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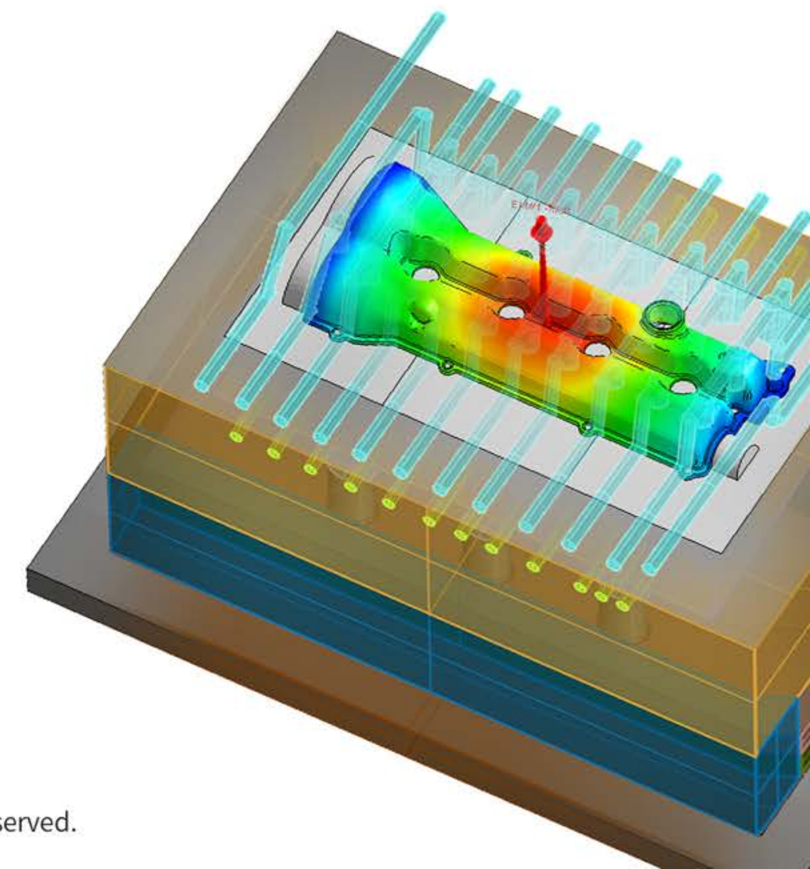
Moldex3D 在先进成型技术上的整合与应用



www.moldex3d.com

Moldex3D 在先进成型技术上的整合与应用

> In-Mold Decoration (IMD) Process Simulation

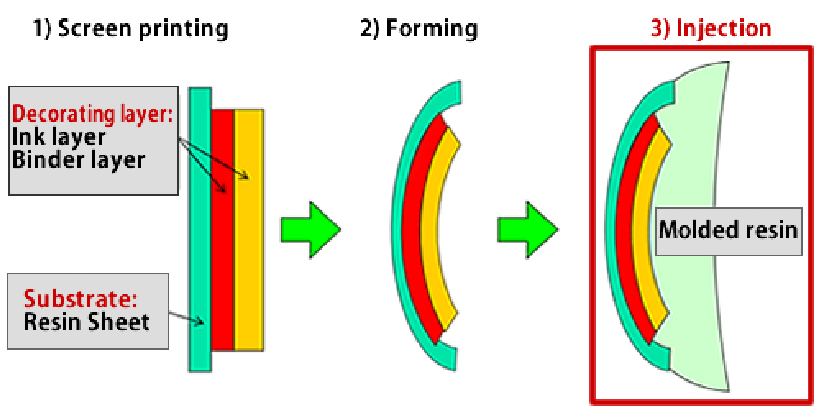
> Foaming Process Simulation

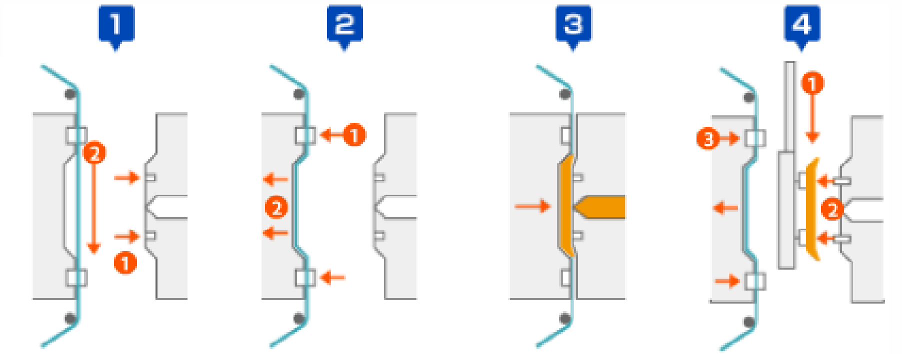
> Compression Molding Simulation

In-Mold Decoration (IMD) Analysis

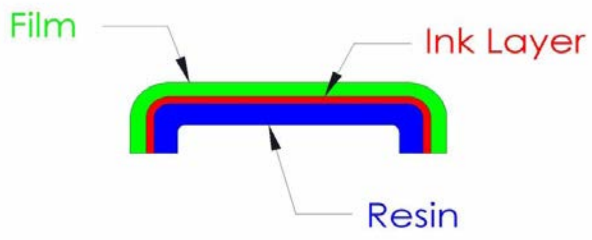
In-Mold Decoration Process

> In-mold decoration/In-mold labeling/Film insert molding (IMD/IML/FIM)
  - Decorating layer(film/label) + molded resin
  - Process flow
    - Screen Printing
    - Forming process
    - injection molding process





Decorating layer



- Decorating layer/Film
  - Strong and consistent ink bonding
  - Material
    - polycarbonate, PET, acrylic, ABS, PVC and PS.
- Decorating layer/Ink layers
  - Based on performance specifications
    - Opacity, transmissivity, IR and RF transparency, chemical resistance, elongation, adhesive strength…etc.
- Molded resin
  - The insert and molded resin no need to be identical, but compatible
  - Material
    - PET, SAN, PC/ABS, PVC, nylons, ABS, PS, acrylic, PP and PE.

Applications

> Common applications

Defects

> Defects could occur during injection molding process

- Wrinkle
- Warpage

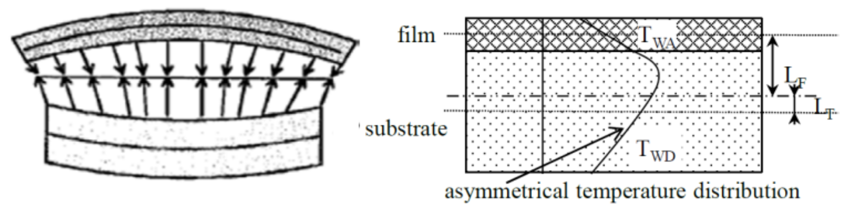
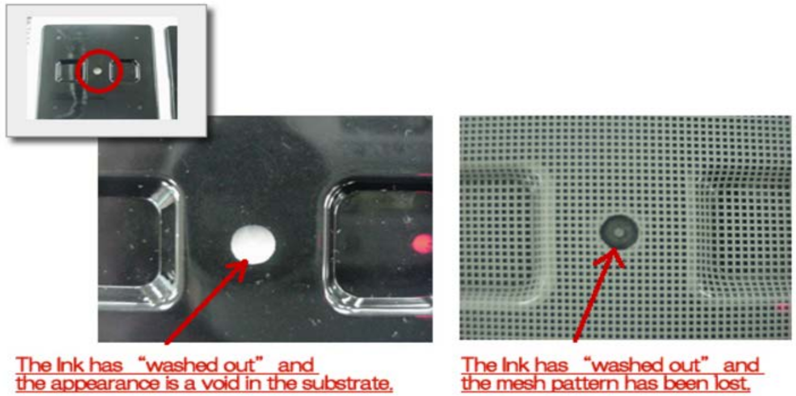


Figure 2: warpage of the film and substrate because of the asymmetrical temperature distribution

- Ink Wash-off/Wash-out
  - The phenomenon which the base material and ink surface around the gate is melted by the pressure and heat of resin that is injected at high temperature during injection.



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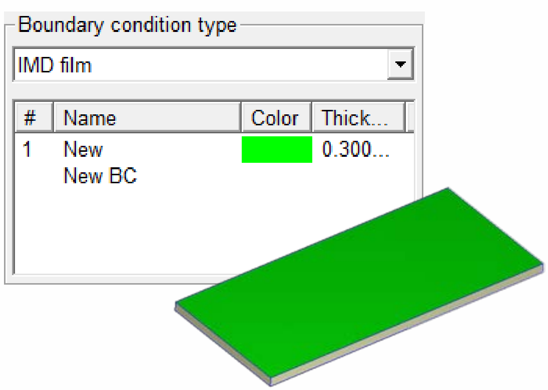
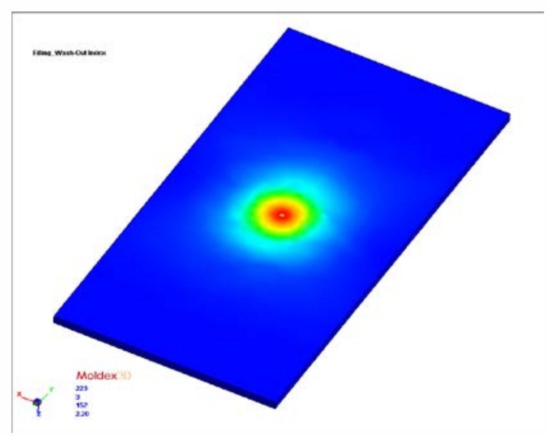
In-Mold Decoration (IMD) Simulation

> Allow to consider IMD film with BC setting
  - Simply model preparation by assigning IMD BC with thickness
  - Consider thermal and mechanical property of decoration film with material assigned
  - Provide wash-out index result considering thermal and shear effects during filling

> Benefit
  - Easy model preparation to approach a very thin film
  - Quick diagnosis of wash-out issue





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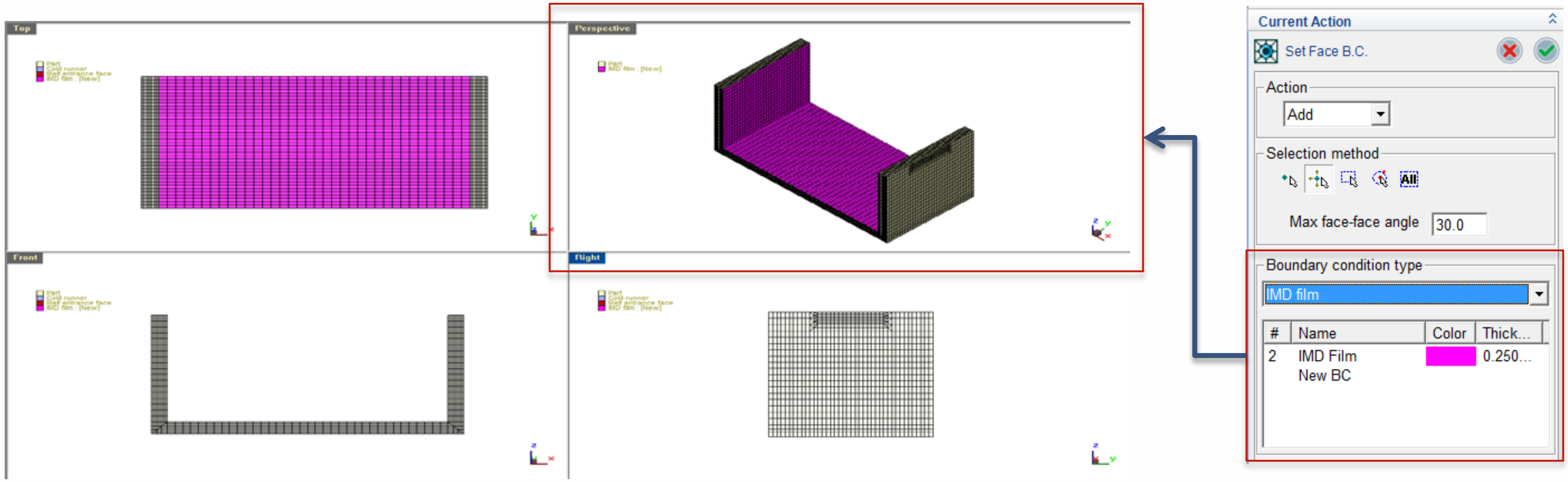
Designer BLM: Simple Setup Procedure for IMD Film

- Apply simple BC setting instead of creating solid mesh
  - Save effort significantly for the IMD film meshing
  - Support MFE only
- Assign the properties of IMD film in Moldex3D Designer
  - Thickness of IMD films
  - Group number of IMD film (for multiple material cases)



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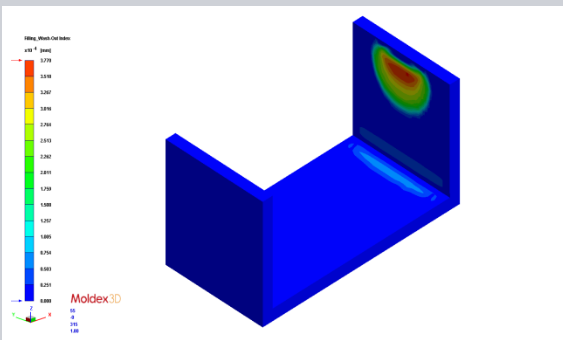
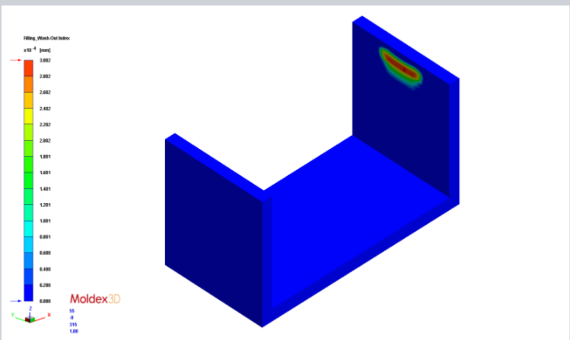
Flow/Pack: Wash-out Indicator

> Wash-out Index

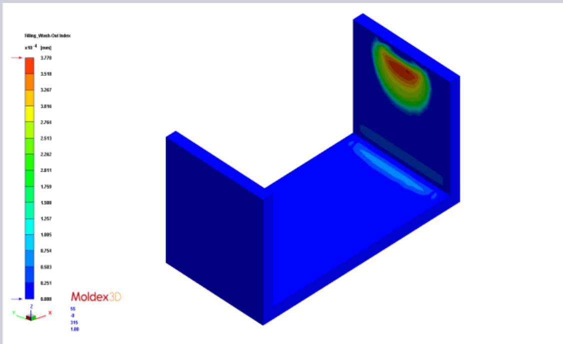
– To evaluate wash-off severity of IMD film

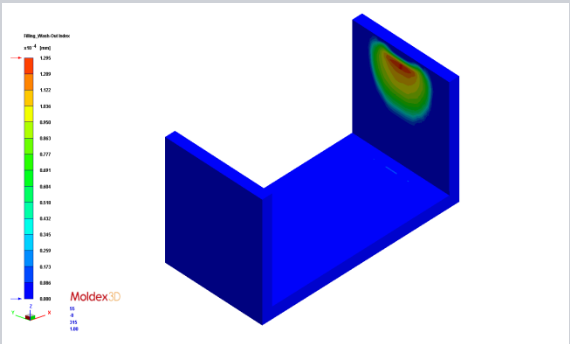
Melt T = 310 ℃	Melt T = 300 ℃





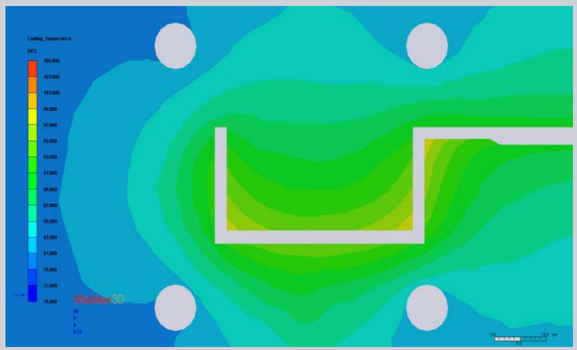
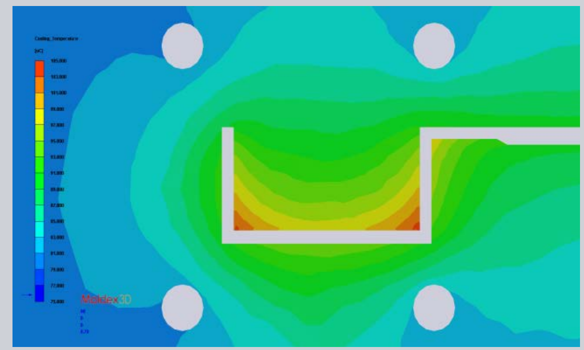
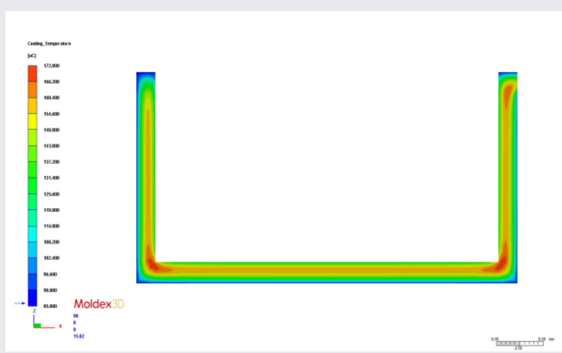
Inj. time = 1.0 sec	Inj. time = 0.7 sec





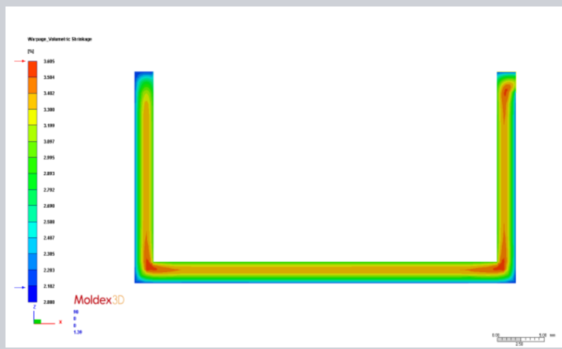
Cool: Thermal Effect by IMD Film

> Asymmetric temperature distribution due to thermally insulated IMD film

	With IMD film	No IMD film
Mold Base Temperature distribution		
Part Temperature distribution		

Warp: Constrain Effect of IMD Film

> **Imbalanced shrinkage induced by:**
  - **Constrain effect during warpage**
  - **Thermal effect during cooling (non-uniform temperature)**

	With IMD film	No IMD film
Volumetric Shrinkage (%)		
Warpage X displacement (Scale factor x 2)		

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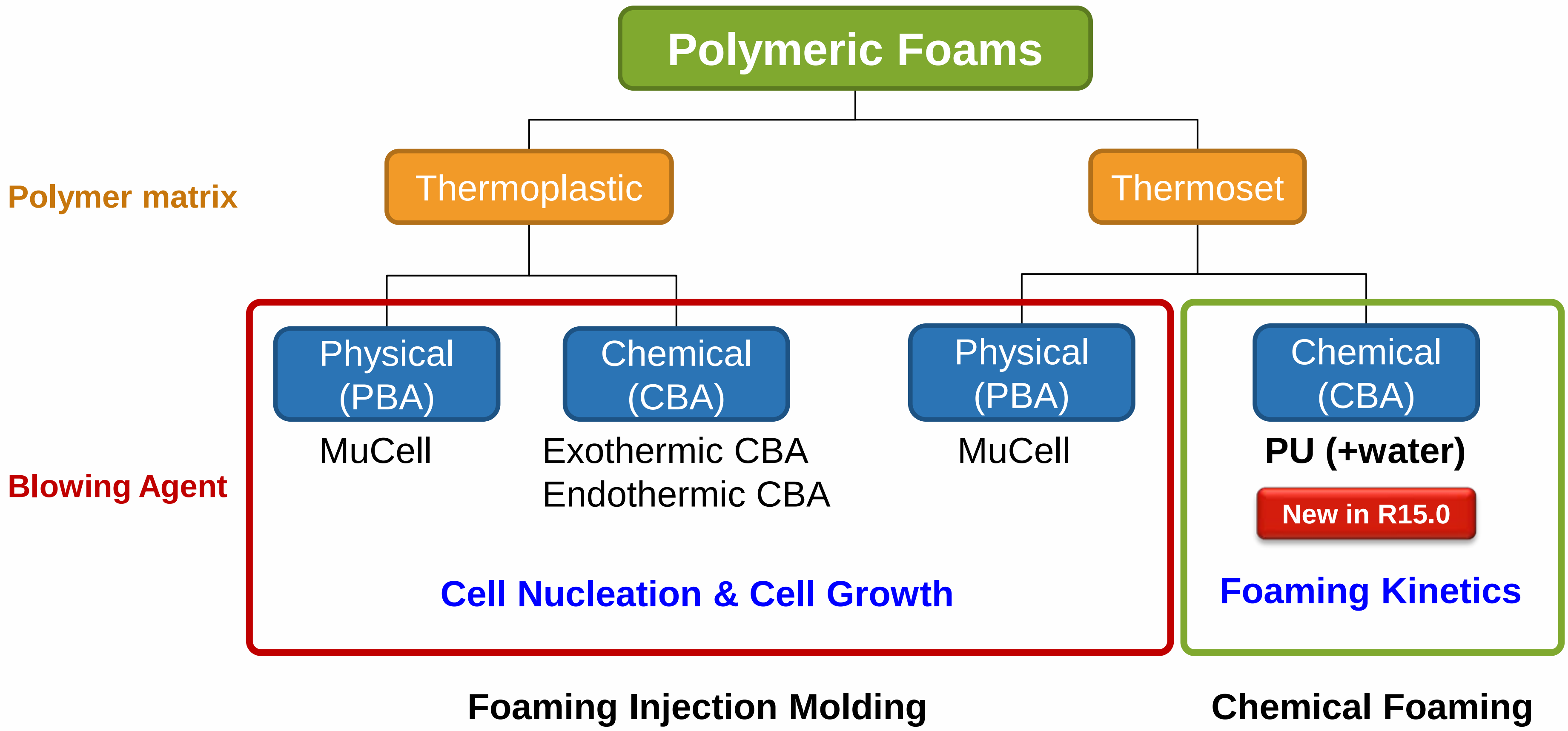
Foaming Process Simuation

Category of Polymeric Foams



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Blowing Agent in Polymer Processing

> **Physical blowing agent**
  - **Gas produced by phase change.**
  - **Organic: CH_4, C_3H_8, CFCs**
  - **Inorganic: N_2, CO_2, Inner gas**

> **Chemical blowing agent**
  - **Gas produced by thermal decomposition or by polymerization reaction**
  - **Thermal decomposition**
    - **Organic: Azo compound, OBSH, DPT**
    - **Inorganic: Bicarbonate**
  - **Polymerization reaction**
    - **PU reaction with water**

Chemical Foaming Application

> **Polyurethane foam can be used in**
  - **Automotive industry (dashboard, steering wheel, seat)**
  - **Refrigeration industry (refrigerator insulation layer, insulation sandwich)**
  - **Footwear industry (soles)**
  - **Medical industry (bed mattresses)**
  - **Building and Construction**

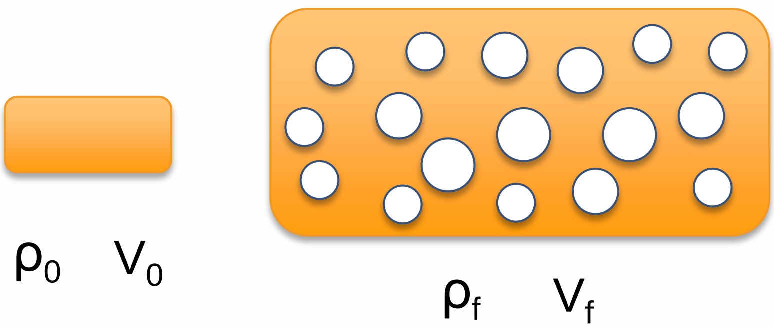
Pictures from kraussmaffei

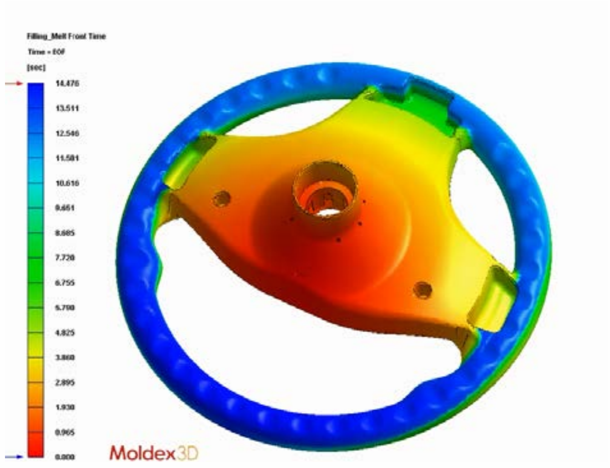
Support PU Chemical Foaming Process

- Provide foaming kinetics for different by-products in chemical foaming process
  - By-products during the chemical reaction are simulated according to the foaming kinetics equations for the gas generation

Benefit

- Visualize density variation by considering the foaming kinetics
- Evaluate the effected results of foaming conversion

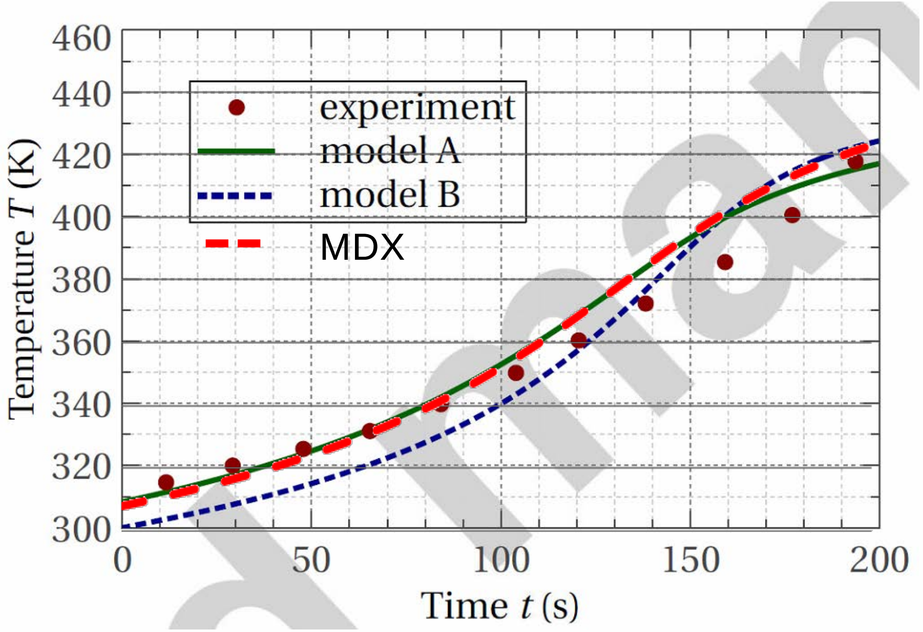




Validation: Temperature

> **Reaction heat to heat source**
  – **Cp (polyurethane = 1.8e7, water = 0.8e7 erg/g-°C)**

$$\frac{dT}{dt} = \frac{(-\Delta H_p)\, c_{p,0}}{\rho_{rm} c_{p,f}} \frac{dX_p}{dt} + \frac{(-\Delta H_w)\, c_{w,0}}{\rho_{rm} c_{p,f}} \frac{dX_w}{dt}$$



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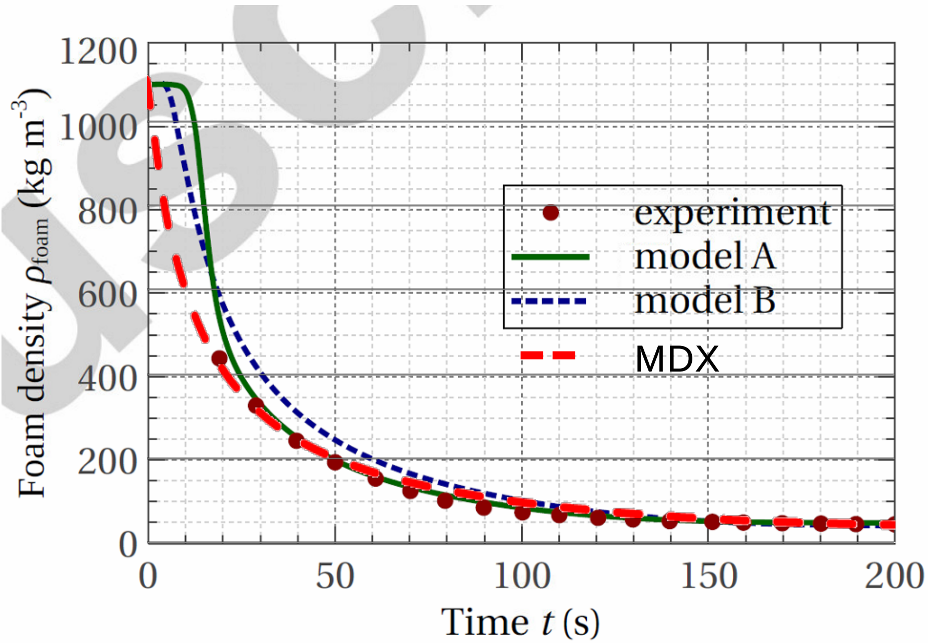
Validation: Density

- The more the CO2 gas, the smaller the density
- No Physical BA, L=L0=G=0



$$\rho_F = \frac{1 + L_O}{\dfrac{CO_2 1000RT}{PM_{CO2}} + \dfrac{G1000RT}{PM_B} + \dfrac{L}{\rho_{BL}} + \dfrac{1}{\rho_P}} \quad (11)$$

where $G = L_O - L$

$$CO_2 = \frac{[W]_O X_W M_{CO2}}{1000\rho_P} - (CO_2)_D$$

Ref: S. Baser and D. V. Khakhar, Modeling of the Dynamics of Water and R-11 Blown Polyurethane Foam Formation (1994)

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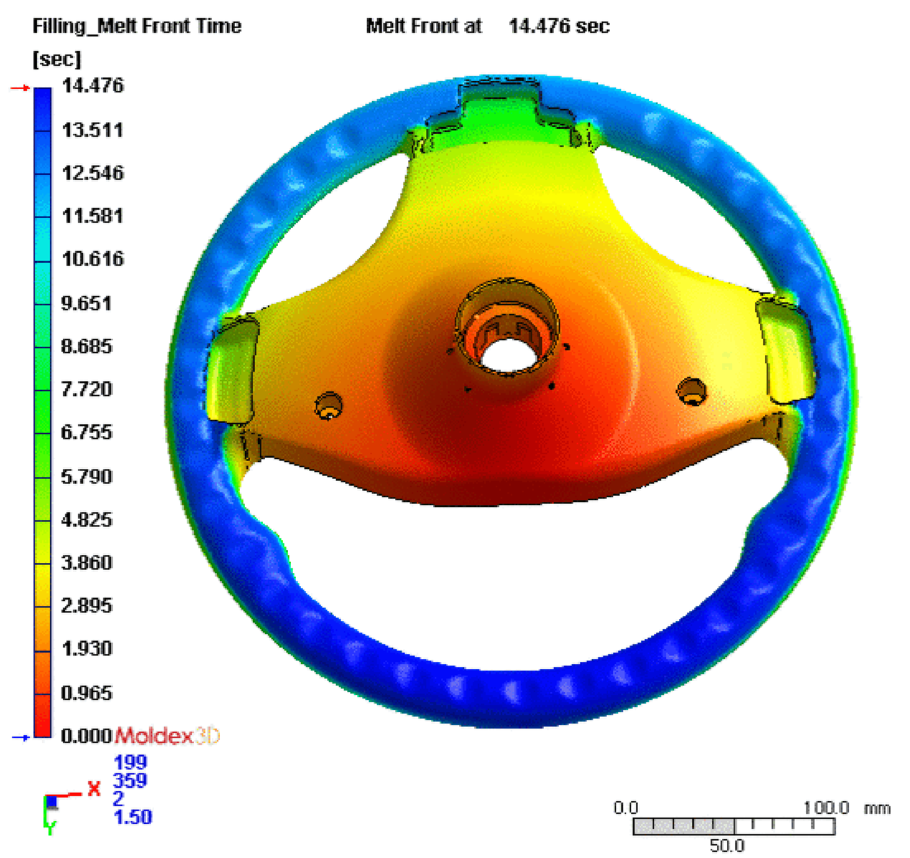
Analysis Output

> **Melt front time**

– **Melt front advancement is a position indicator as melt front boundary movement in different time duration in the filling process**



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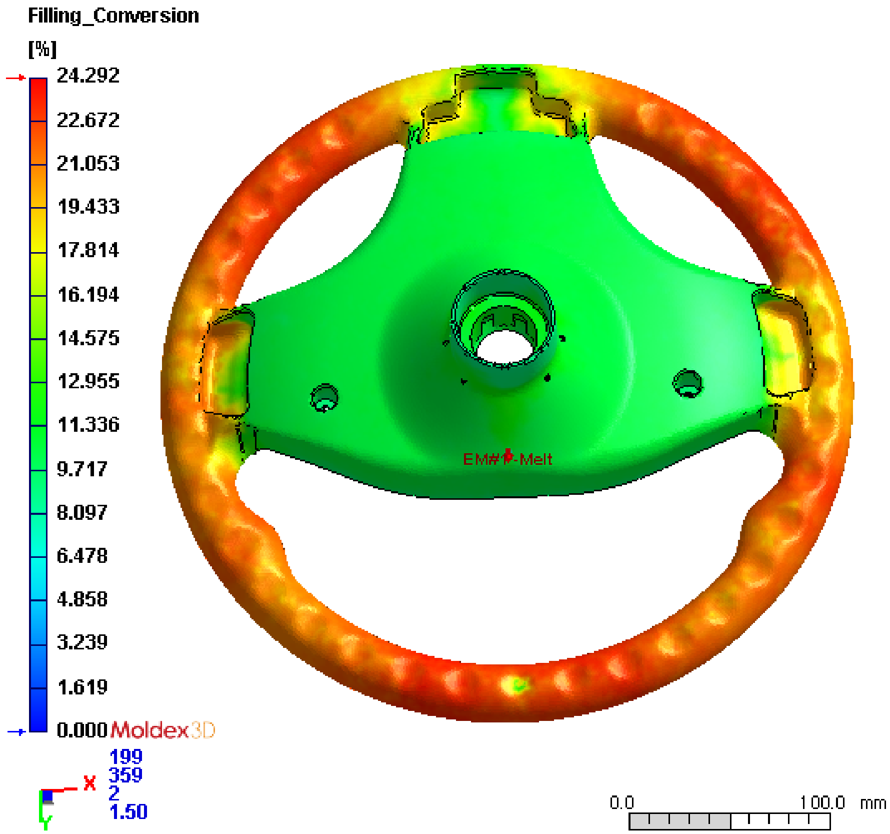
Analysis Output

> **Conversion**

– **Conversion is a measure of degree of curing/crosslinking of the reactive molding compound. Higher degree of crosslinking of the microstructure of the molding compound will reveal a higher conversion**



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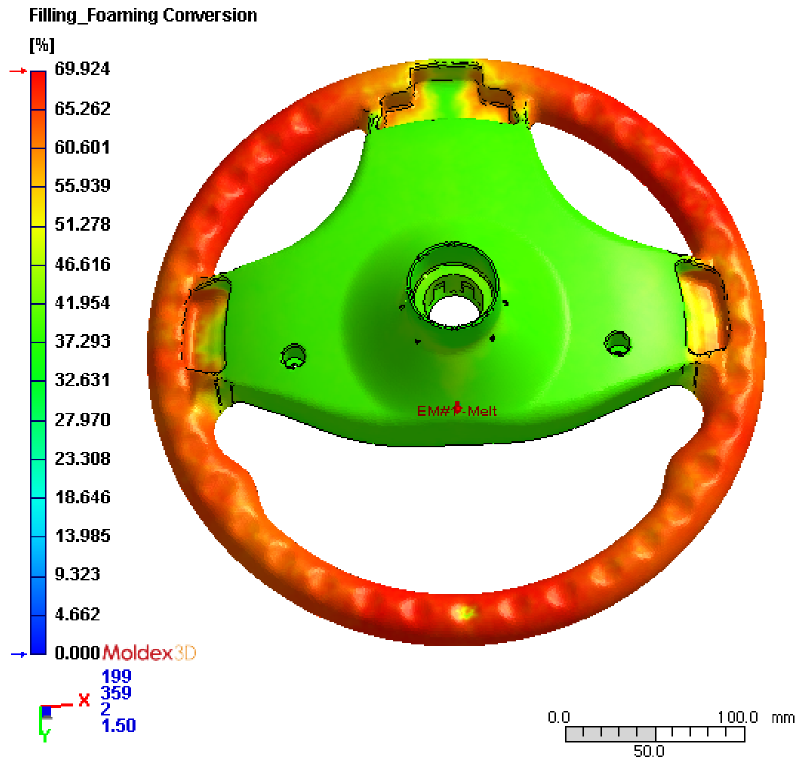
Analysis Output

> **Foaming Conversion**

– **Foaming conversion is a measure of degree of foaming reaction of the reactive molding compound. Higher degree of foaming reaction of the microstructure of the molding compound will reveal a higher foaming conversion. Fast-foam reactive material will have a higher foaming conversion value after molding.**



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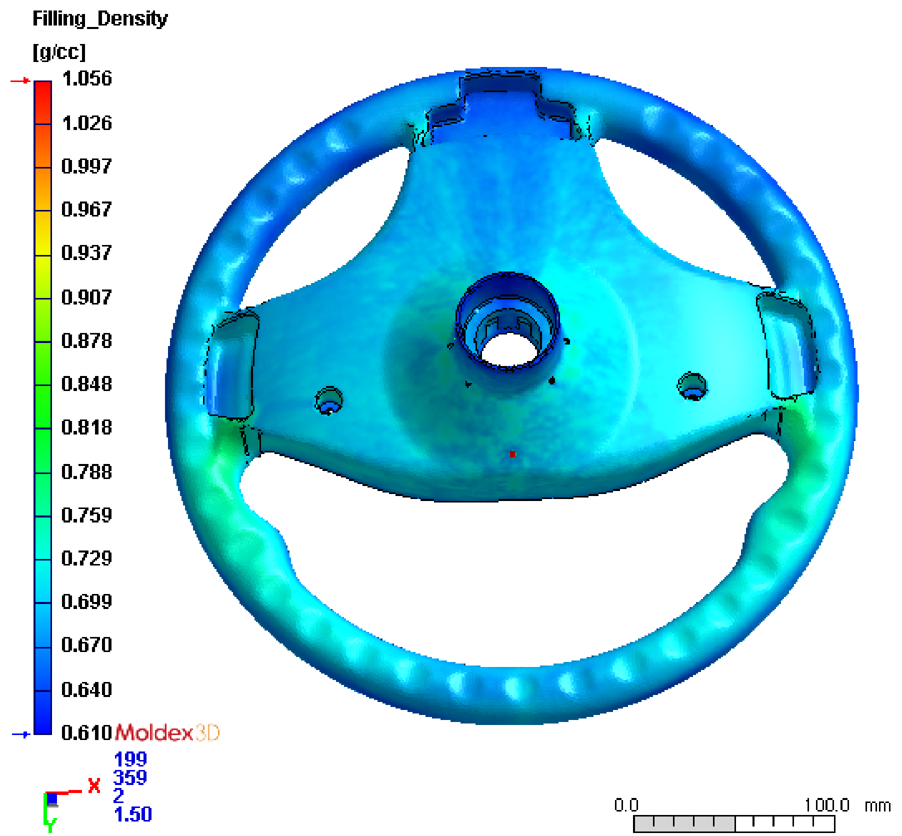
Analysis Output

> Density

– Users can also examine Density distribution, which reveals the weight reduction effect during foaming process



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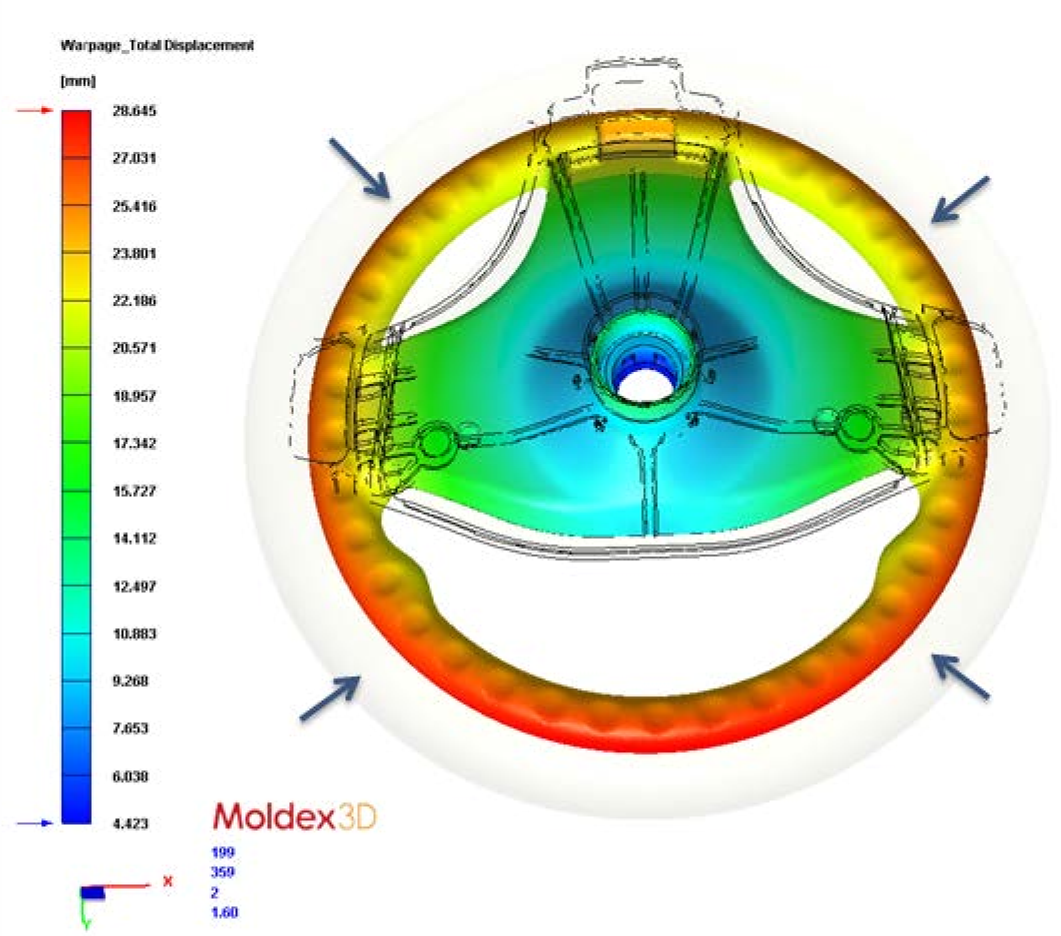
Analysis Output

> **Warpage**
  - **The total displacement can provide final deformed part after foaming process**



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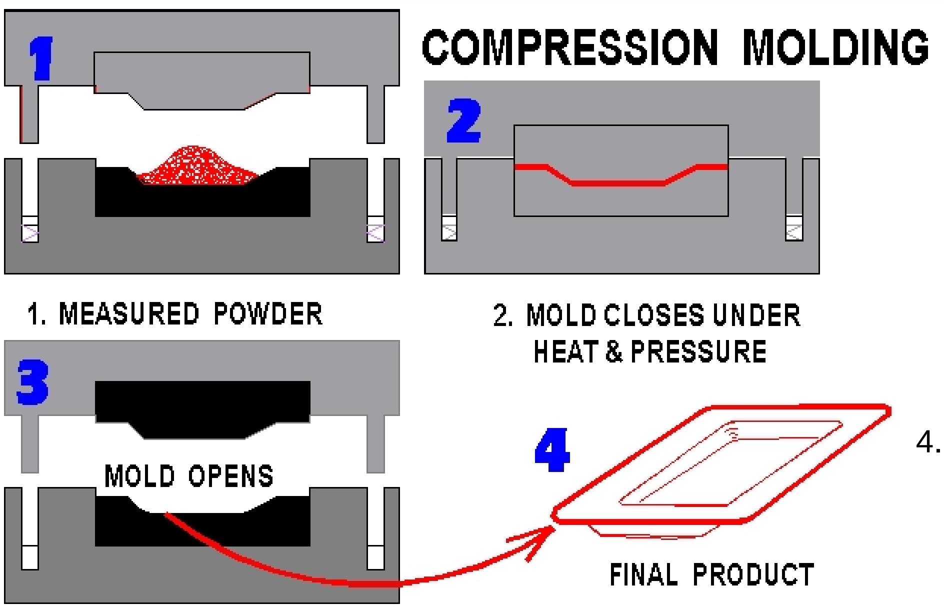
Compression Molding Simulation

Compression Molding Process

> A simplest way to make rubber products
> It's a process which involves:



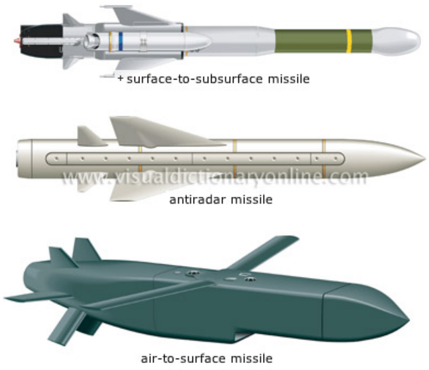
4. Open the mold and remove the part (The excess rubber, called flash, needs to be trimmed off the part)

> In some applications, compression molding is still the best way

Image Ref:
http://paws.wcu.edu/ballaaron/www/met366/modules/module5/imageJPS.JPG

Compression Molding Applications

- Automotive parts
  - Hoods, bumpers, fenders, spoilers, etc.
- Medical equipment
  - Caps and plugs to blood separation machines and ultrasound equipment
- Aerospace
  - Electrical connectors to guided missiles



Factors in Compression Molding

> Some considerations need to know for the process:

- Material property
  - Viscous behavior
  - Plastic-elastic behavior
  - Anisotropic filler orientation behavior
- Geometry
  - Wall thickness design
  - Charge placement (location)
  - Single or multiple charges
- Manufacturing
  - Mold wall heating
  - Mold closing range
  - Max. clamping force (for proper shape)
  - Gel time for thermoset material
  - De-molding time

http://www.bizlink-lighting.com/products/vista

http://thriarrpolymers.com/?p=90

http://www.indiamart.com/ghardachemicals/gpaek-polyether-ketone.html

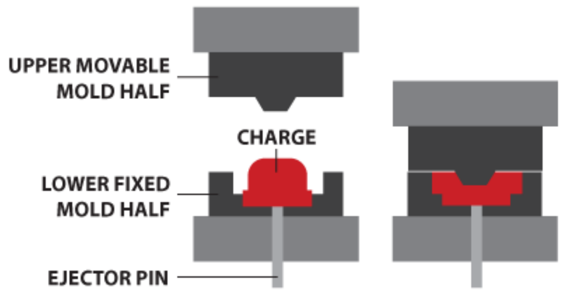
Benefits of Moldex3D Compression Molding

> Provide flexible compression settings to efficiently determine the required process conditions

> Elastically support multiple charge design

> Further assess design by analysis result visualization, including:

- Pressure distribution
- Fiber orientation
- Volumetric shrinkage
- Residual stress distribution
- Deformation



http://www.coremt.com/processes/compression-molding/

> Optics and residual stress analysis with viscoelastic behavior consideration

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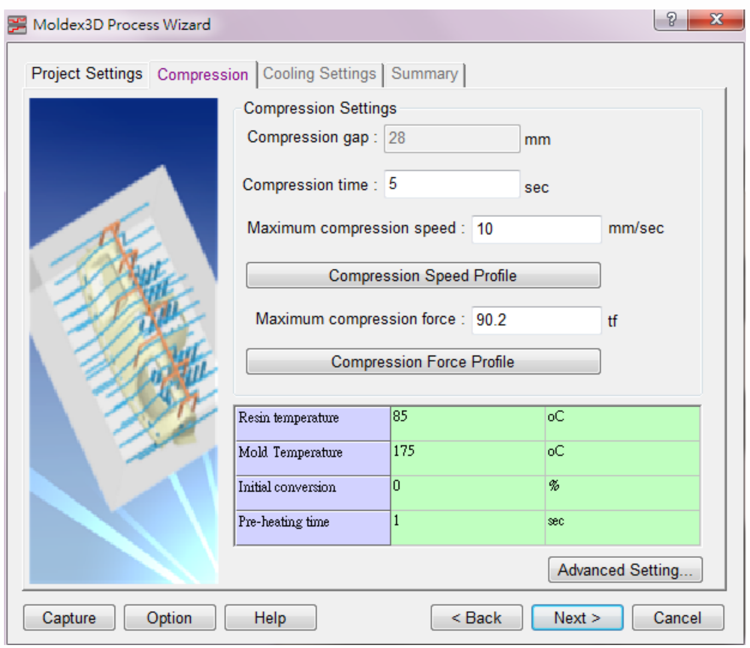
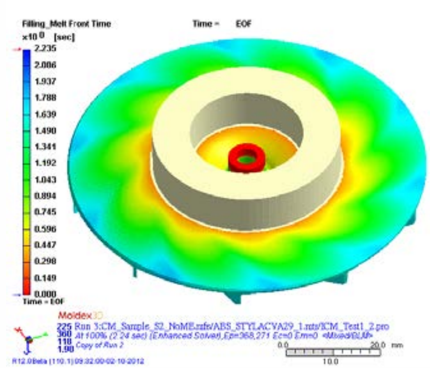
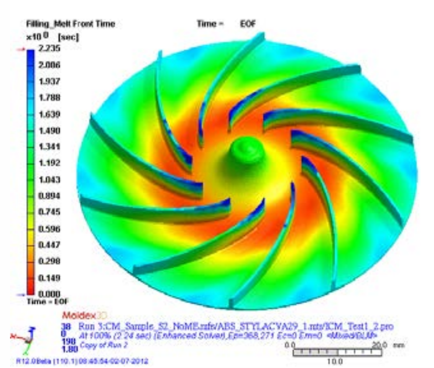
Flexible Compression Process Settings

> Moldex3D provides compression molding simulation with complete process condition settings

> Flexible compression settings allow efficient heating and pressure control to optimize wall thickness design
  – Mold compression speed and compression force
  – Melt temperature and mold wall temperature



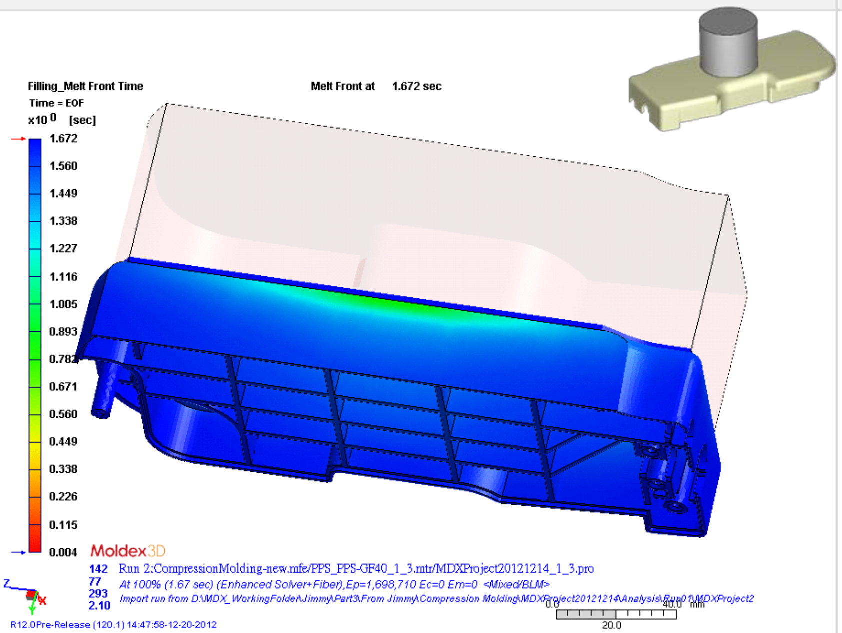


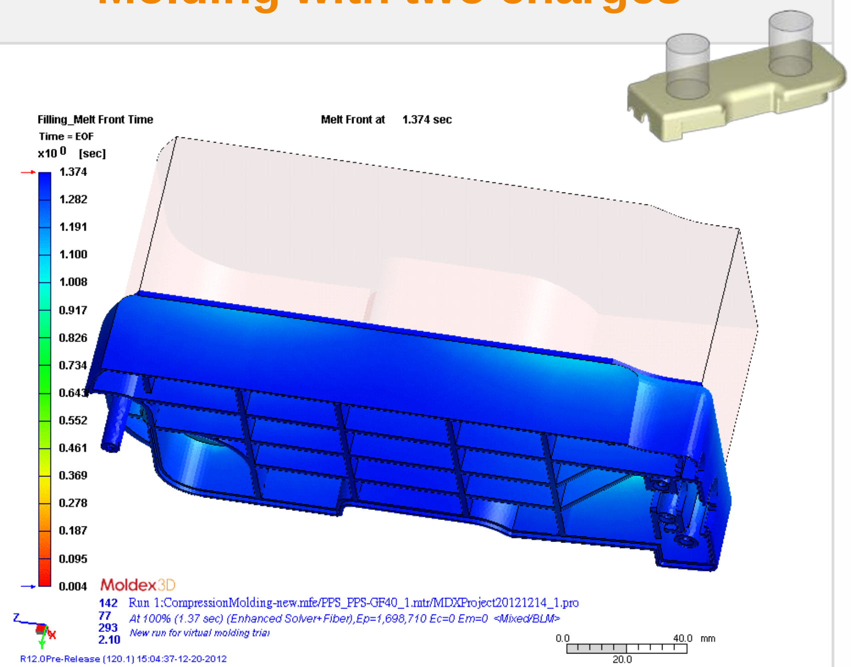


Multiple Charge Design Simulation

- Support arbitrary charge volume & shape setting
- Support single or multiple charges

Molding with one charge	Molding with two charges





Moldex3D simulation enables users to easily find the better solution

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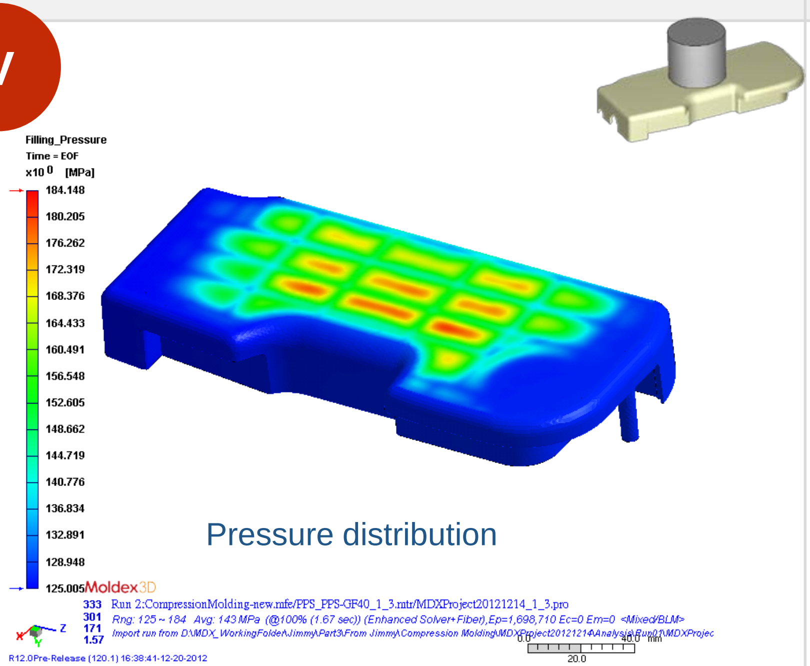
Result Comparison of Charge Designs (1)

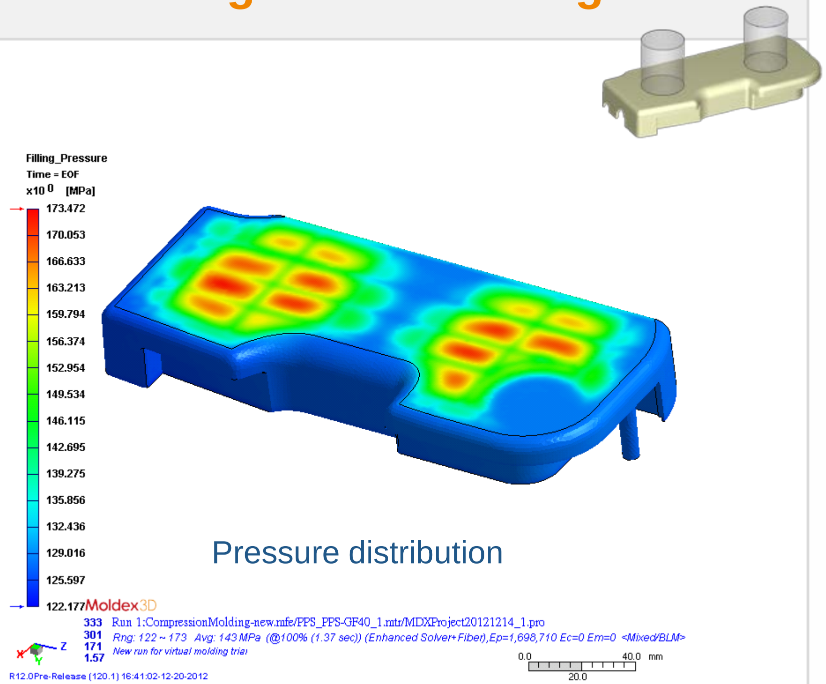
- One-charge design has more uniform pressure distribution than two-charge design
- Uneven pressure distribution leads higher deformation

Molding with one charge

V



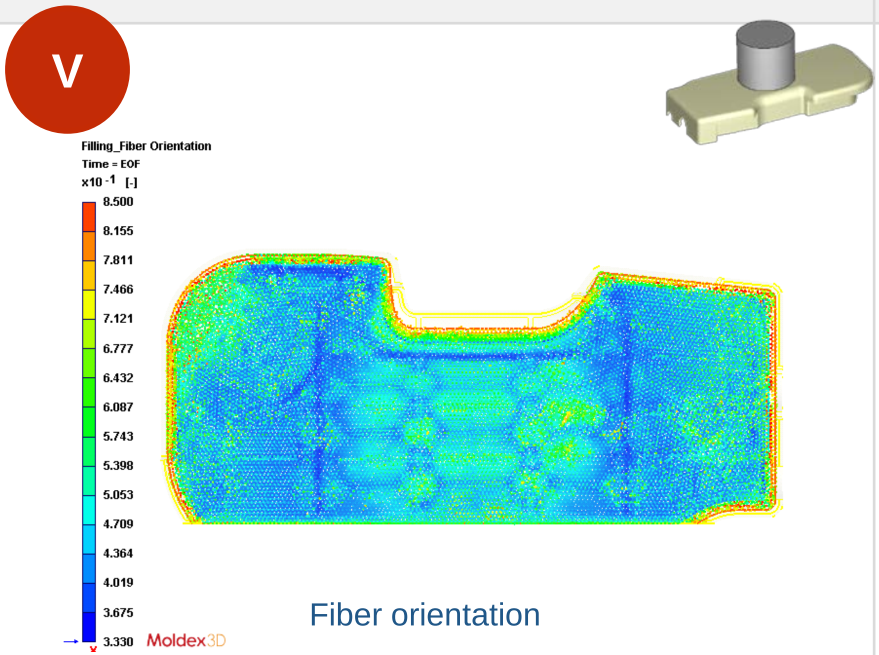
Molding with two charges



Result Comparison of Charge Designs (2)

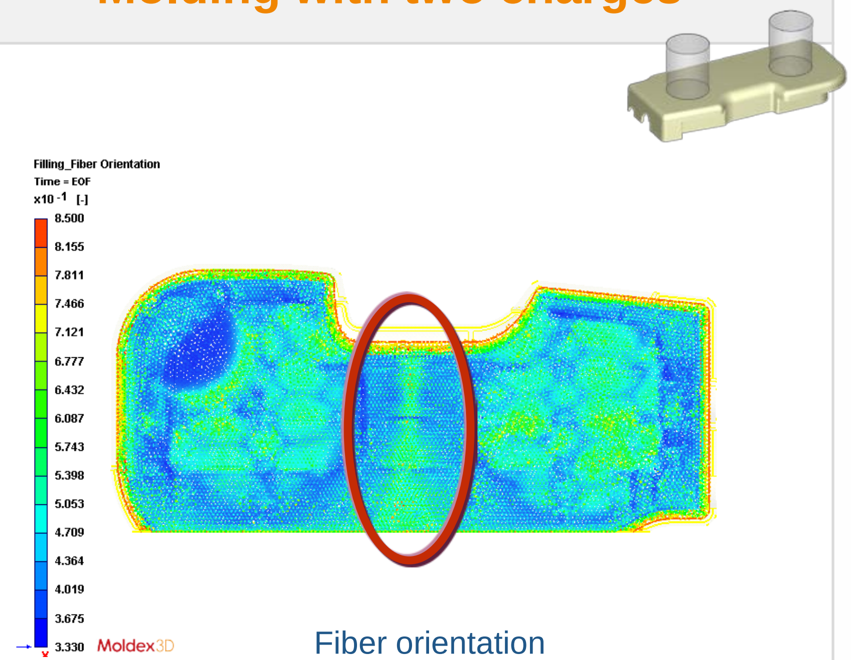
- One-charge design has more uniform fiber orientation distribution
- The area of perpendicular fiber distribution leads part weakness to external force loading

Molding with one charge



Fiber orientation

Molding with two charges



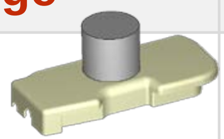
Fiber orientation

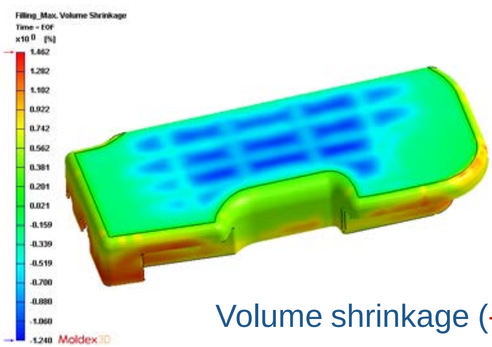
Result Comparison of Charge Designs (3)

> One-charge design minimizes the deformation losses

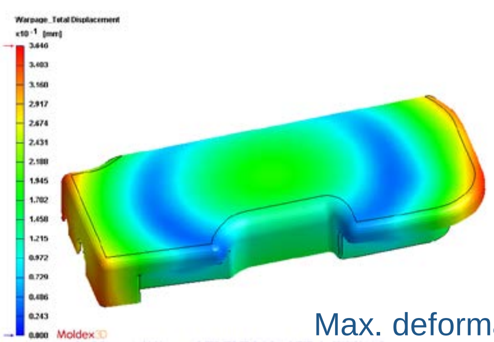
Molding with one charge

V



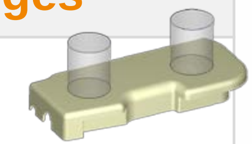


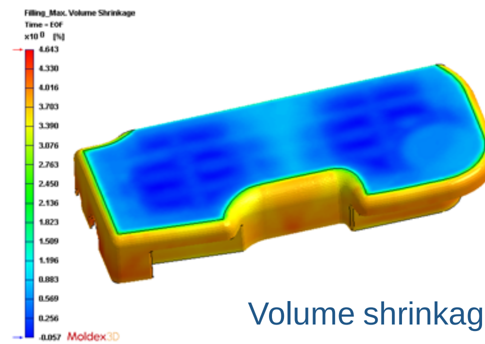
Volume shrinkage (-1.24%~1.46%)



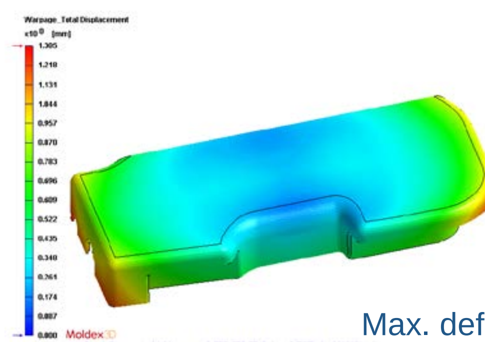
Max. deformation: 0.36 mm

Molding with two charges





Volume shrinkage (0.57%~4.64%)

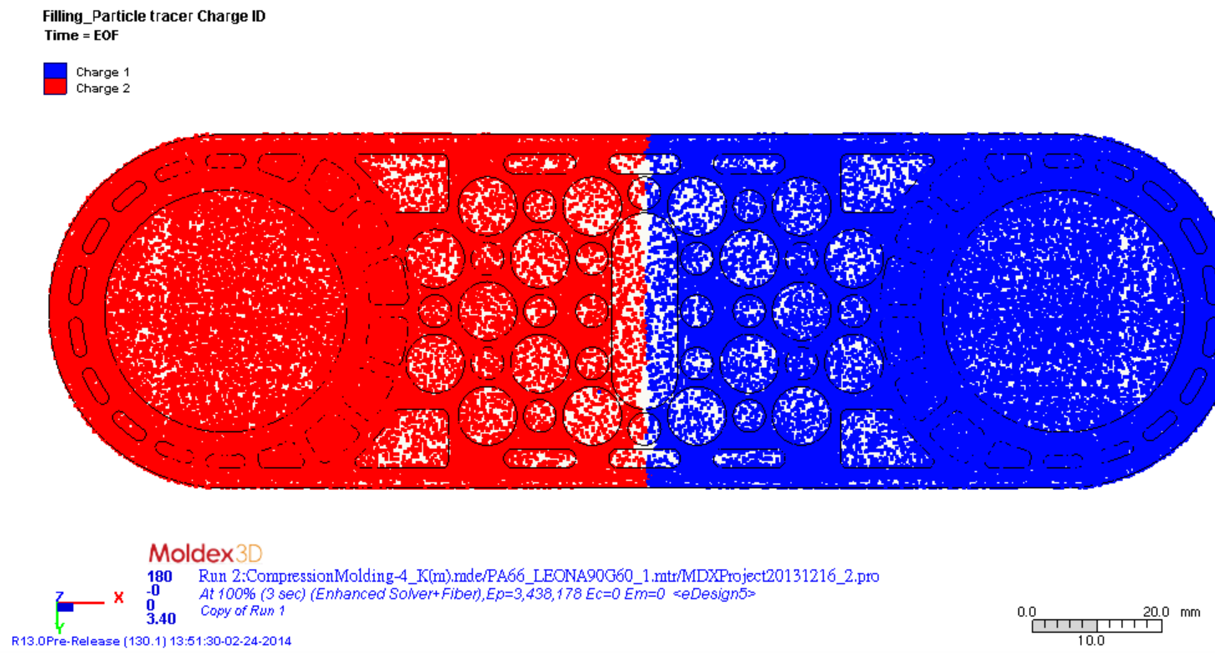


Max. deformation: 1.3 mm

With Moldex3D, users can find a shortcut to design solution

Charge Distribution

- > Visualize the area each charge fills by tracking approach
- > Show the volume filled of melt for each charge
- > As a indicator of compression charge contribution
- > Better design of charge size and position design



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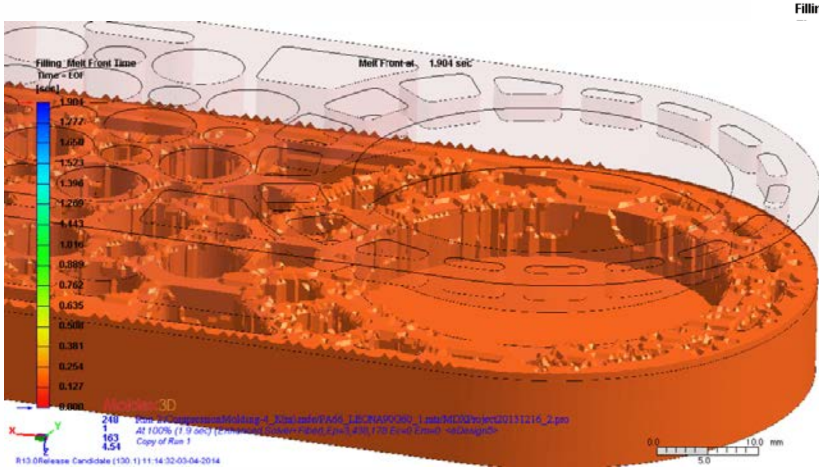
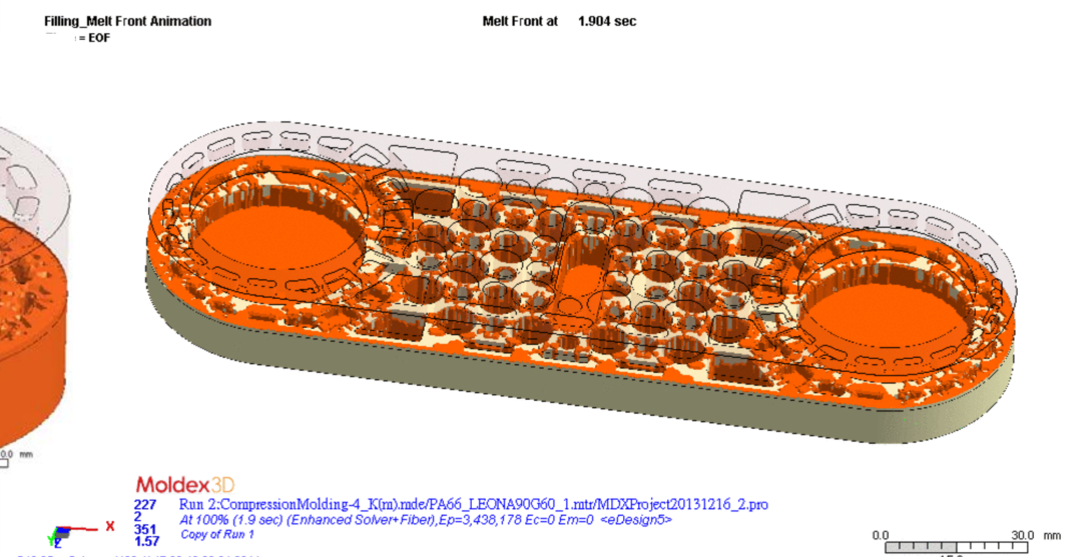
Support Simulation by eDesign Mesh

- Improved kernel robustness and capability
- Hybrid mesh types supported, such as tetra and structural elements, of compression zone to eliminate the geometry limitation due to mesh quality
- Easier to run compression molding simulation by eDesign mesh approach
- Closer to real compression molding situation





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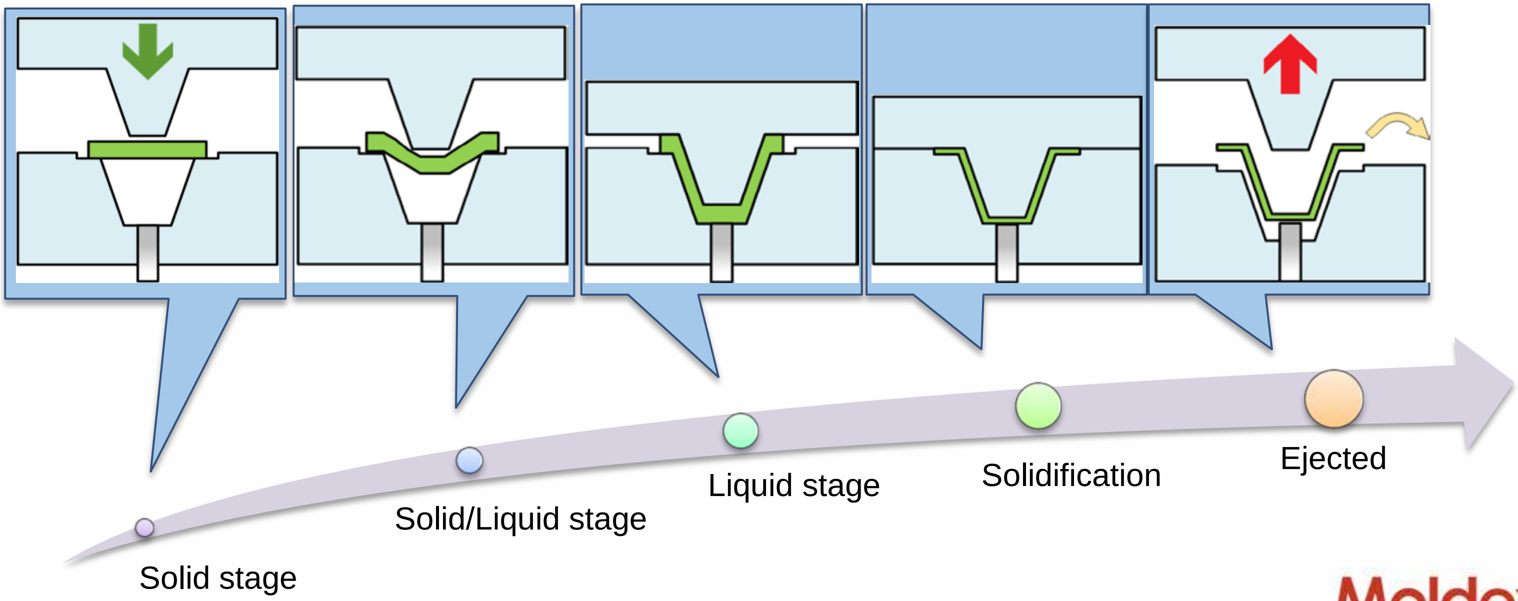
Support to Read Deformation Information from LS-DYNA

- Compression molding calculation
  - Moldex3D can import the deformed shape and initial temperature from LS-DYNA calculation
  - Different initial fiber settings are enabled

Benefit

- More precise to describe the full process from Solid deformation stage to Liquid filling stage



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Conclusion

1. **Moldex3D can provide Ink Wash-off indicator in IMD module.**
2. **Moldex3D can provide complete solutions for foaming process simulation (include physical foaming and chemical foaming).**
3. **Moldex3D support several kind of composites forming process simulation.**
4. **More detailed fiber behaviors can be visualized in compression molding analysis**

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MOLDING INNOVATION

www.moldex3d.com