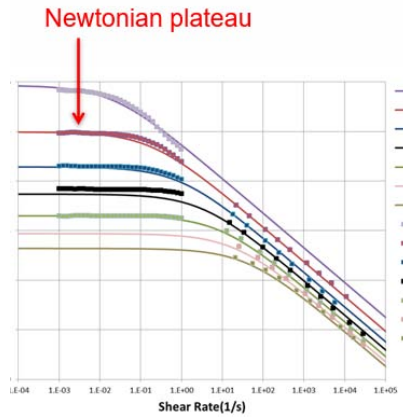
33

A1

0.2

DATUM A

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Thermosets

Thermoset Material Properties

Thermoplastics

Newtonian plateau
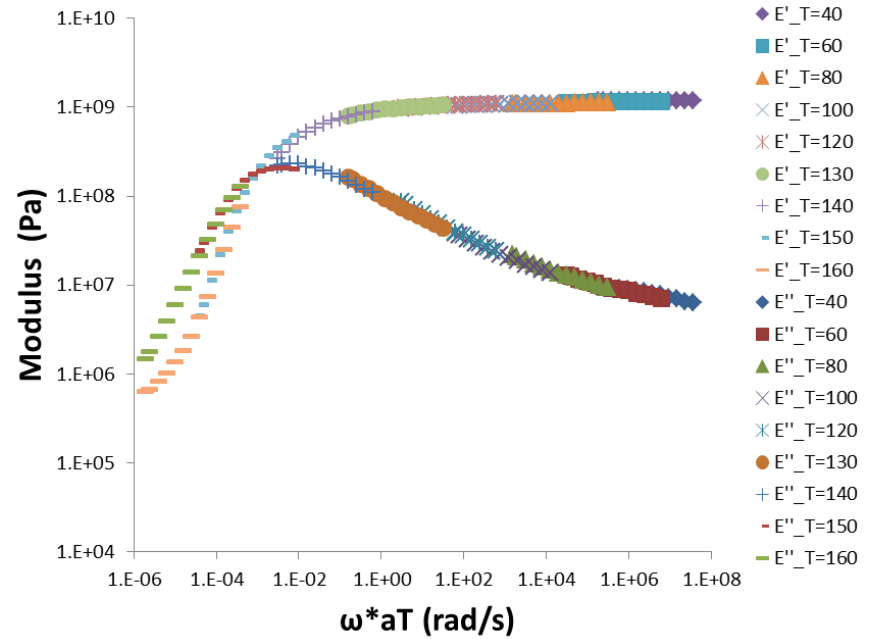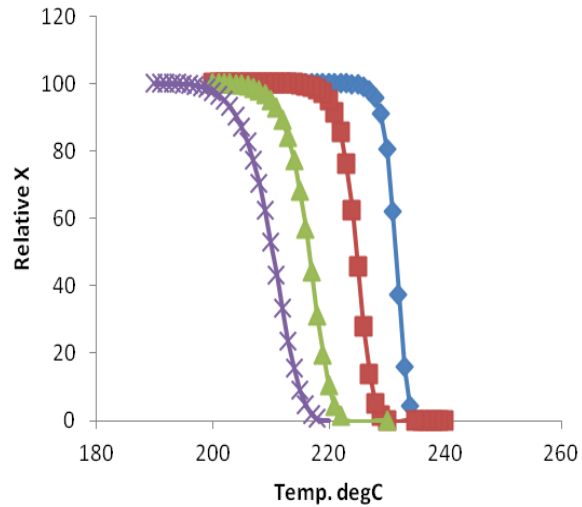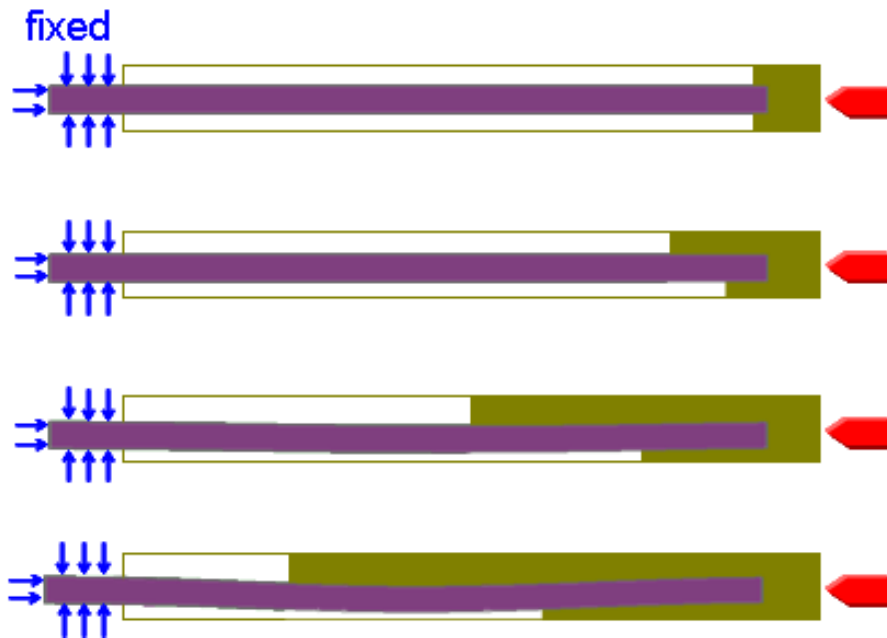
Core Shift Prediction

- Uses two-way Fluid-Structural Interaction (FSI) Analysis
- Simulate plastic or metal inserts
- Shows deflection due to pressure imbalance in filling
- Provide pressure loading distribution on part (or mold insert)

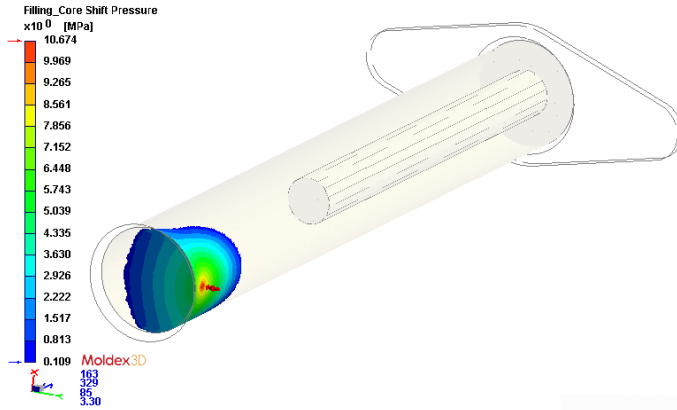**FSI (Fluid-Structure Interaction)**

Filling analysis: **Interaction**   Structural analysis:

Pressure loading   mesh deformation   Core deflection

Inject Plastic
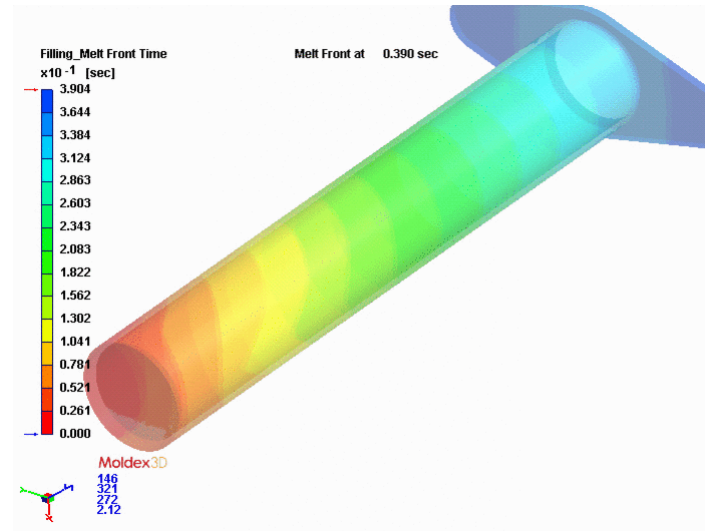
Filling_Melt Front Time   Melt Front at   1.056 sec

Part Insert or Mold Insert

Medical Application: Syringe

Pressure Loading History

Core deflection during filling stage

Core Shift

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Medical Application: Syringe

Pressure Loading History

Core deflection during filling stage
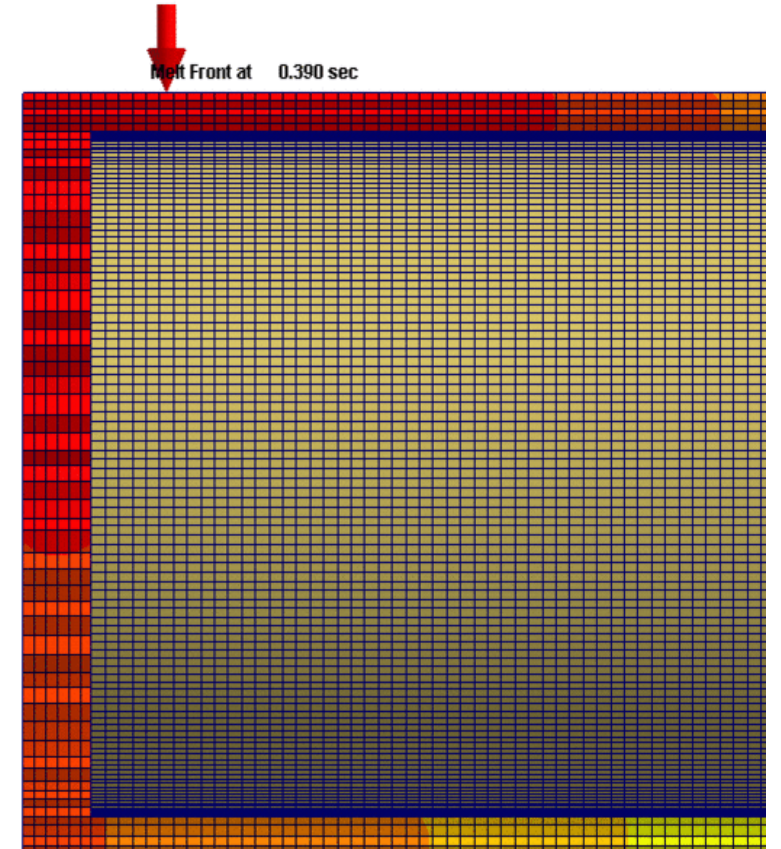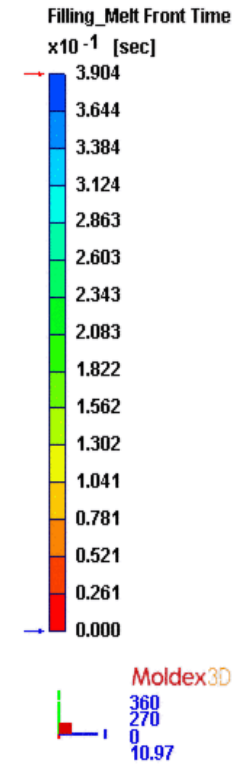
Core Shift
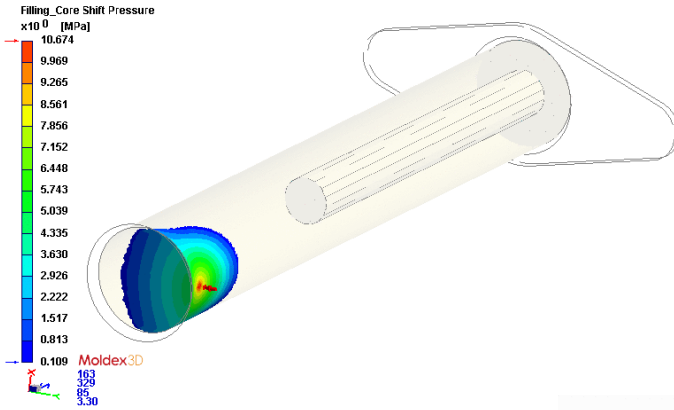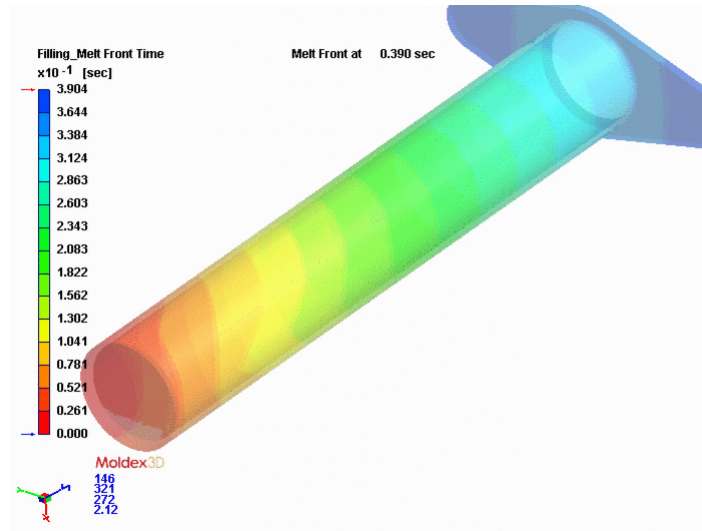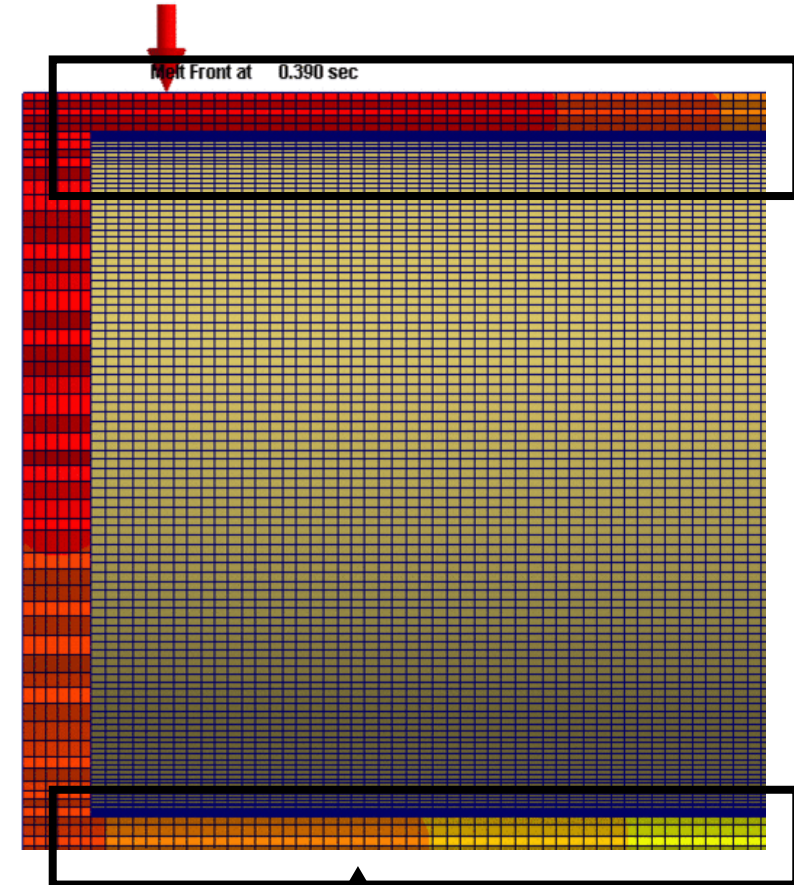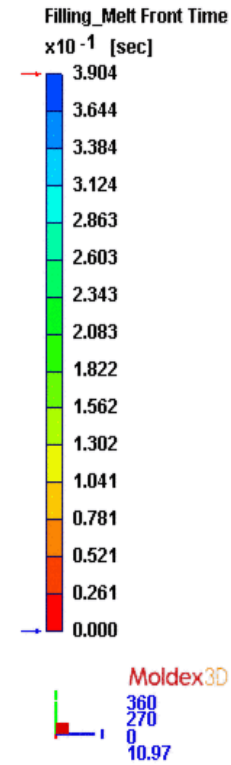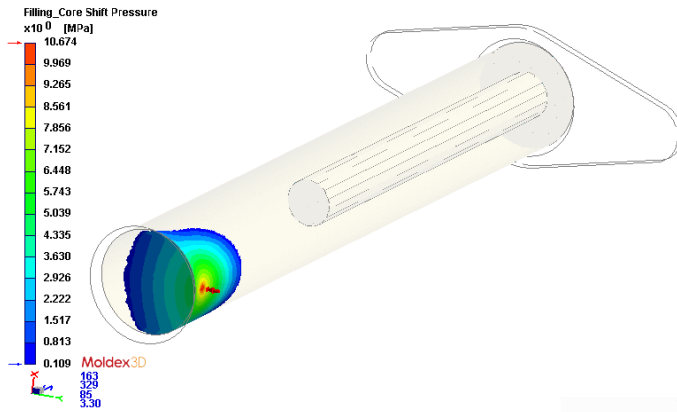
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Medical Application: Syringe

Pressure Loading History

Core deflection during filling stage

Core Shift

Filling_Melt Front Time
x10⁻¹ [sec]

Melt Front at 0.390 sec

Core Shift

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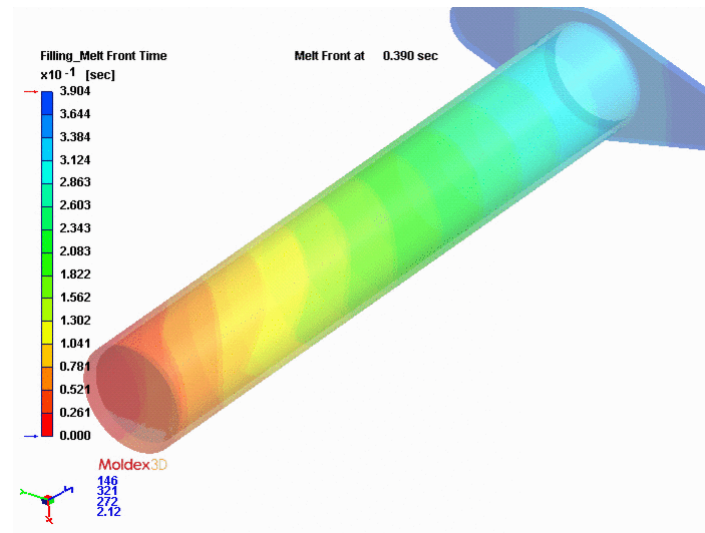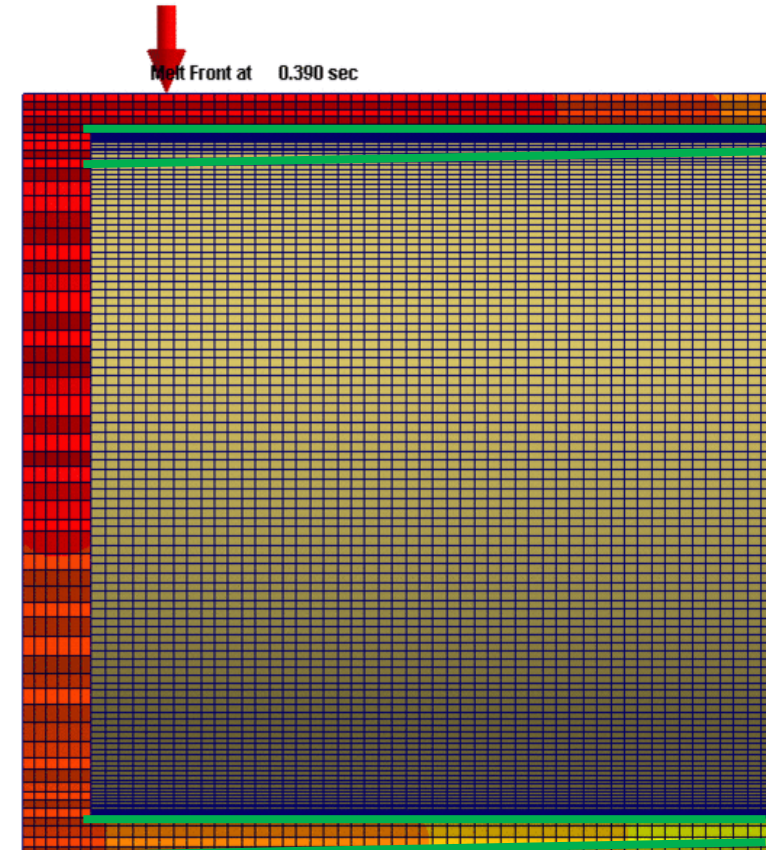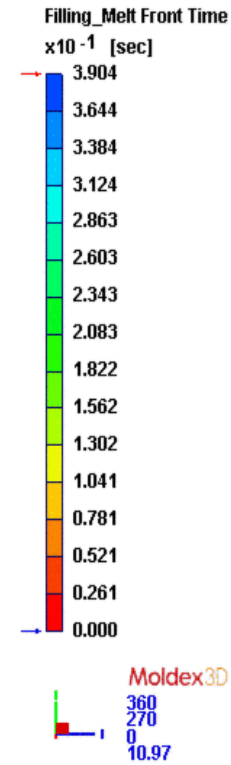
Core Shift Prediction Benefits

- Optimize Wall Thickness / Reduce Variability

- Material Savings

- Cycle Time Savings

- Optimized Flow

- Select Mold Materials (Inserts)

- Establish Wider Processing Window

- Final Part Shape Prediction

Filling_Core Shift Total Displacement
x10^0 [mm]

1.001	
0.934	
0.868	
0.801	
0.734	
0.667	
0.601	
0.534	
0.467	
0.400	
0.334	
0.267	
0.200	
0.133	
0.067	
0.000	
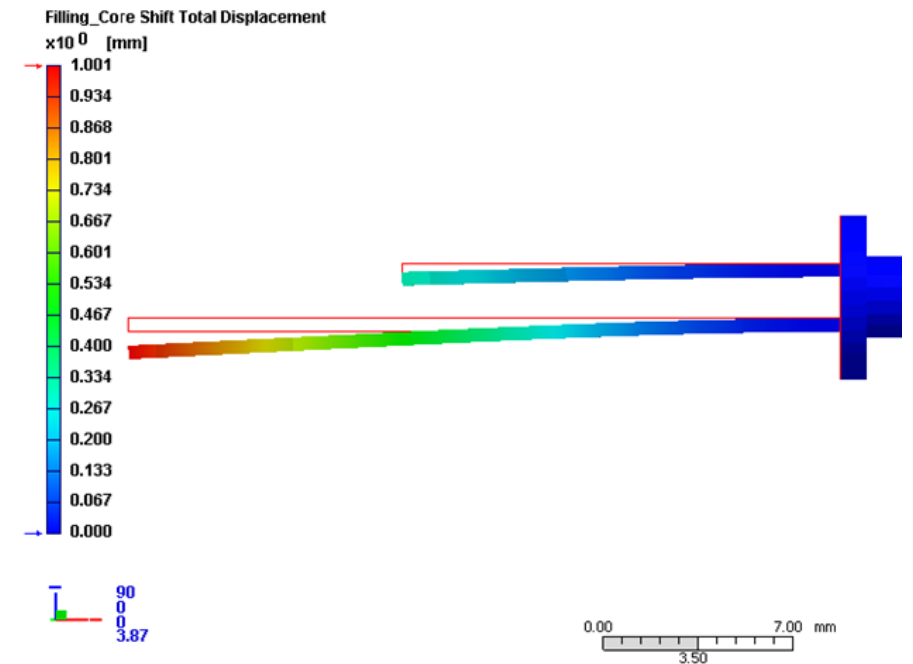
Controlling the Quality of LSR Molded Part

- The quality of LSR molded part depends on so many factors, the original part design, material properties and molding conditions, and so on.

LSR Material

- Metering / Mixing
- Heat is Catalyst
- Temperature Sensitive
- Low Viscosity
- Curing Properties
- Quality of Mixture

  Liquid A % / Liquid B %

+

Mold Design

- High Mold Temp
- Heater Cartridges
- Coolant Design
- Low Runner Temp
- Precision Components
- Vacuum Needed
- Venting is Important

+

Injection Molding Conditions

- Barrel Kept Cooler
- Injection Speed
- Injection Pressure
- V/P Point
- Packing Pressure
- Packing Time
- Curing Time

→

Final Part Quality

- Part Dimension
- Physical Property
- Chemical Property
- Optical

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Case Study

- Part description: Lens

- Mold dimension: 200 x 120 x 200 mm (L x W x H)

- Mold type: 3-Plate Mold (with a single melt entrance)

- Melt entrance：φ2 mm

- Heat rod：φ13.5 mm
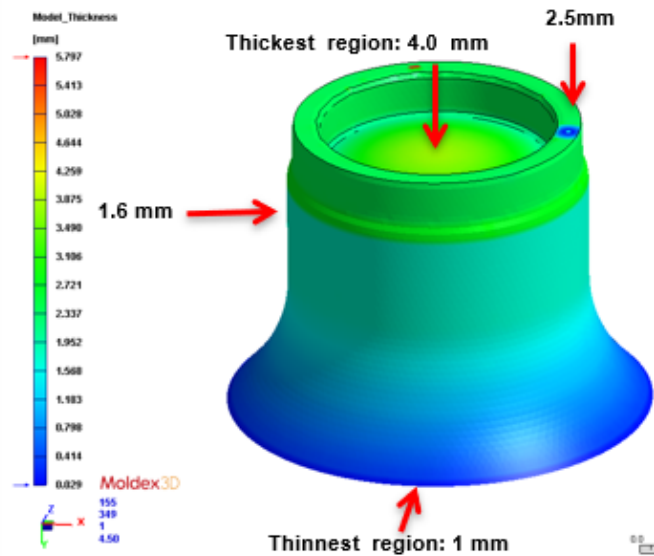
Model_Shaded Model

- Part-1:LSR(Wacker Chemie AG Lumisil 7600/60_M)
- Cold Runner:LSR(Wacker Chemie AG Lumisil 7600/60_M)
- Mold Metal Material [MoldBase]:P20
- Mold-Clamping Unit
- Heating Rod-1:By Temperature

Model_Thickness
[mm]

Thickest region: 4.0 mm

2.5mm

1.6 mm

Thinnest region: 1 mm
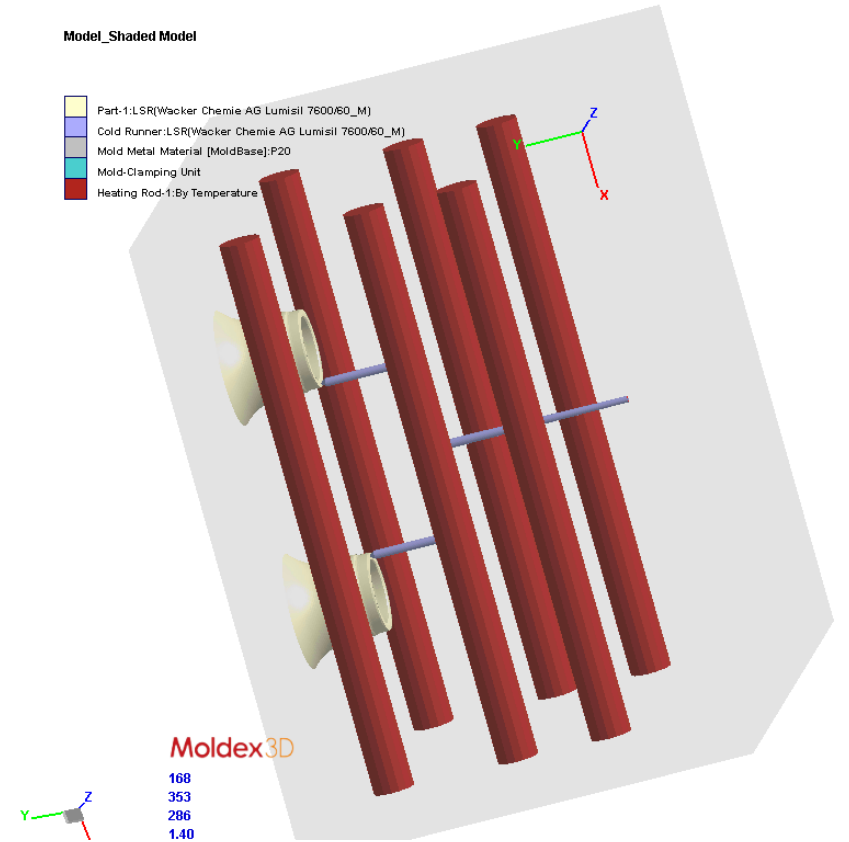
Melt Temperature: 30°C
Mold Temperature 175°C
Initial Conversion: 5%

Gating Design / Concerns

- Gate is designed to have minimal vestige and easy de-gating to avoid damage to the part.
  - ➢ However, this may result in severe shear heating and premature curing before LSR goes into cavity

Gate: φ 0.5 mm

Part
Cold runner
Melt entrance face

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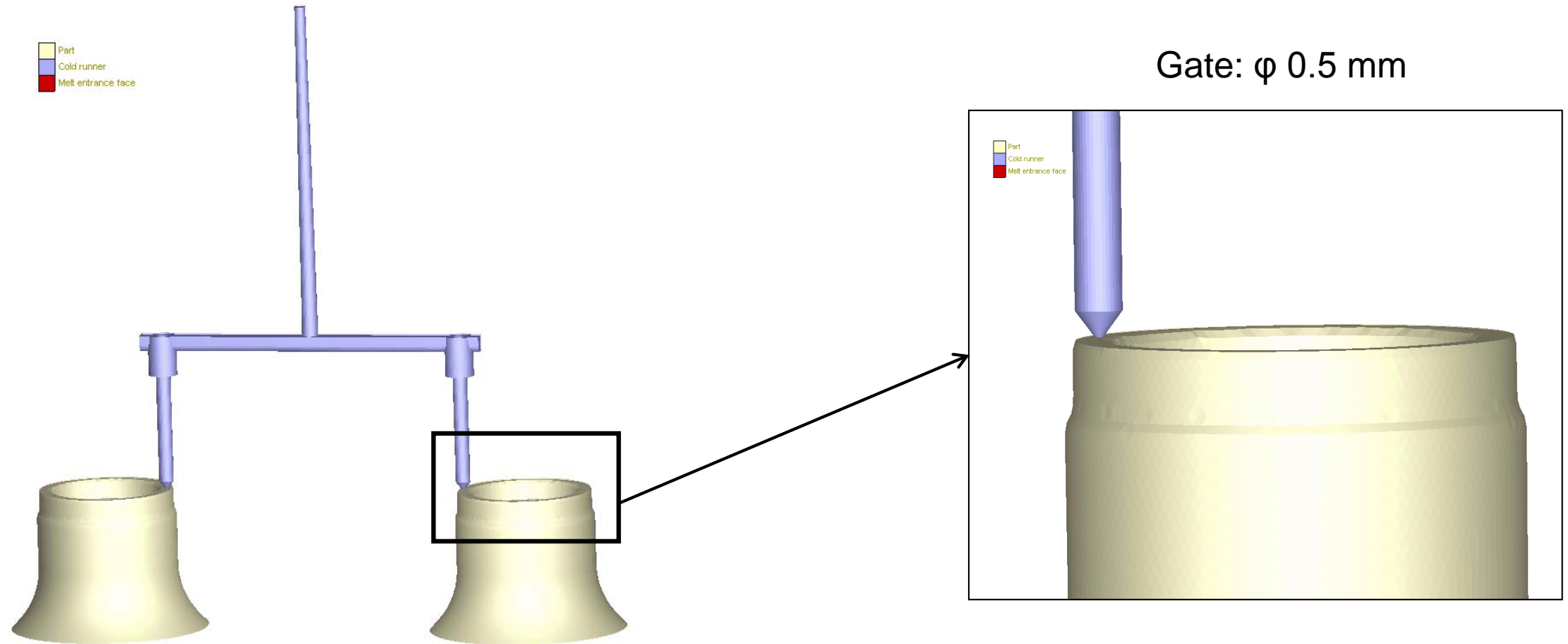
Filling - Melt Front Time

- Melt front advancement through the mold cavity during filling
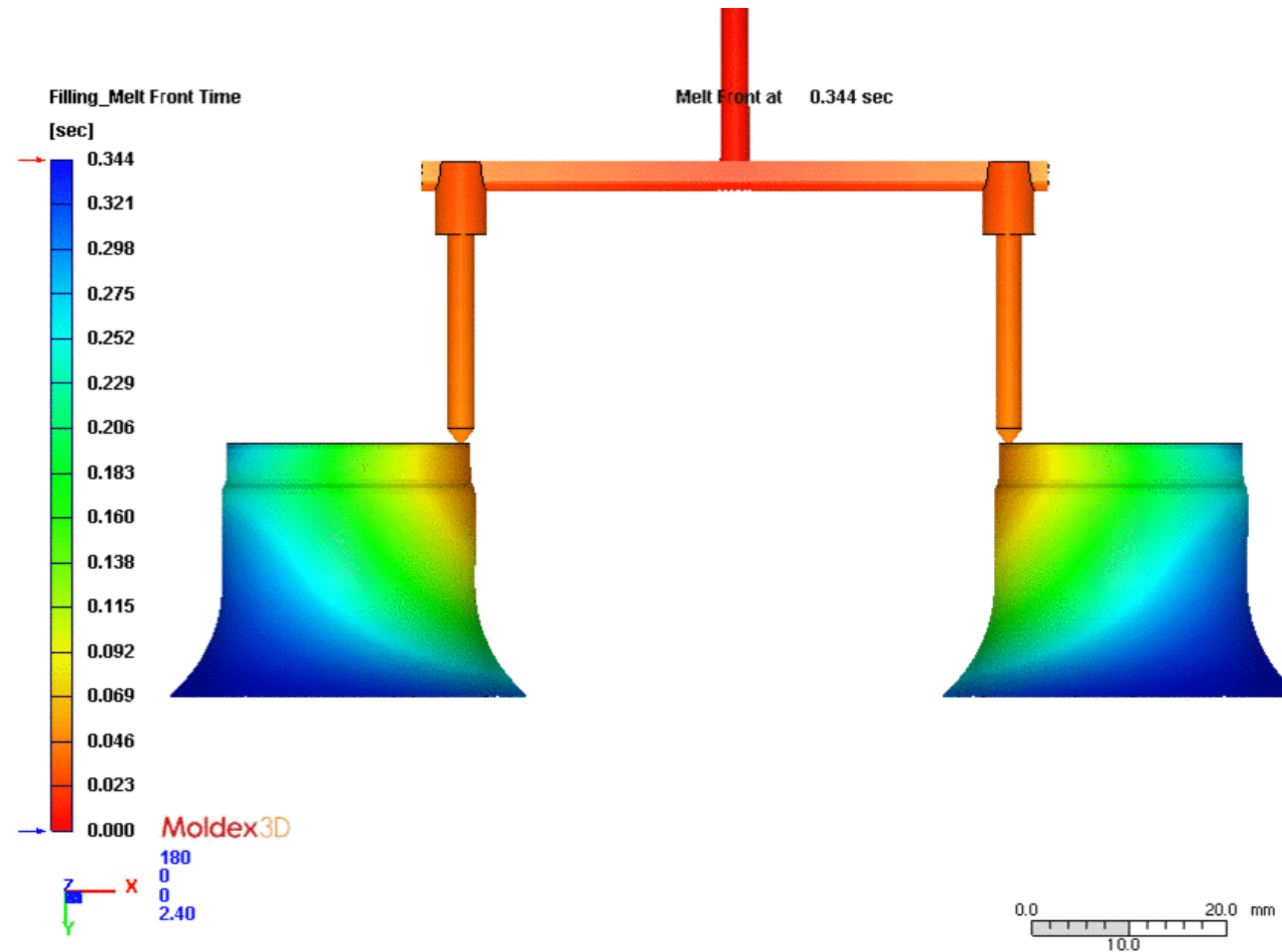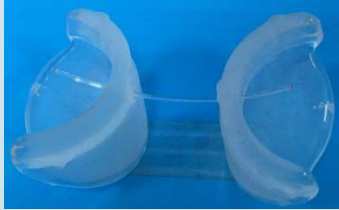
Filling Pattern Evaluation
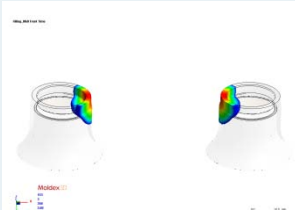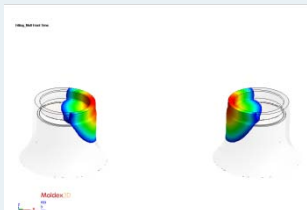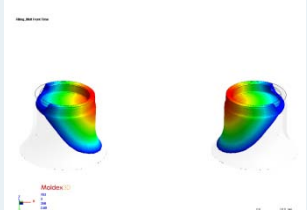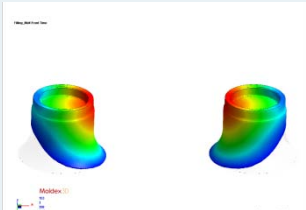
- From the melt front advancement simulation, one can identify potential problems during the injection molding filling phase such as

Short shot   #   Weld lines   #   Air Traps

| % Fill	20 %	40 %	70 %	90 %
Actual Short Shot				
Simulation				

Filling Pattern Evaluation

- Melt front is flowing faster in the thickest center region, which could create a potential void at the last filled area

- Flow pattern may be improved to be uniform by changing the thickness around the region near the gate so as to slow down the melt enter the thickest center region

Thickest region: 4.0 mm
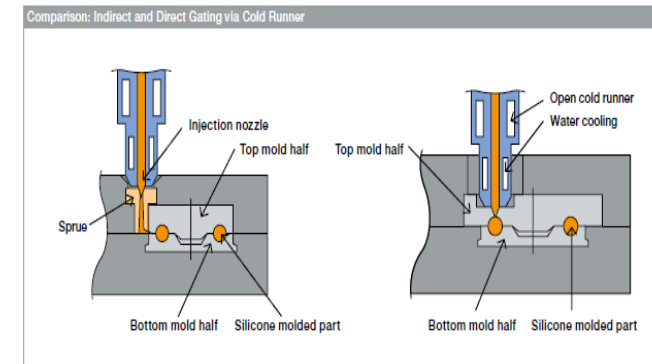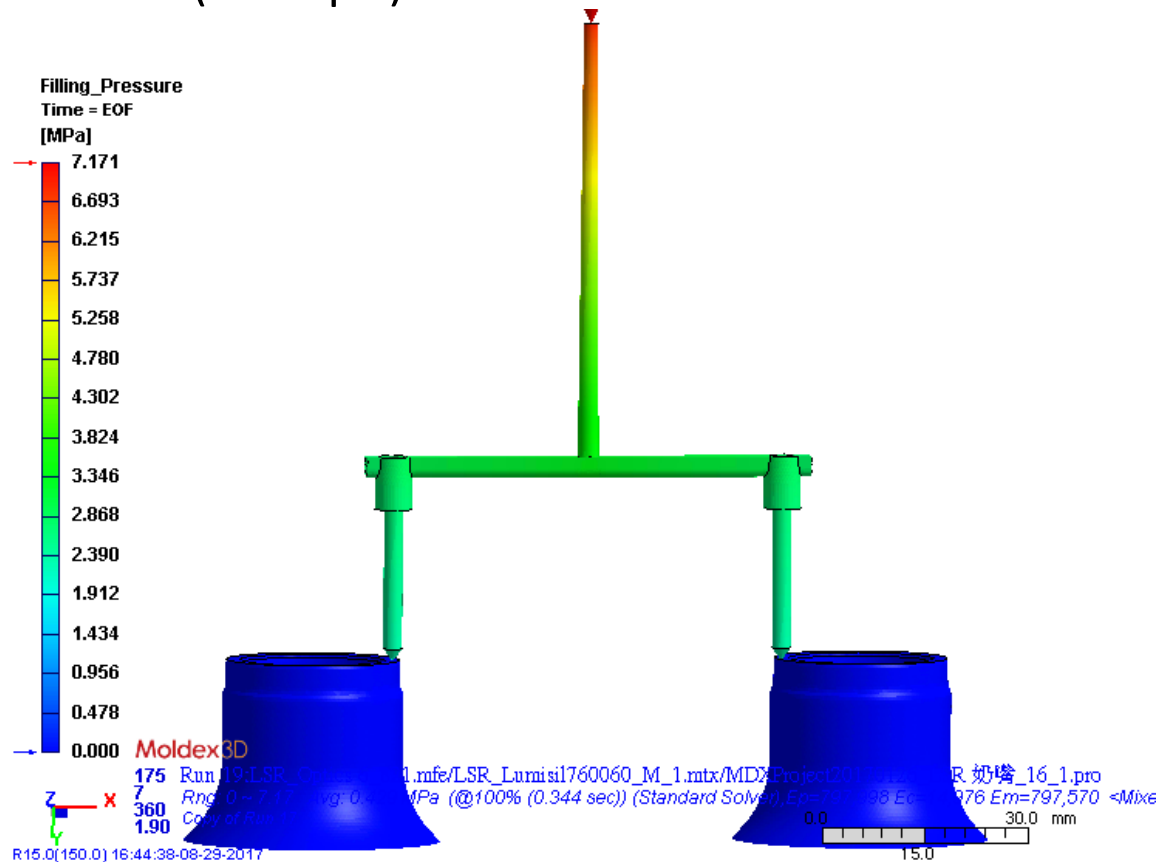2.5mm
1.6 mm
Thinnest region: 1 mm

40 %   70 %
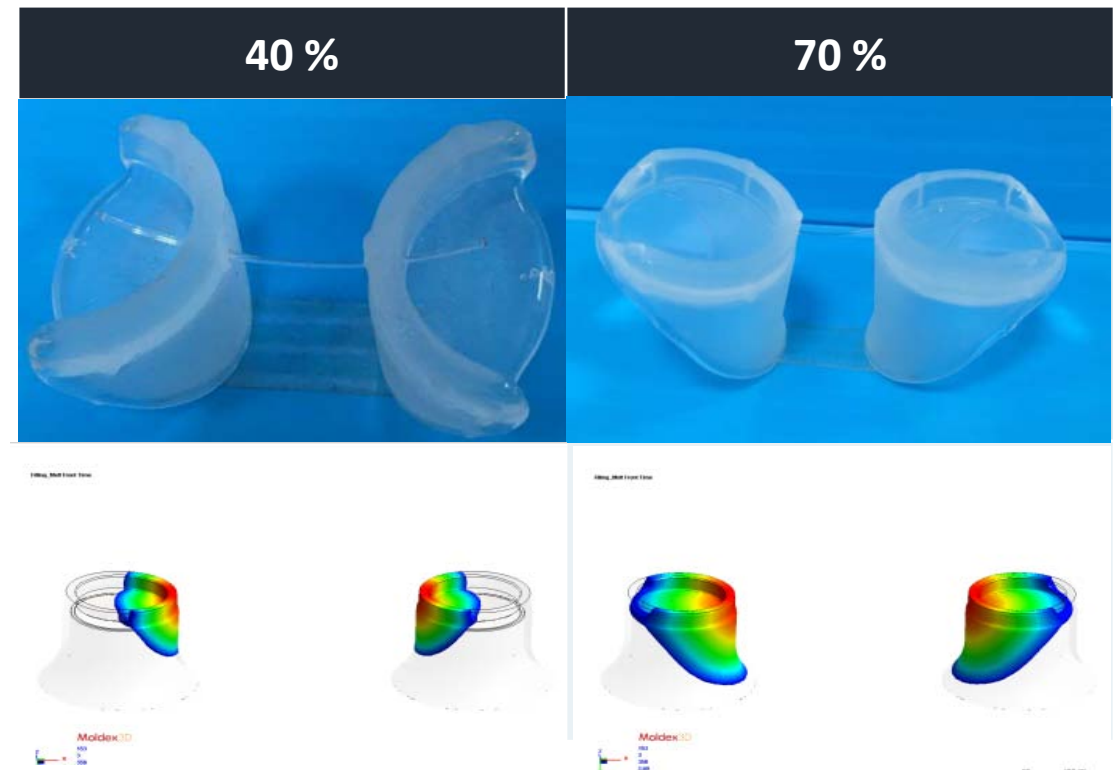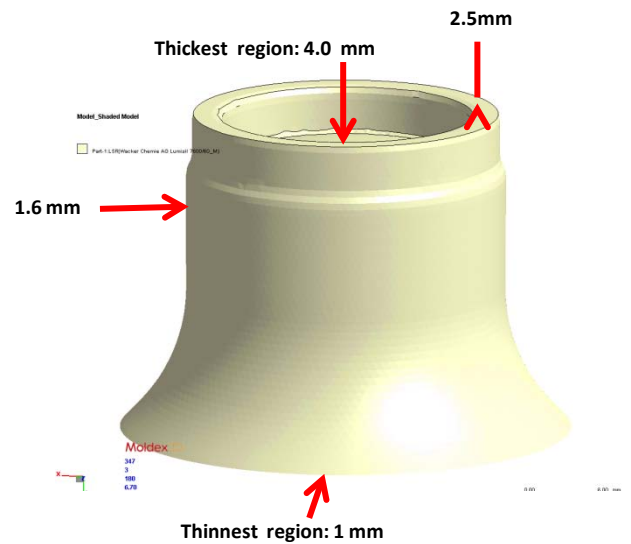
Air trap

- Normally happens at the last fill regions

- Needs to pay particular attention to venting near these regions because LSR has a very low viscosity relative to other polymers


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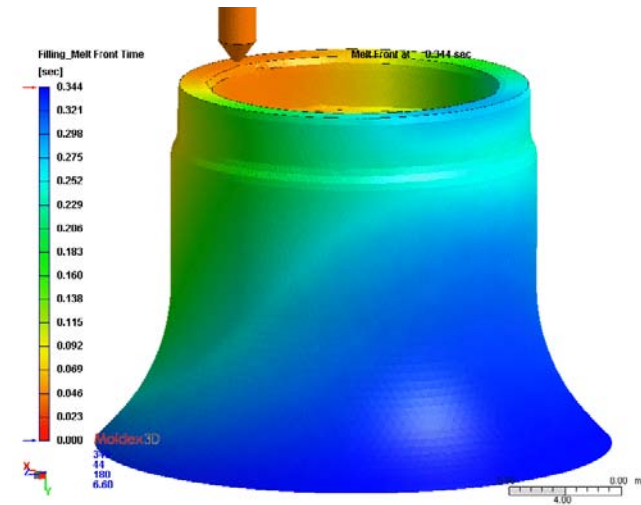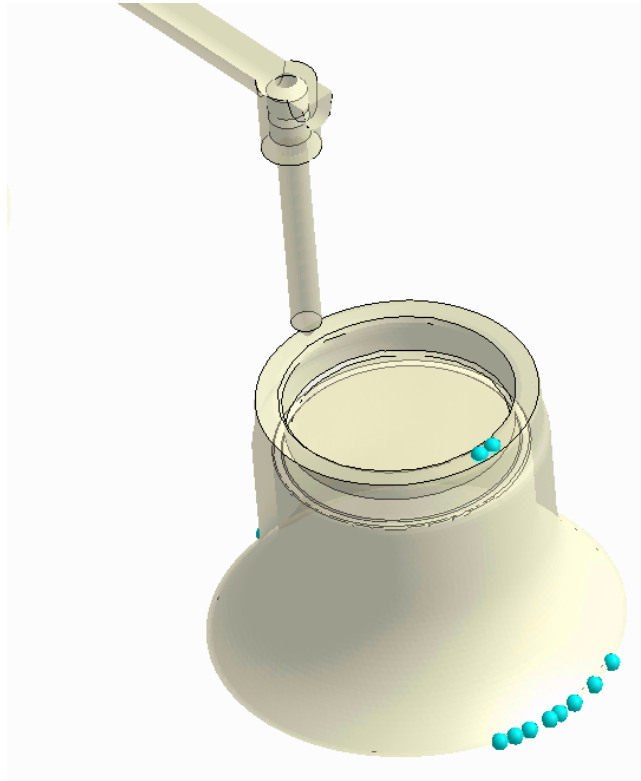
Filling Pressure

- Based on the pressure drop and distribution, engineers can revise the part and mold design.

- Due to the low viscosity of LSR, the filling pressure is usually quite low, normally below 20 MPa (3000 psi).

Filling_Pressure
Time = EOF
[MPa]

7.171
6.693
6.215
5.737
5.258
4.780
4.302
3.824
3.346
2.868
2.390
1.912
1.434
0.956
0.478
0.000

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Comparison: Indirect and Direct Gating via Cold Runner

Open cold runner
Water cooling
Injection nozzle
Top mold half
Sprue
Bottom mold half   Silicone molded part
Bottom mold half   Silicone molded part

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Thermal Mold Evaluation

- Temperature distribution at the mold heating equilibrating stage.

- Helps to visualize the thermal distribution around the part and in the entire mold

- Mold temperature is uniform. Current heater location design is acceptable.
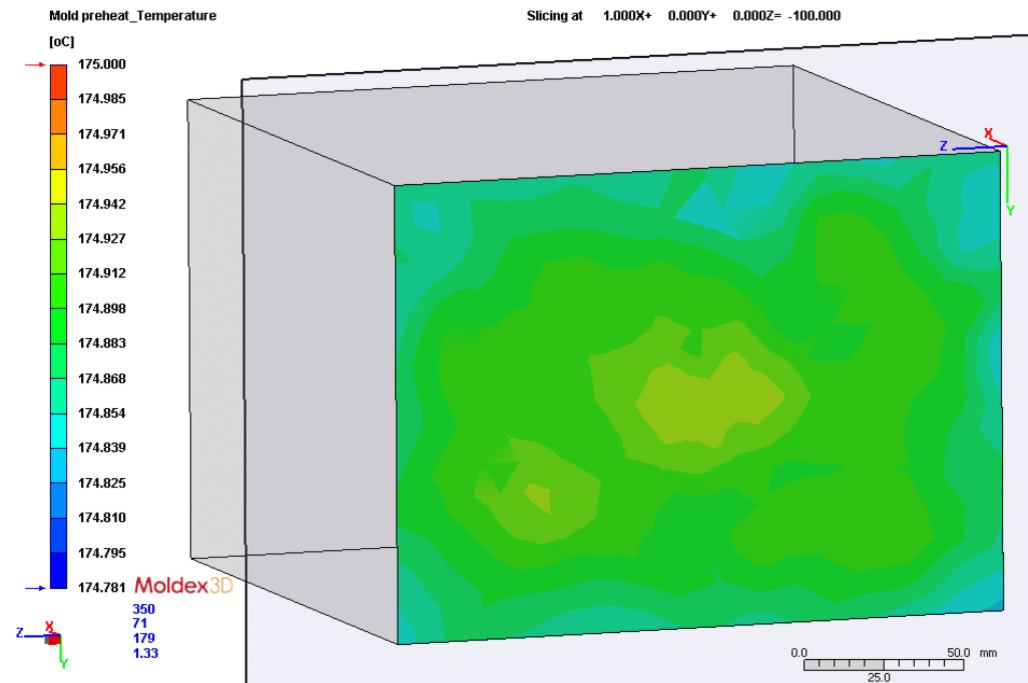
Melt Front Temperature During Filling

- During filling the temperature evolution is observed.
  - Temperature has a profound effect on filling resistance
  - Based on the temperature information, heating rods placement and settings can be adjusted.

| Beginning of Fill	Towards End of Fill

175 ºC

30 ºC

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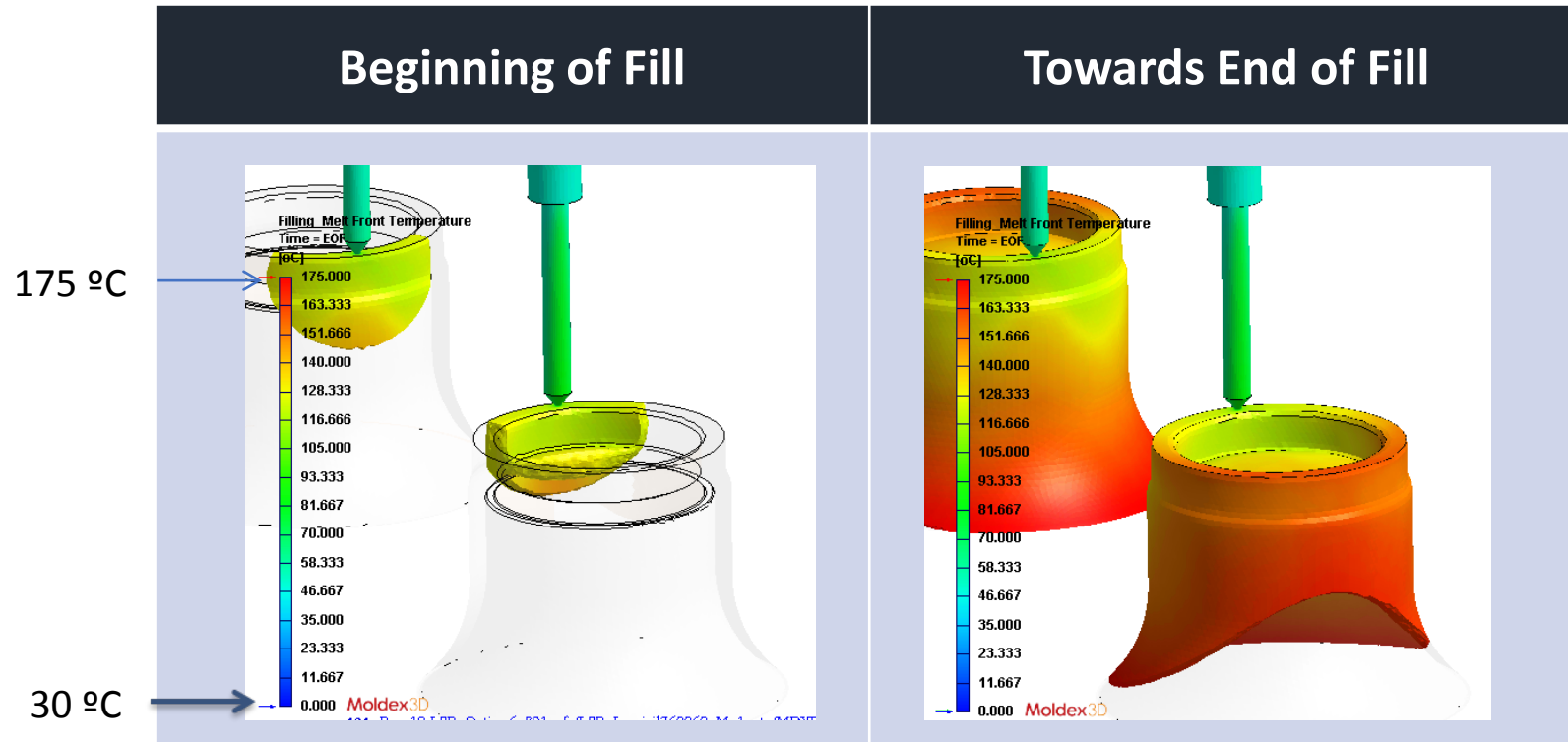
Nozzle Temperature Causes Pre-Curing

- Insulation between hot mold and nozzle tip is not working effectively
- When temperature is too high, it initiates curing reaction inside the cold runner nozzle
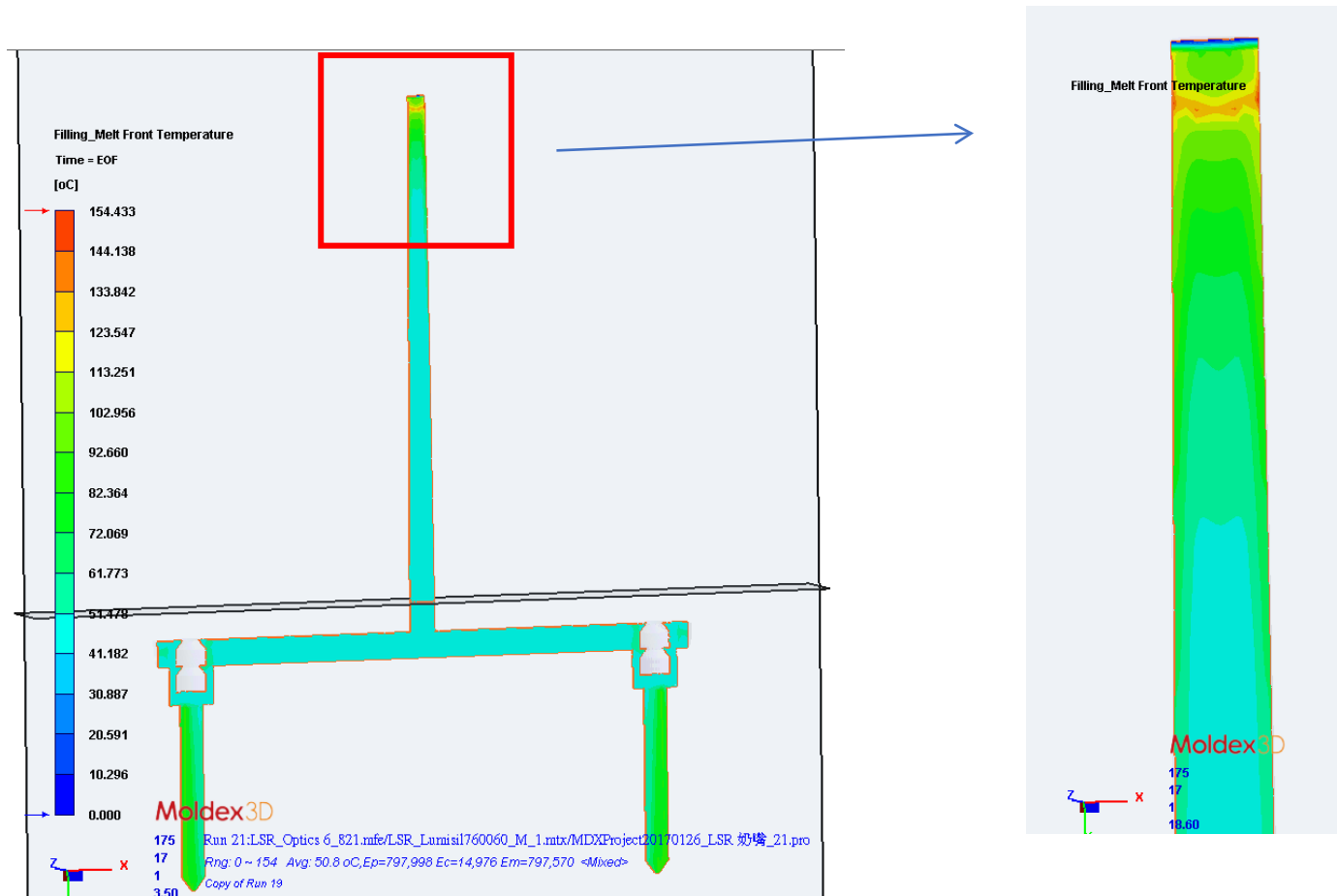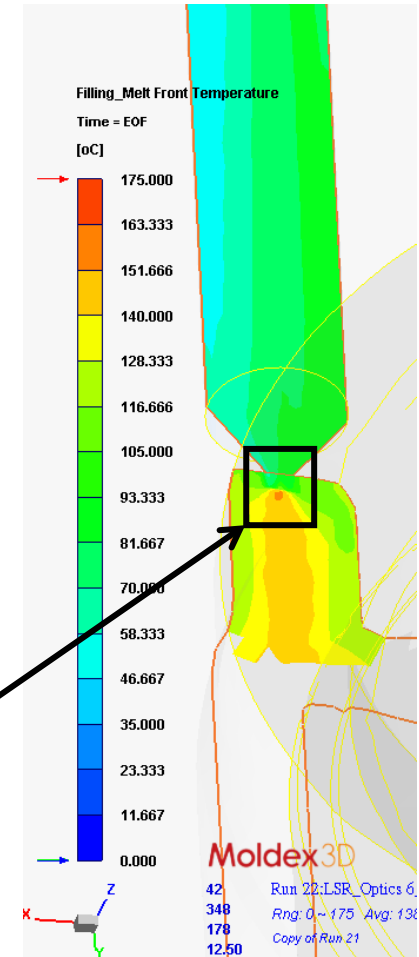
Max Shear Rate

- Generally, the shear rate remains quite low (below 50 s-1) during filling. The highest shear rate is observed at the gate region with magnitude reaching 3.8e5 S^{-1} .
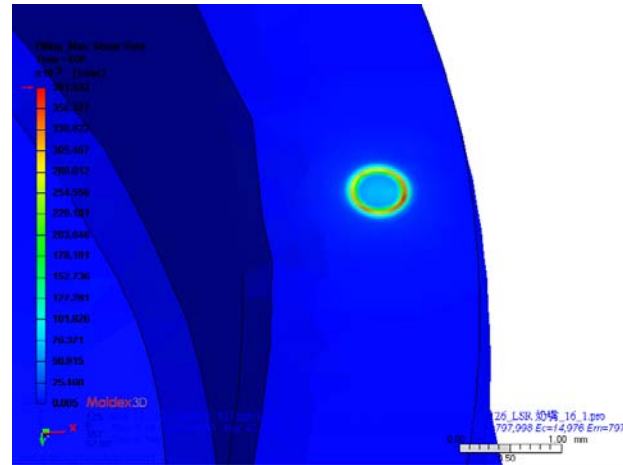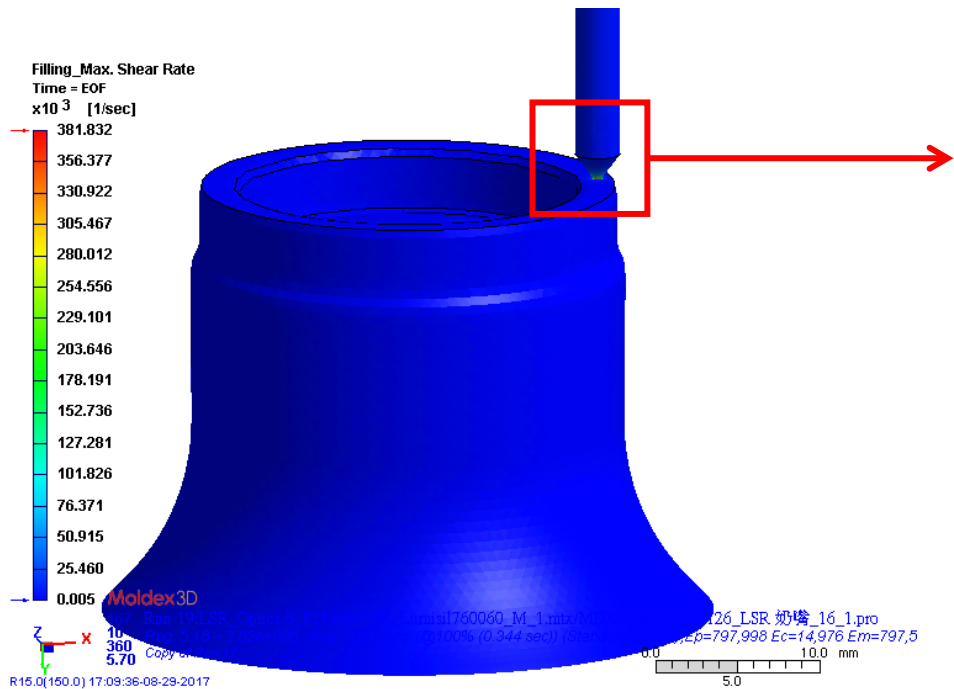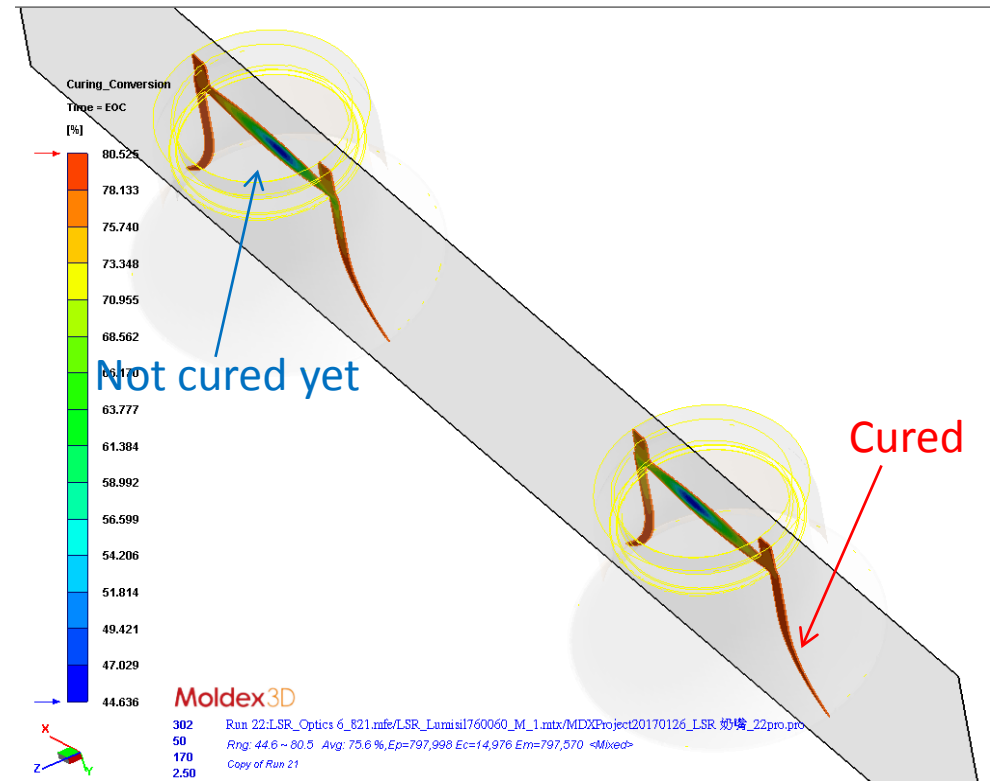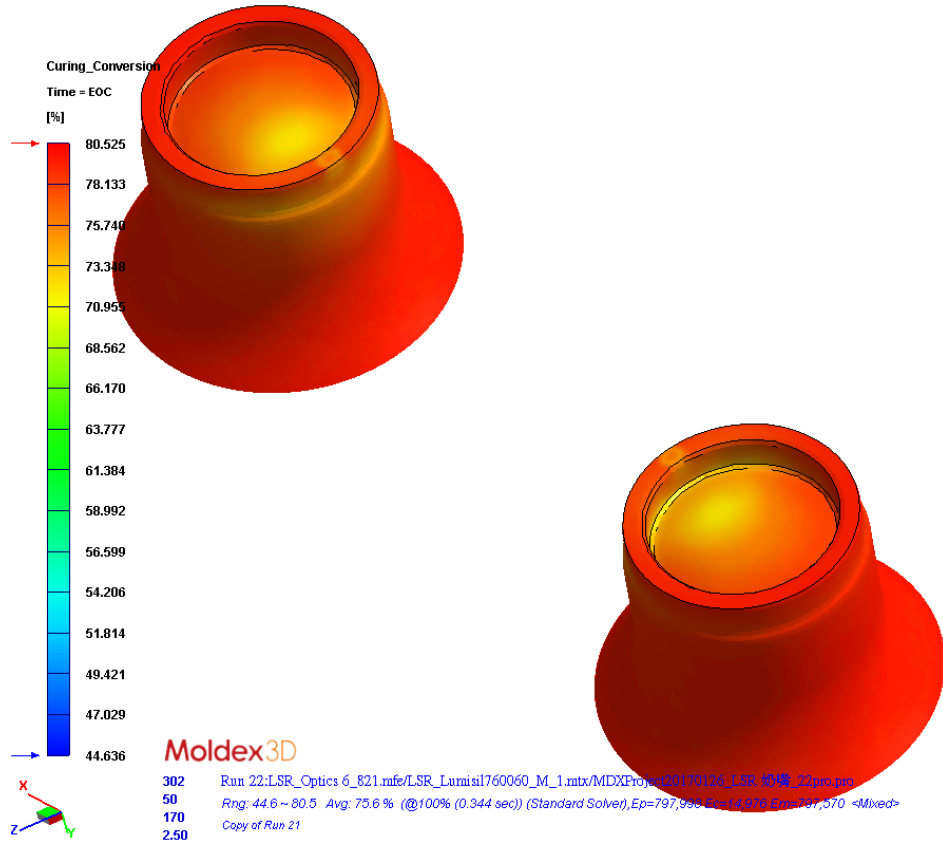

Concern: Excess Shear Rate in Gate Region
- shear heating
- premature curing

Make Change Early: Reconsider Gate Design

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Evaluation Cycle Time and Curing Reaction

- In the lens region, curing has not started yet while most region at the edge has been cured.
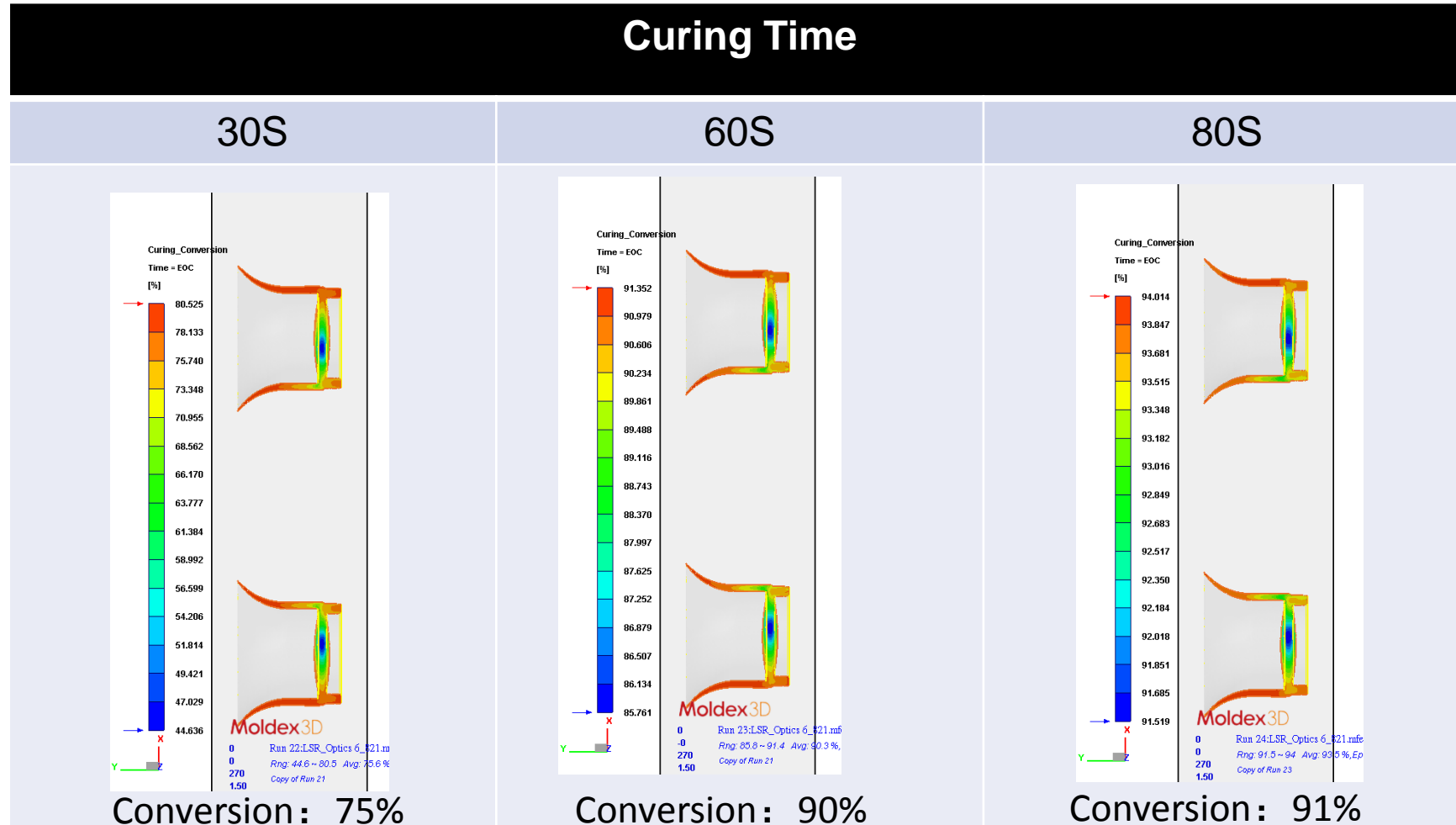

Blue color: curing reaction not yet started
Red color: curing reaction started
Part curing time: about 30 seconds

Evaluation Cycle Time and Curing Reaction

- Curing conversion prediction helps to accurately predict curing time and shorten cycle time.

Curing Time		
30S	60S	80S
Conversion：75%	Conversion：90%	Conversion：91%

Material Selection Guidance (MHC)

Summary

Software	Development Weakness	Moldex3D Advantages	Featured Customers
• Product Design • Mold Development • Production Issues	• Molding Defects • Warpage • Structure Analysis	• Automatic Meshing • Multi-component Injection Molding • Advanced Hot Runner • Multi-cavity	**WIDEX** high definition hearing **B BRAUN** **BD** **DEANTRONICS**

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