Moldex3D

最新注塑压缩成型技术之理论与实务应用)

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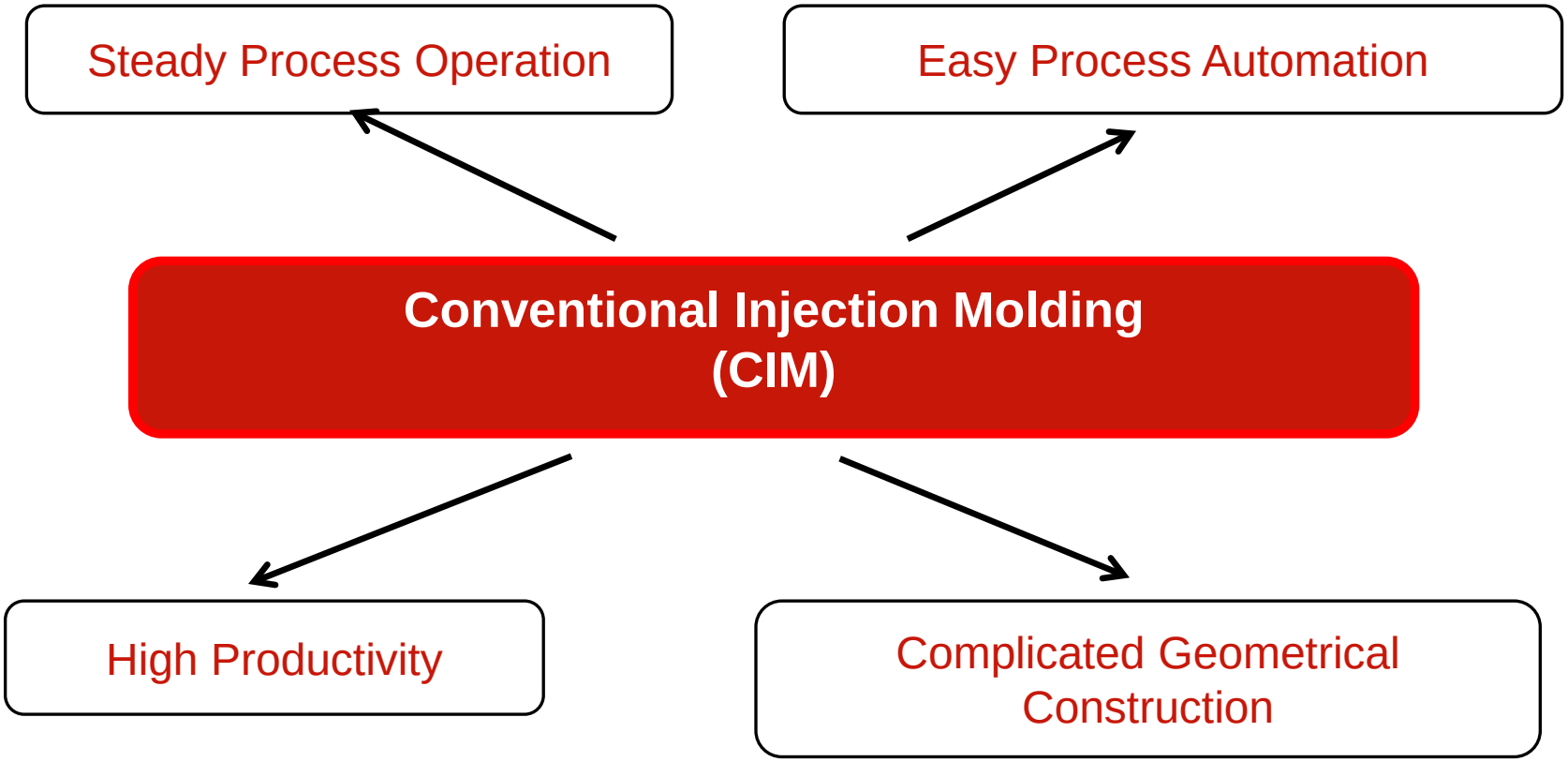
Content

- Introduction
- The challenges for using ICM
- Real Case Studies
- How to setup the key steps for Moldex3D to simulate ICM process
- Conclusion
- Q and A

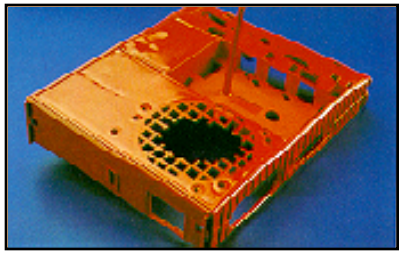
Applications of Conventional Injection Molding (CIM)

Overview of CIM



General Problems and Challenges

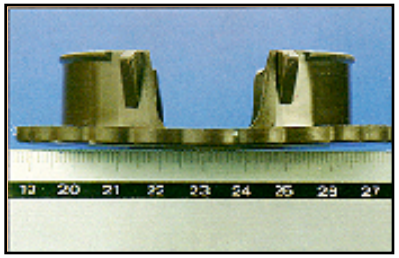
Short shot



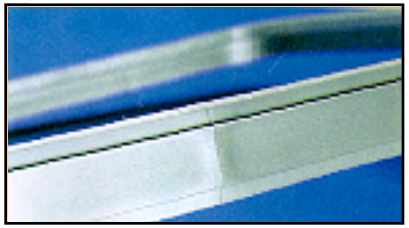
Sink mark

Burning

Warpage



Weldline



Flash

Overview of Conventional Injection Molding (CIM)

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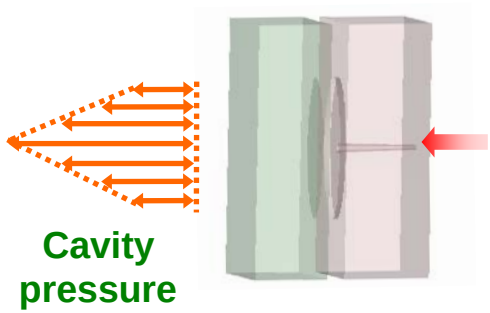
Filling → Packing → Cooling → Mold open /Ejection

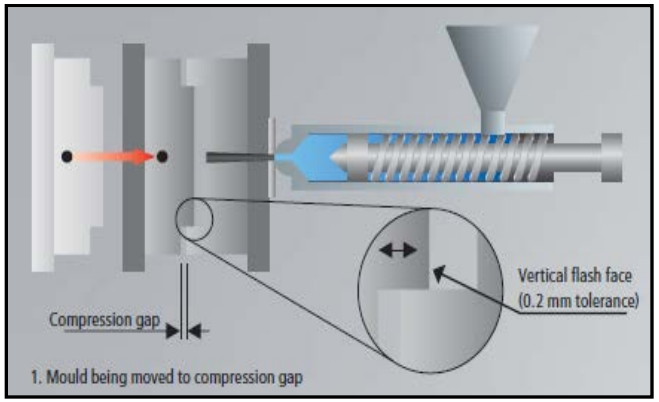
Non-uniform packing effect



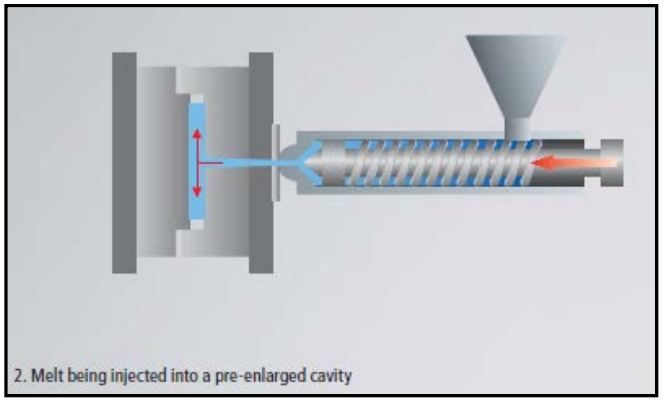
Problems

- Non-uniform shrinkage
- Severe Warpage
- Sink Mark
- Residual Stress /Birefringence

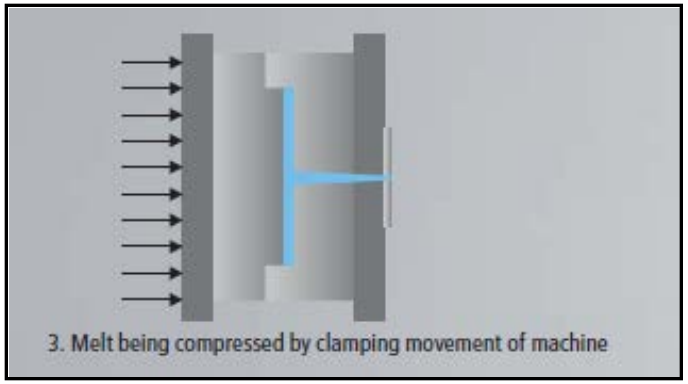
ICM Process Cycle



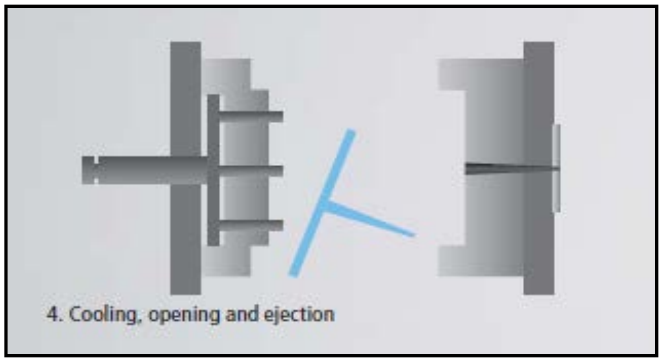
Close mould down to the compression gap



Inject and fill cavity 80 – 95%
(equivalent to 100% or more of the ultimate volume)

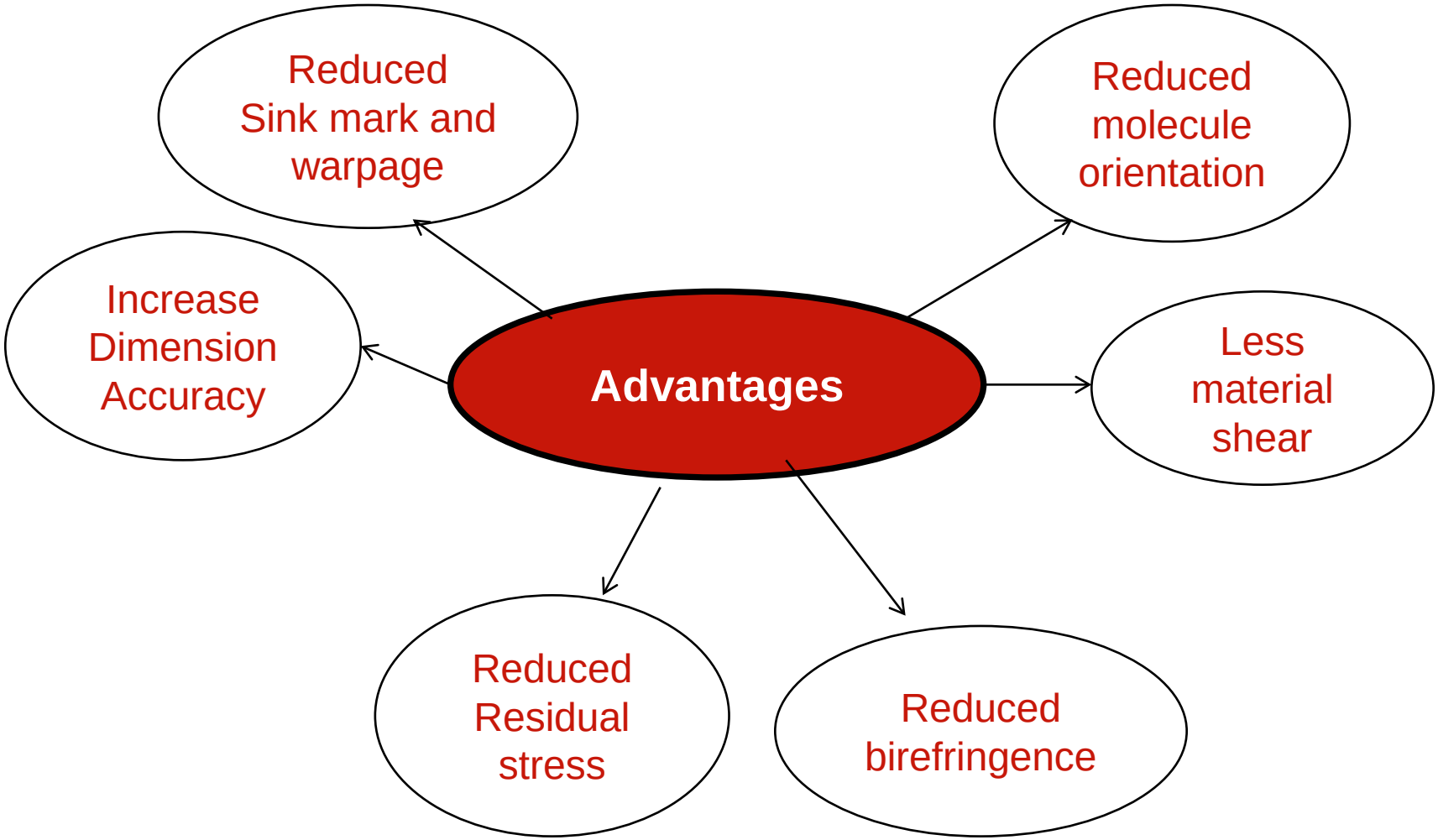


Sequential or simultaneous compression by clamping the mould

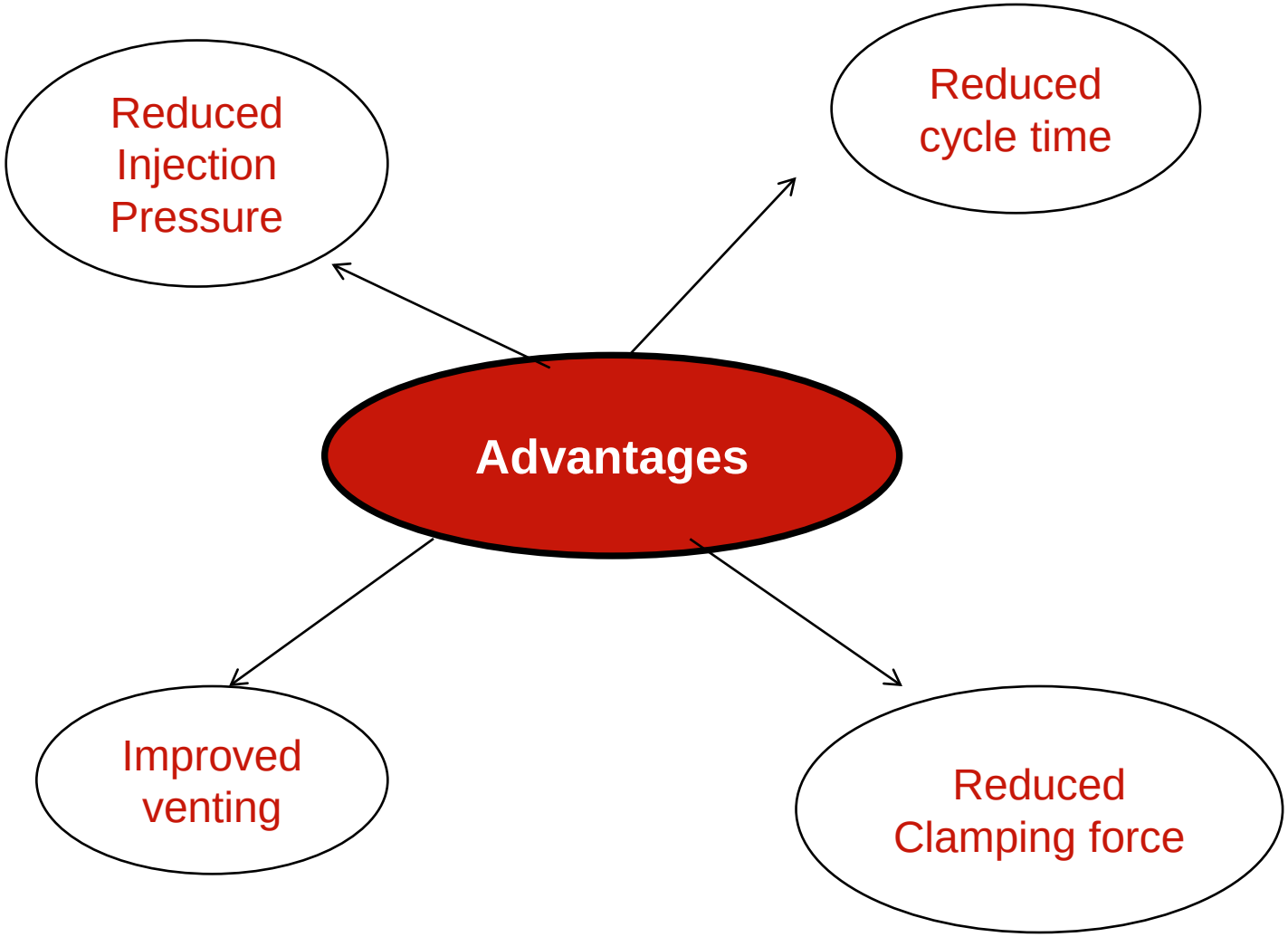


Apply hold pressure, cool, open mold, and eject part

Benefits of ICM for Parts



Benefits of ICM for Process



ICM Applications

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> Application Fields

- In-Mold decoration parts

- Optical parts

- Finely textured surfaces

ICM Applications

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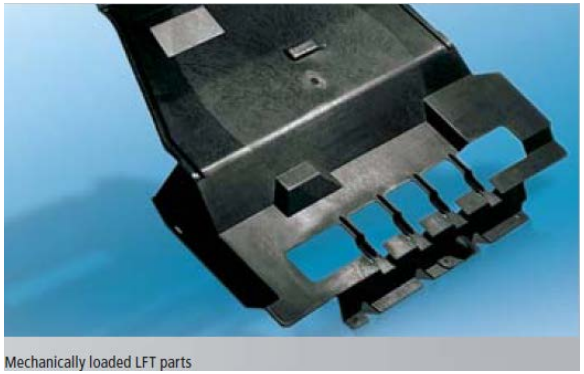
> Application Fields

- Automobile parts

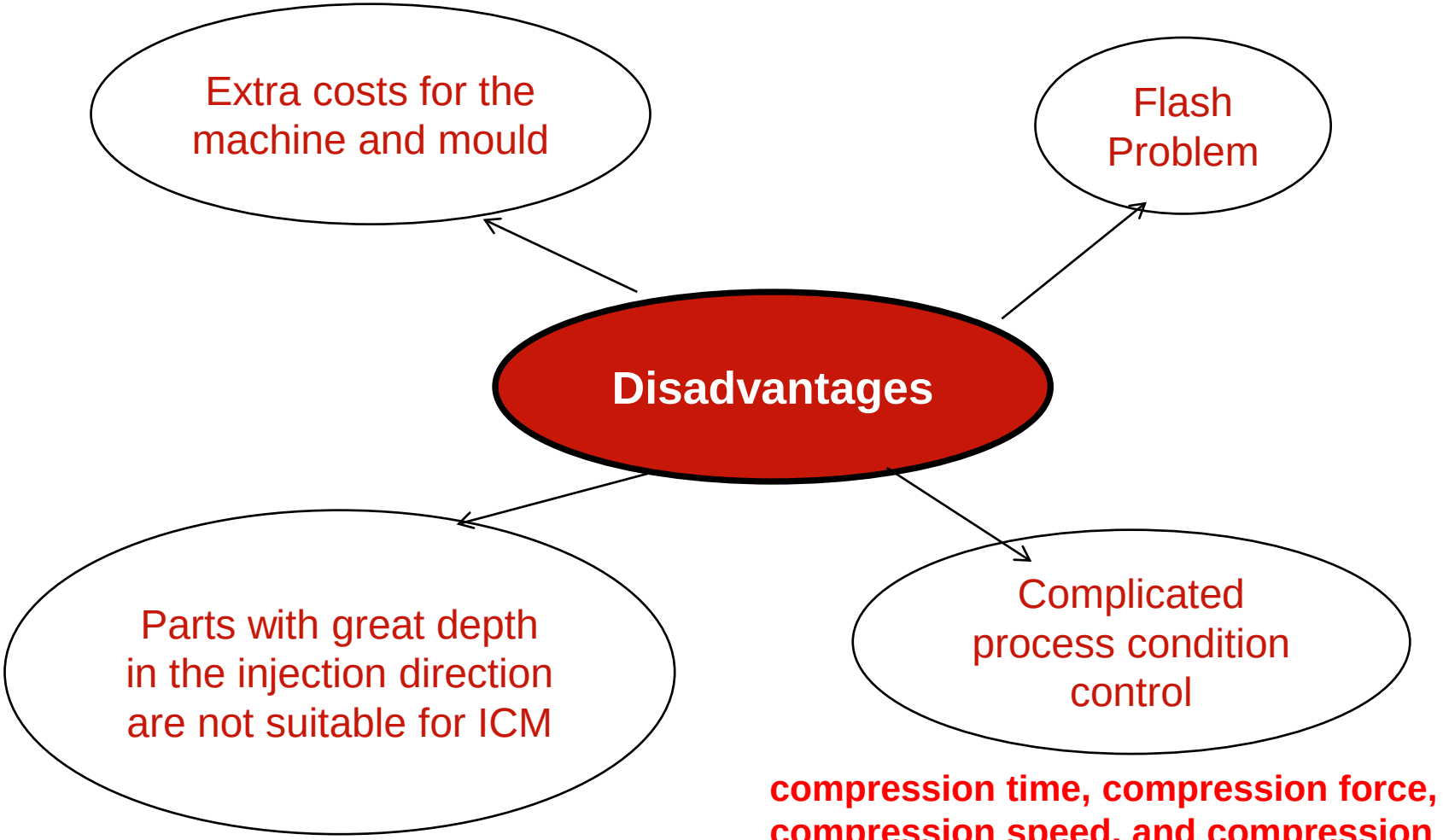


Mechanically loaded LFT parts

- 3C products (PDA cover, cell phone cover, Notebook cover etc.)

- Others(Fuel cell bipolar plate, SD card etc.)

Challenges for using ICM



compression time, compression force, compression speed, and compression distance

Key Issues for ICM

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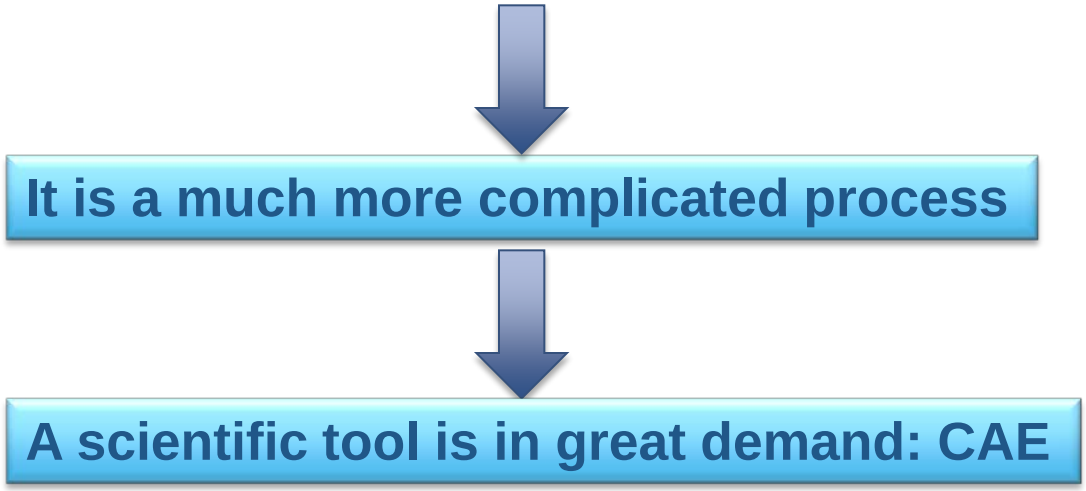
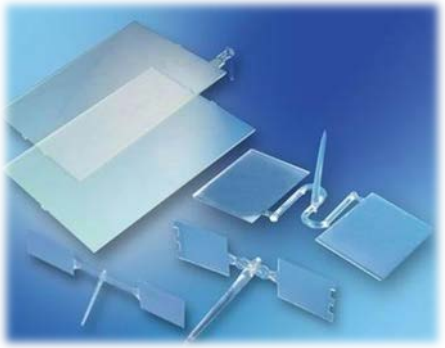
> Issues from CIM to ICM
  - Very complicated process parameter control,
  - Smaller process window,
  - The injection pressure, temperature, clamping force and their histories become very different,
  - The physical mechanism and the detailed internal information cannot be fully understood by the experiments,
  - Different materials have different viscosity, compressibility etc.



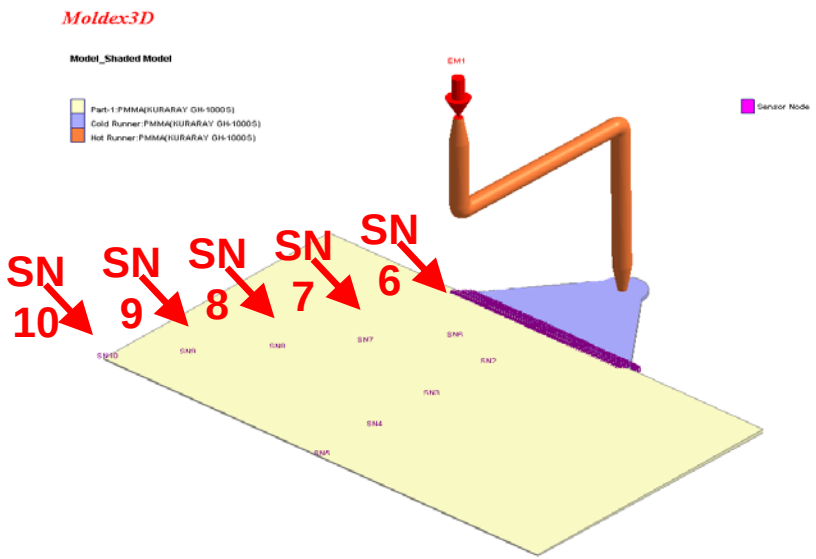
Case Study (1): light guide plate

Two different geometry designs and their effects on process and product quality

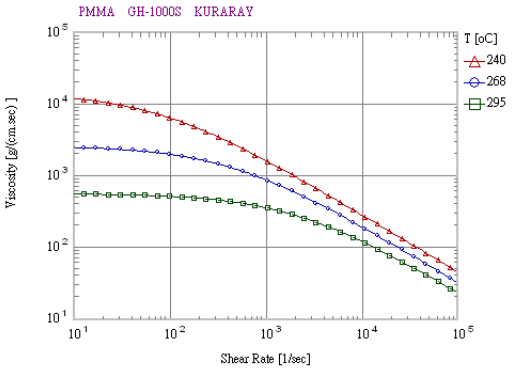


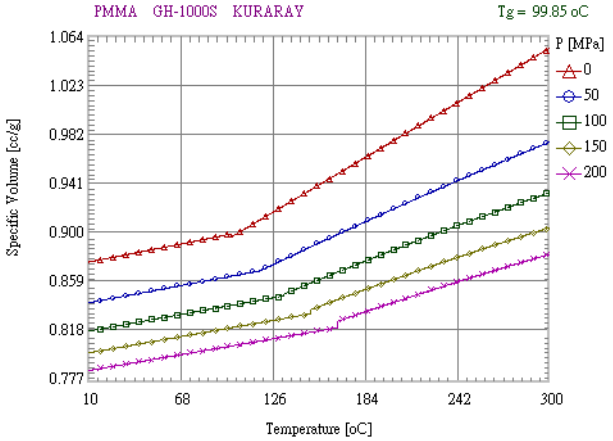
Two Type LGP Model

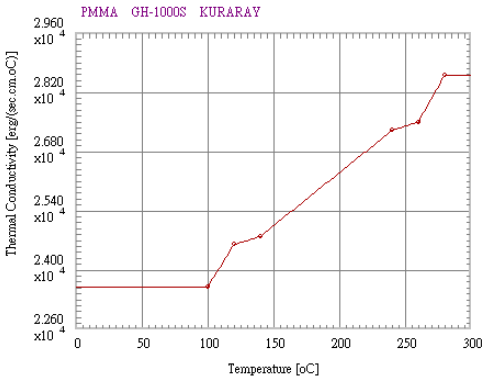
- Wedge LGP
  - 176mm × 99mm rectangular with wedge-shape, which the thickness varies from 1.5mm at one end to 0.5mm at the other end
- Flat LGP
  - 176mm × 99mm rectangular with constant thickness 1.0mm

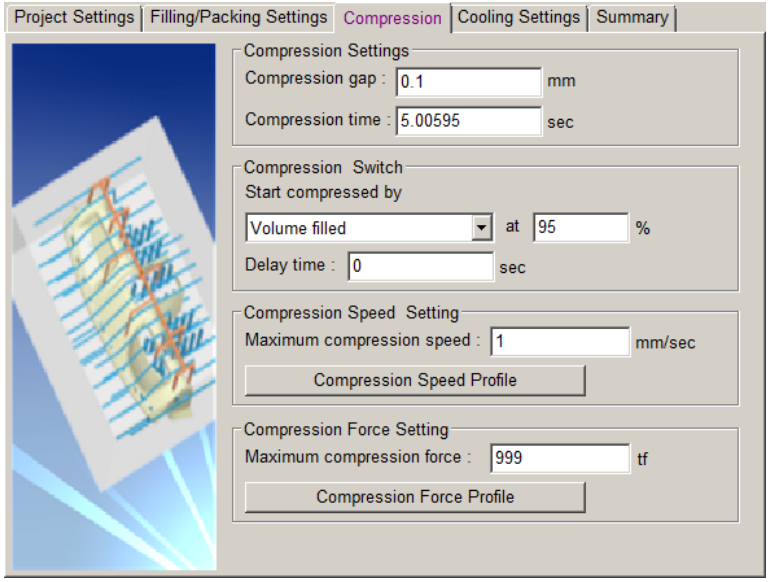


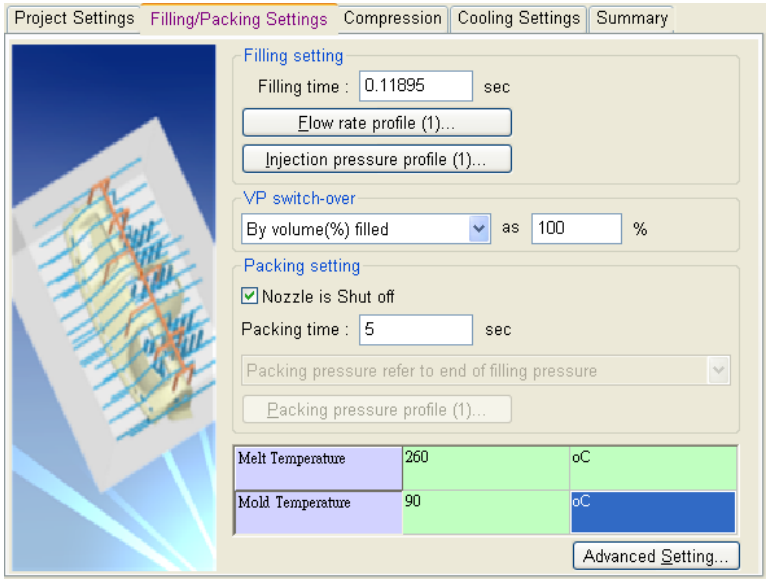
Material and Process Condition Information





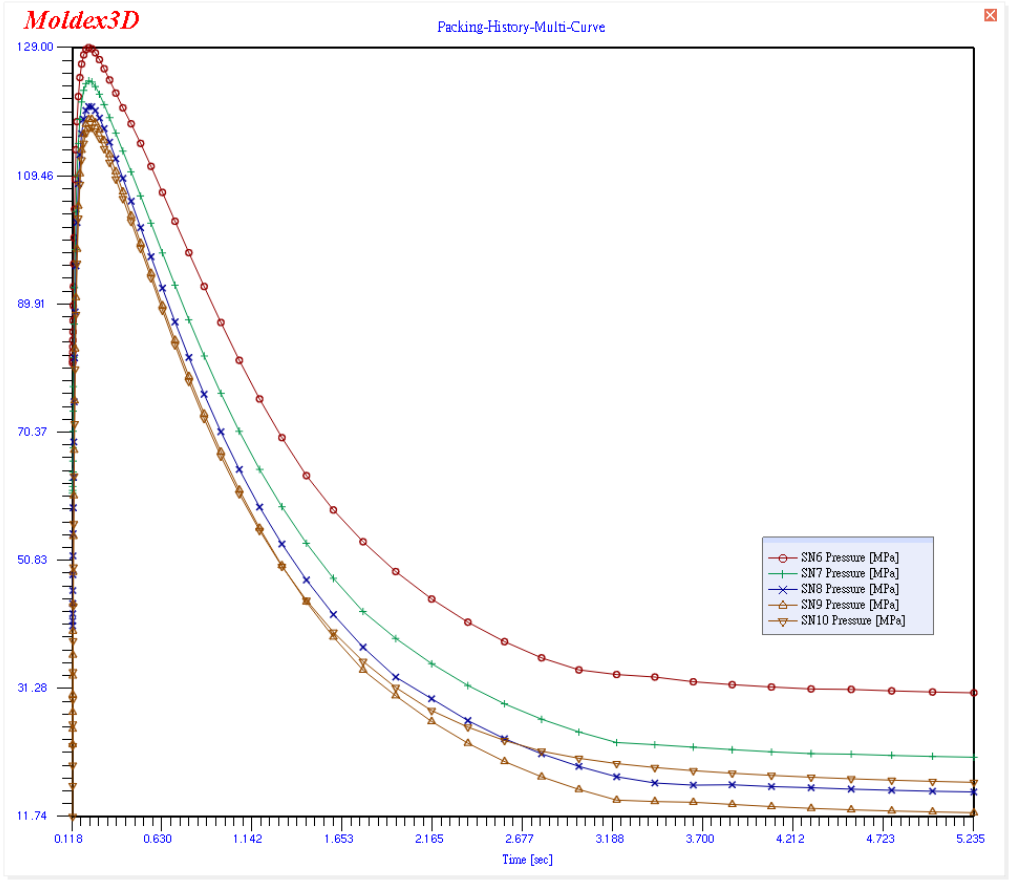


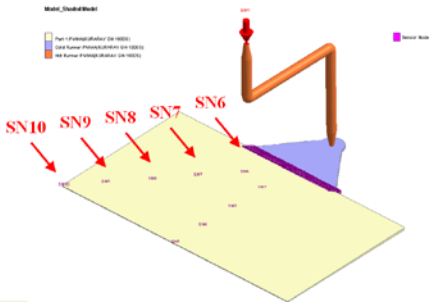




Flat LGP with CIM

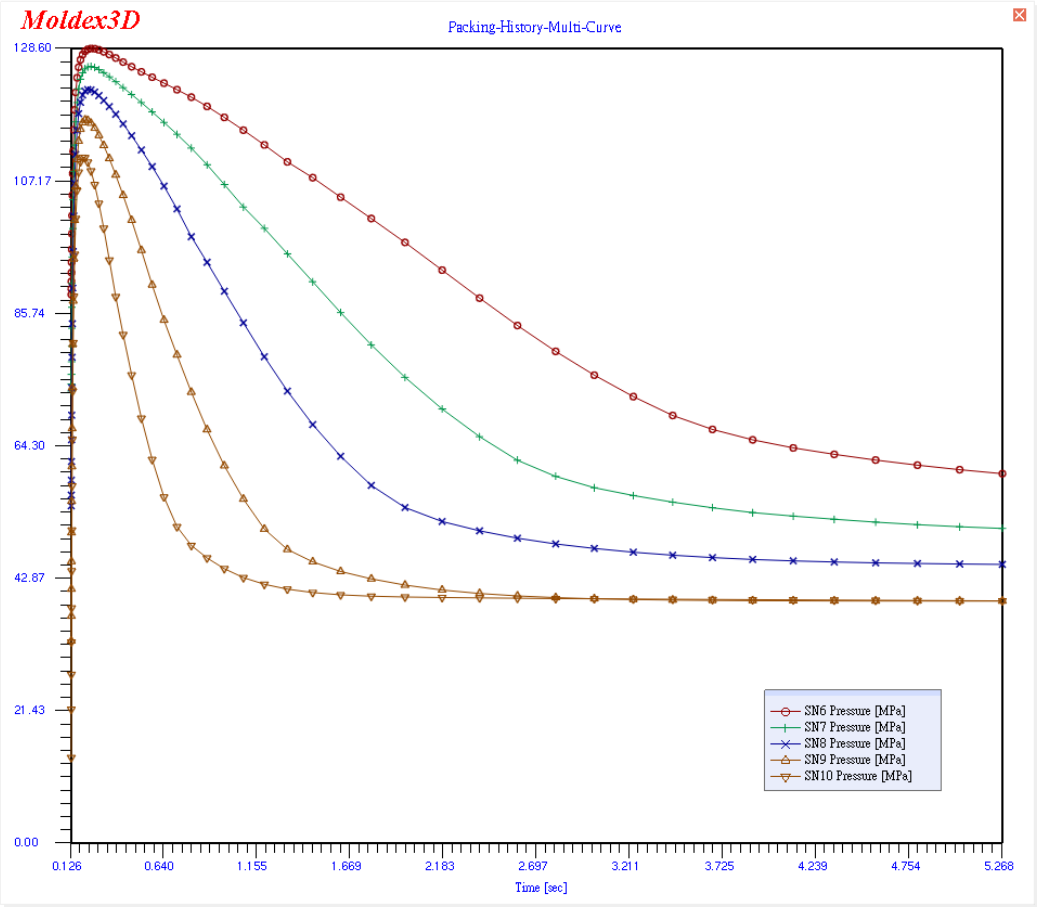
> During the packing stage of CIM, the pressure decreases smoothly as packing starts

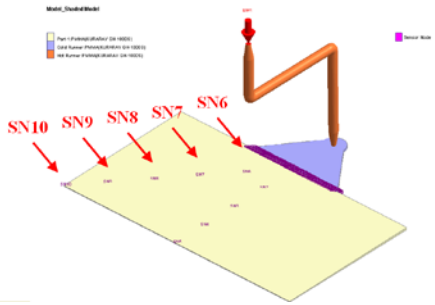




Wedge LGP with CIM

> During the packing stage of CIM, the pressure decreases smoothly as packing starts





Wedge LGP with ICM

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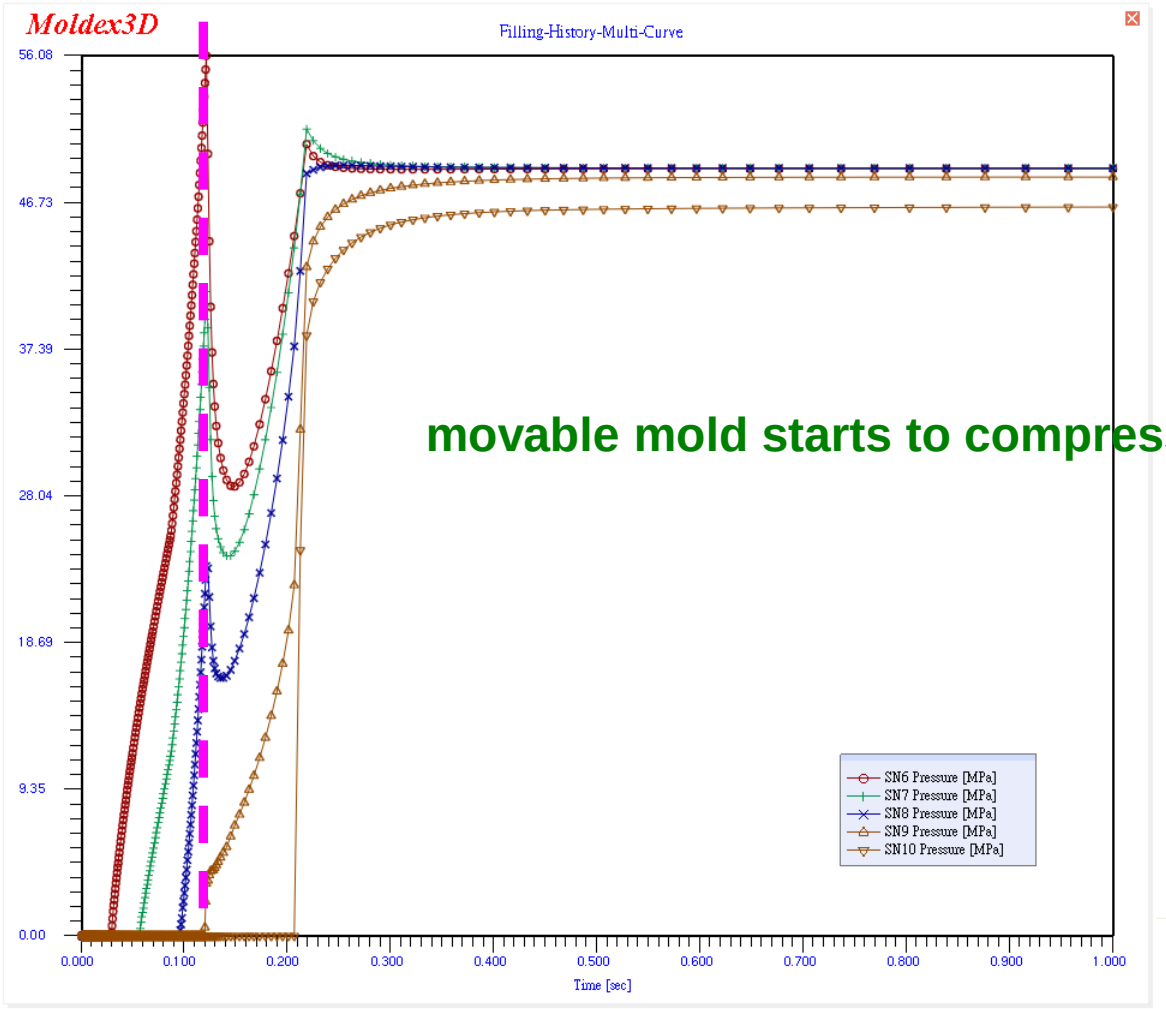
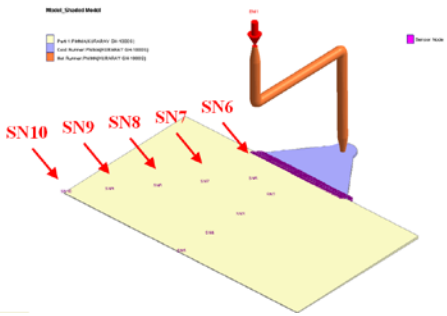
Gate is shut-off



movable mold starts to compress



Flat LGP with ICM

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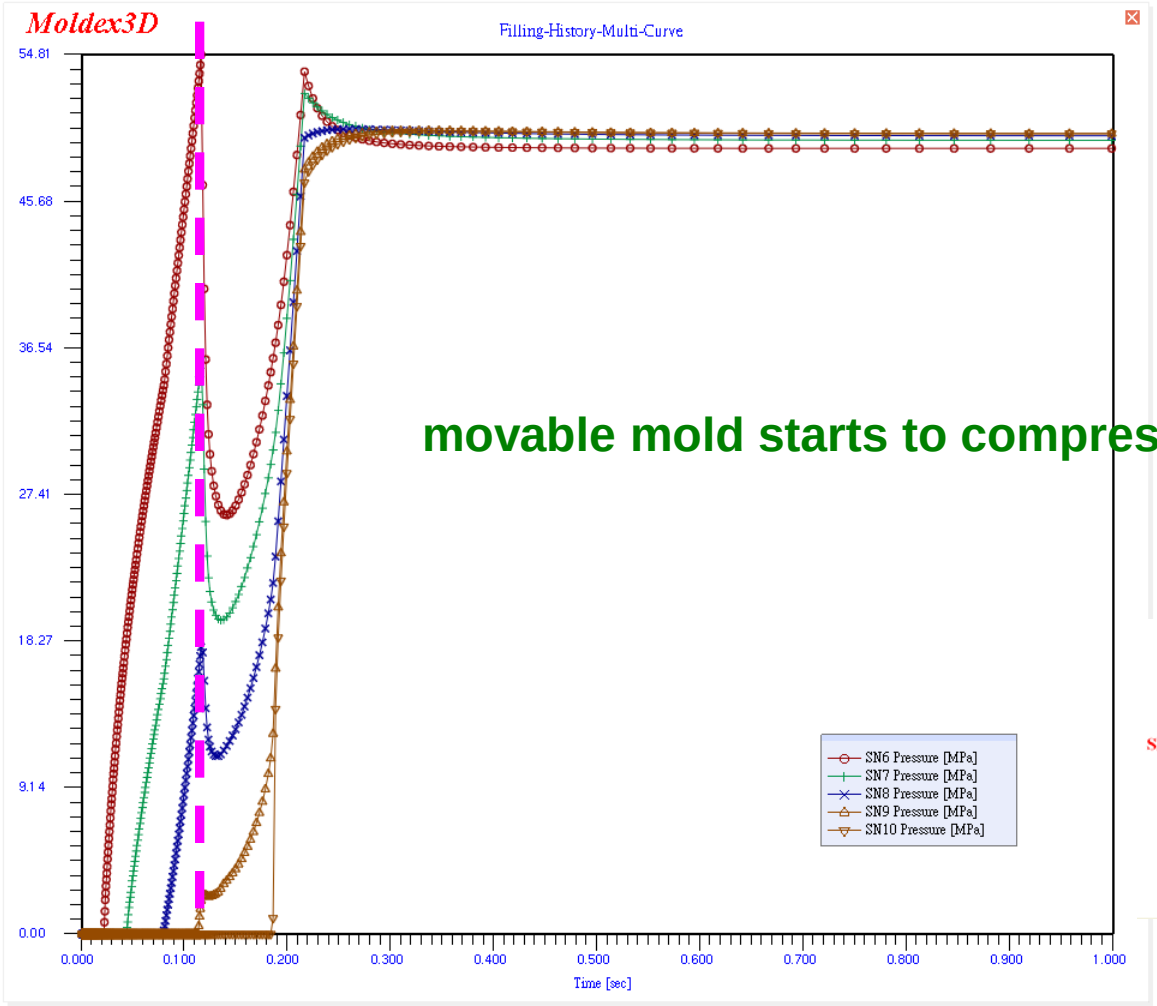
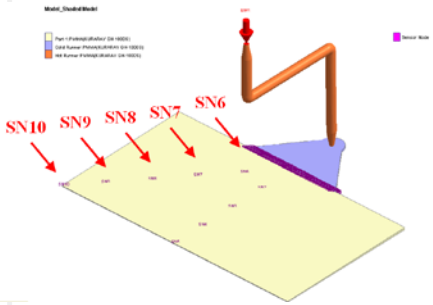
Gate is shut-off

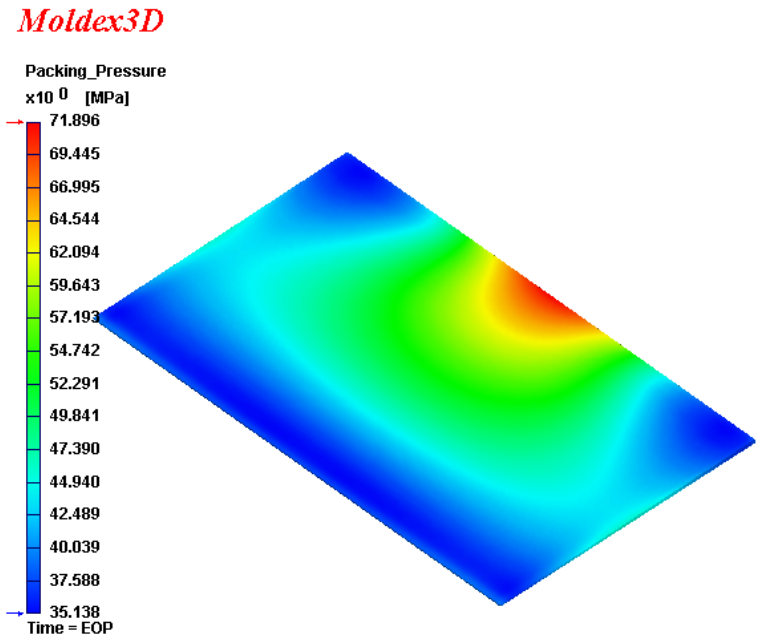


movable mold starts to compress

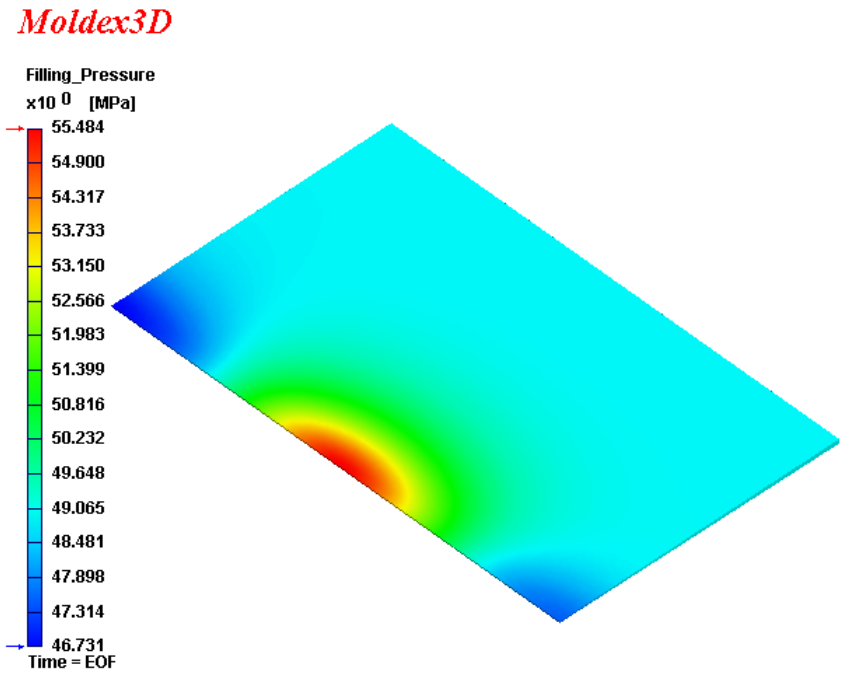


Wedge LGP

> ICM (46~55 MPa) process has more uniform pressure distribution than CIM (35~71 MPa)



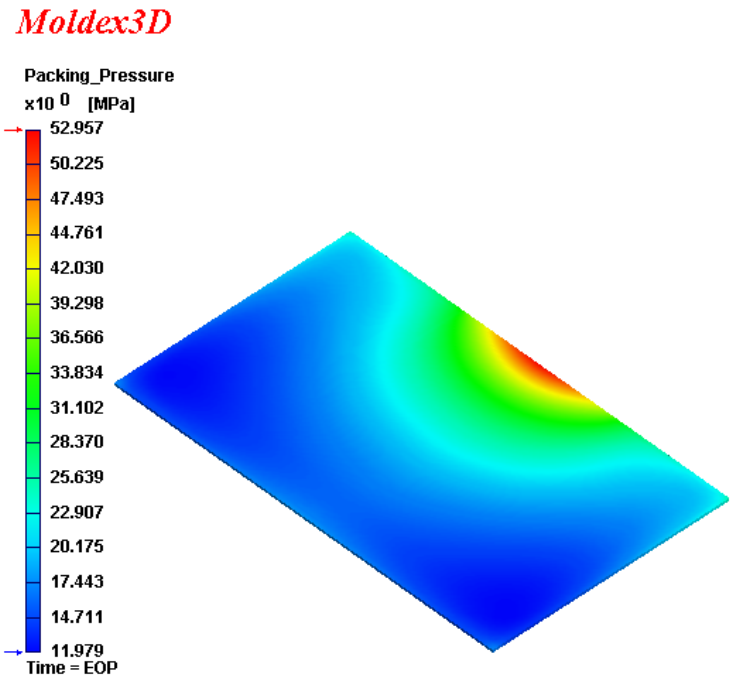
Conventional injection molding (CIM)



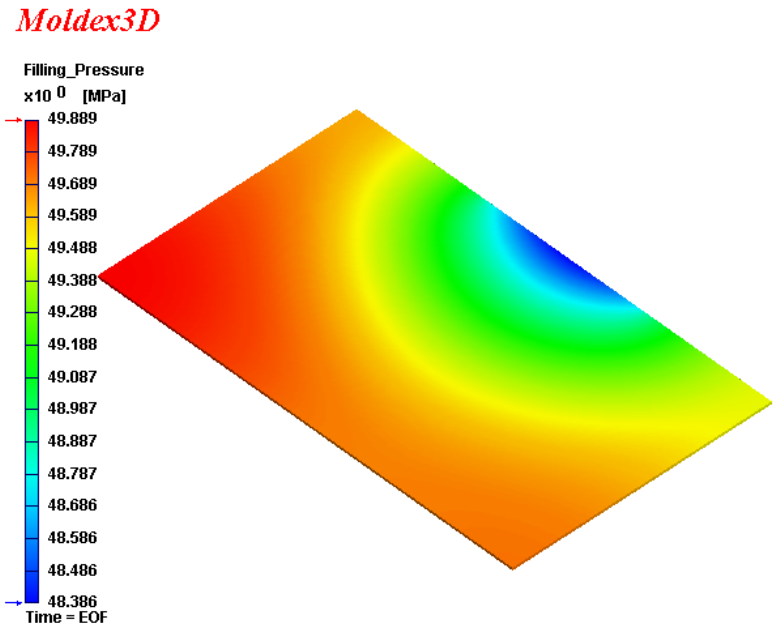
Injection compression molding (ICM)

Flat LGP

> ICM (48~50 MPa) process has more uniform pressure distribution than CIM (12~53 MPa)



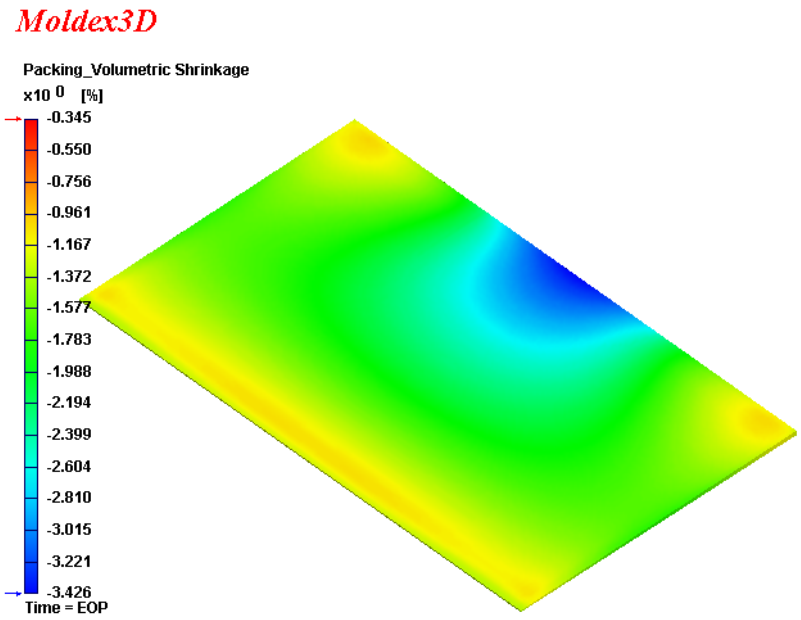
Conventional injection molding (CIM)



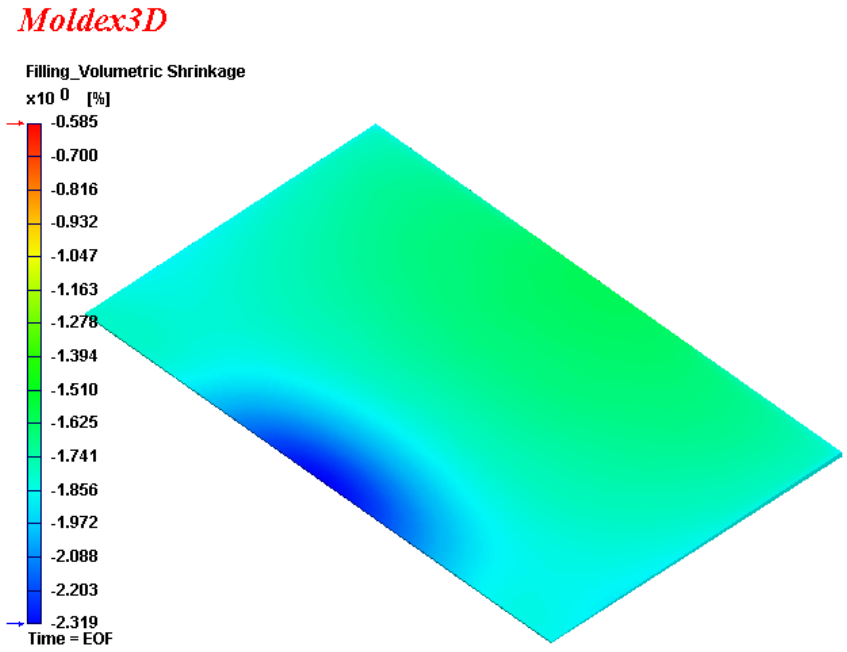
Injection compression molding (ICM)

Wedge LGP - Part Shrinkage

> ICM (-2.3 ~ -0.5 %) has smaller shrinkage variation than CIM (-3.4 ~ -0.3 %) (more uniform pressure distribution)



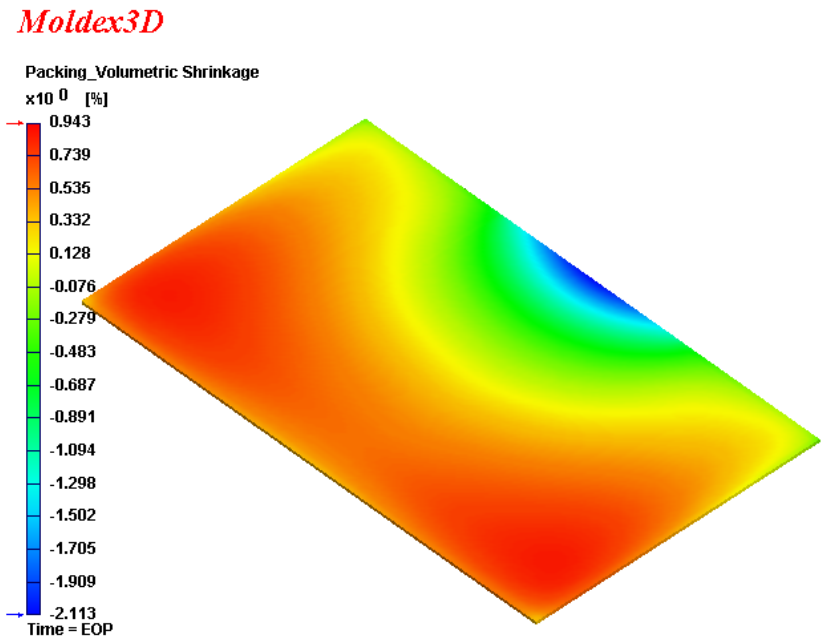
Conventional injection molding (CIM)



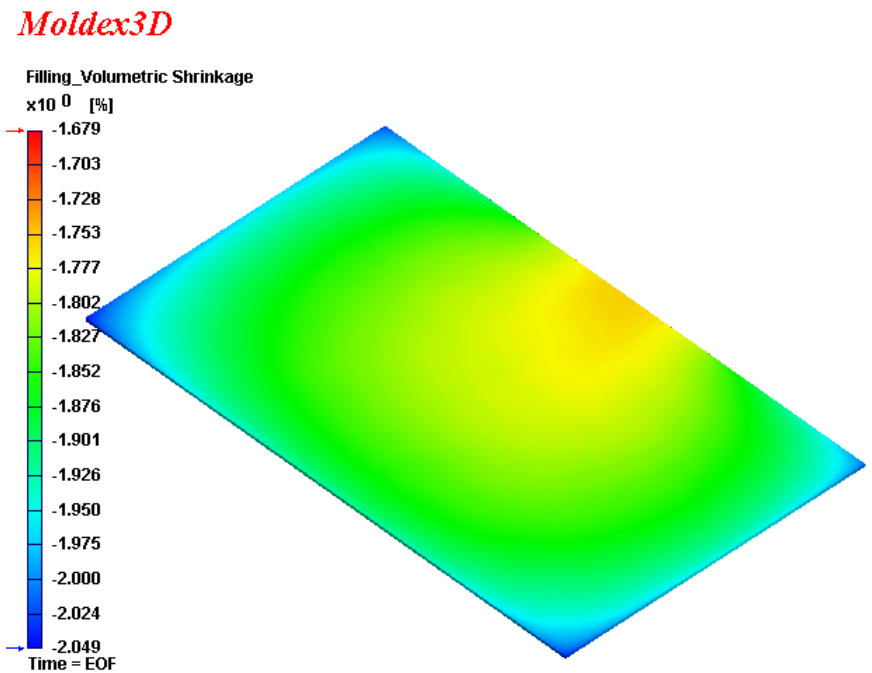
Injection compression molding (ICM)

Flat LGP - Part Shrinkage

> ICM (-2.0 ~ -1.6 %) has smaller shrinkage variation than CIM (-2.1 ~ 0.9 %) (more uniform pressure distribution)



Conventional injection molding (CIM)



Injection compression molding (ICM)

How to Setup Key Steps for Moldex3D to Simulate ICM processes

Numerical Theory-Basic Governing Equation

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- Full 3D theory
- Mass Conservation

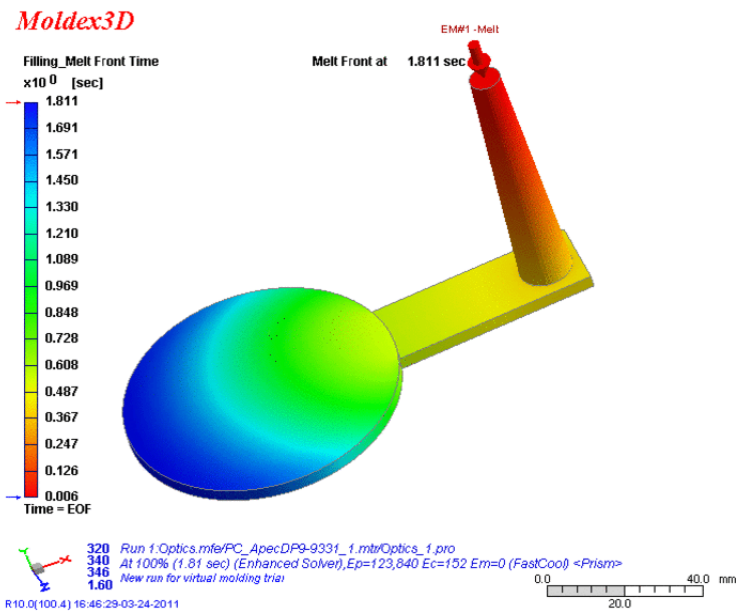
$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0$$

- Momentum Conservation

$$\frac{\partial}{\partial t}(\rho u) + \nabla \cdot (\rho u u - \tau) = -\nabla p + \rho g$$

- $$\rho C_P \left(\frac{\partial T}{\partial t} + u \cdot \nabla T \right) = \nabla (k \nabla T) + \frac{1}{2} \tau : (\nabla u + \nabla u^T)$$

- Moving Grid Approach



Numerical Theory-Constitutive Equations

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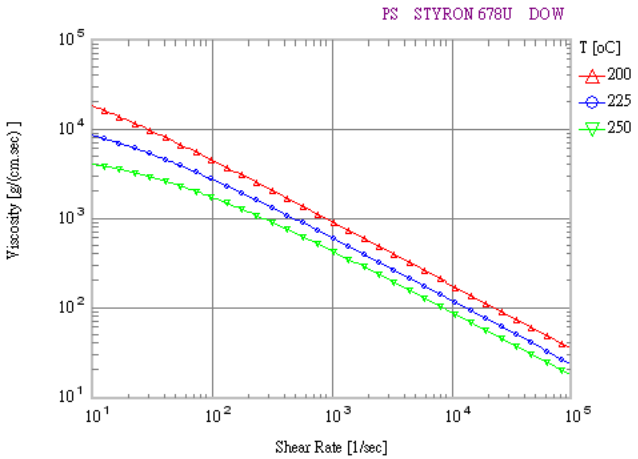
> Generalized Newtonian Fluid

– Modified-Cross model

$$\tau = \eta(T,\dot{\gamma})\left(\nabla \mathbf{u} + \nabla \mathbf{u}^T\right)$$

$$\eta(T,\dot{\gamma}) = \frac{\eta_o(T)}{1+\left(\eta_o \dot{\gamma}/\tau^*\right)^{1-n}} \qquad \eta_o(T) = BExp\left(\frac{T_b}{T}\right)$$



> Viscoelastic fluid

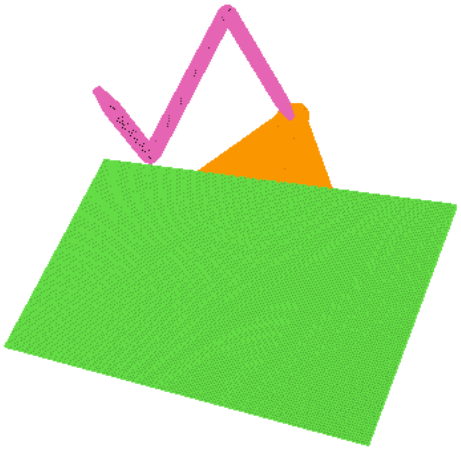
– Constitutive equation (ex White Metzner Model)

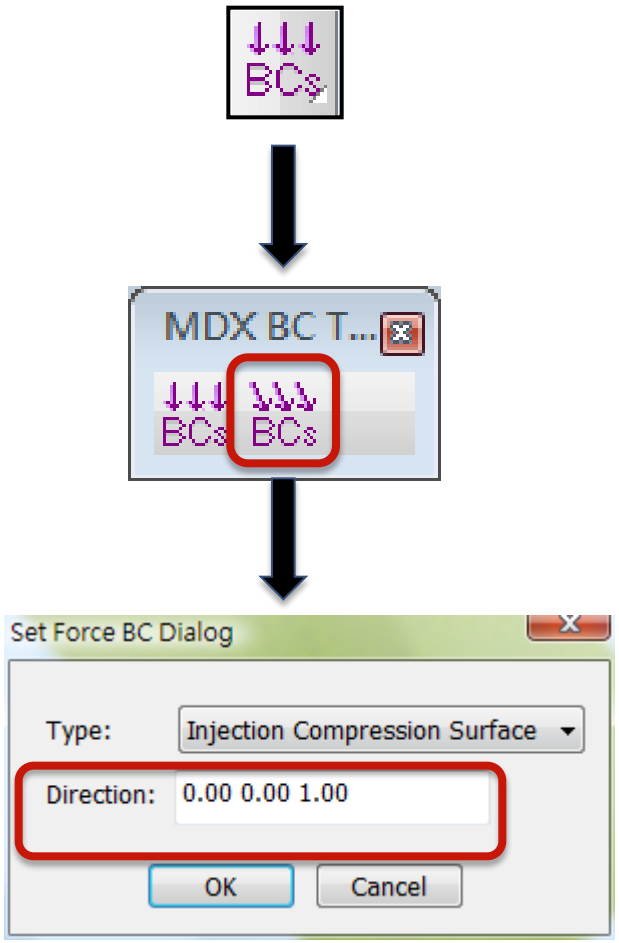
$$\tau + \lambda\left(\frac{\partial \tau}{\partial t} + \mathbf{V}\cdot\nabla\tau - \nabla\mathbf{V}^T\cdot\tau - \tau\cdot\nabla\mathbf{V}\right) = \eta\left(\nabla\mathbf{V} + \nabla\mathbf{V}^T\right)$$

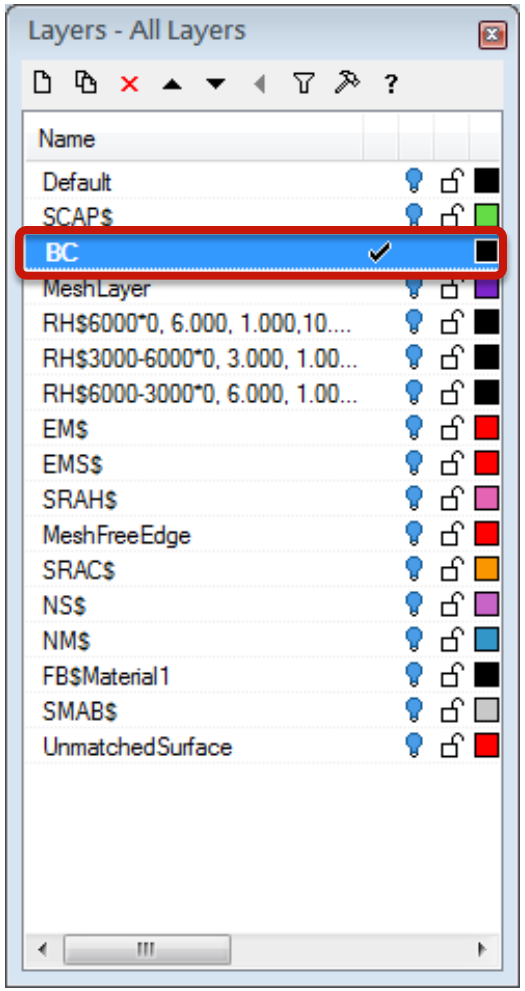
Add elastic characteristic term

Compression Surface Setting in Moldex3D-Mesh

Compression region setting in Moldex3D-Mesh

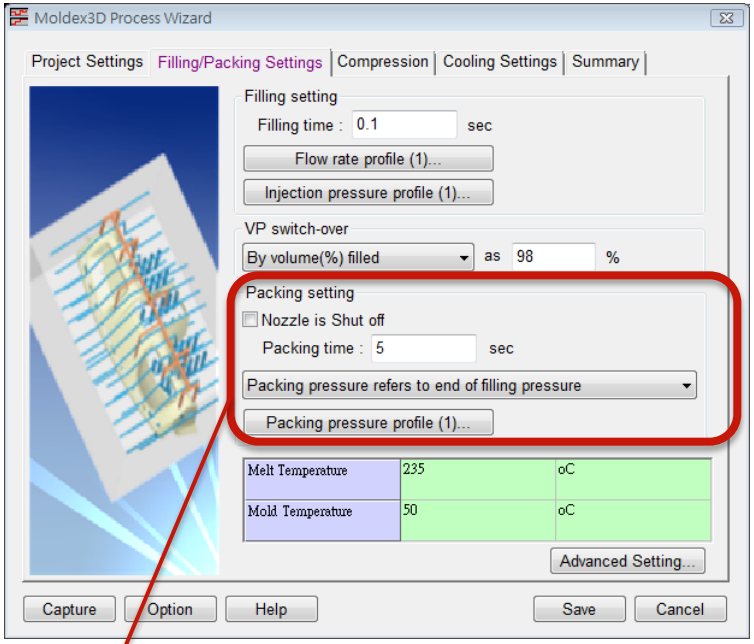


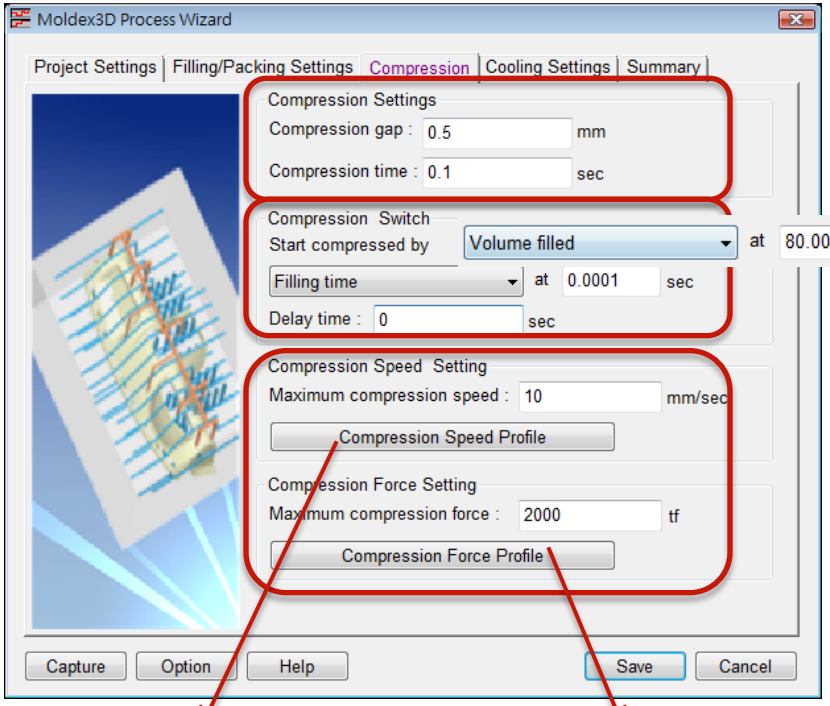


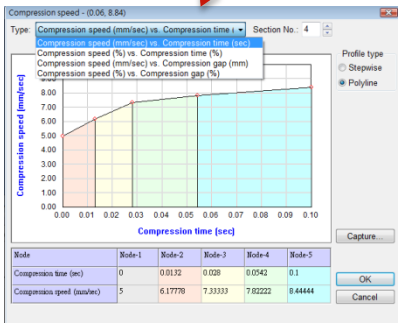


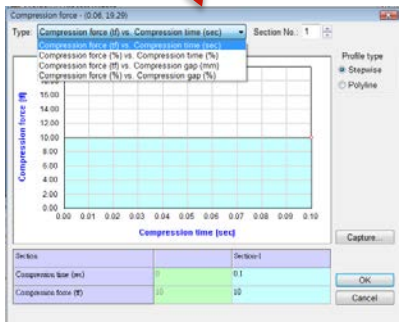
Process Parameter Setting in Moldex3D-Project

Process settings in Moldex3D-Project









Nozzle can be shut off before the beginning of compression

29

Injection Compression Simulation - Key points and features

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- The compression gap, compression speed, delay time and other settings for ICM are all available in process wizard.
- Support injection and compression processing at the same time
- Support new meshing method: compression gap solid mesh
- Support animation of compression action on melt
- Support to calculate flow residual stress and thermally-induced stress.
- Support connection with optical analysis.
- Support multiple-component parts.
- Support multiple-time output.

What we can conclude?

Conclusions

- We have introduced Injection compression and its current industrial applications.
- We have pointed out the issues in design and development for injection compression products.
- We have proposed a useful tool: An innovative 3D injection compression simulation technology-Moldex3D.
- We have learned the benefits from using Moldex3D on practical studies.
- Moldex3D can help us to reduce real mold trials and product development time to save money and time.

Moldex3D

Thank you for your attention!

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