The Filling Process of Molding Ultra-Thin Parts with Multi-Cavities

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- Introduction
- Experimental Setup
  - Mold Design
  - Injection Machine
- Results and Discussion
  - Cavities filling process
  - The pressure variation during filling process
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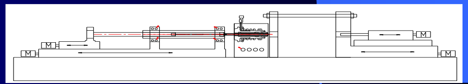
- Conclusions

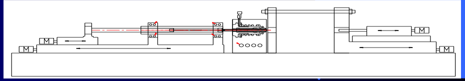


Introduction

- The definition of thin part (Losch1997) :

1. The thickness of molding parts is less than 1.5mm
2. The ratio of flow length to cavity thickness is more than 100 : 1

In this study the thickness of molding parts is 100μm and 250μm, and flow length is 5mm



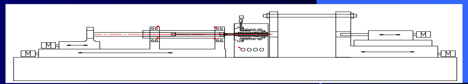
The Demends of Molding Ultra-Thin Parts

- Due to the extremely high flow resistance and fast heat transfer, ultra-thin parts is difficult to mold.

- Results:

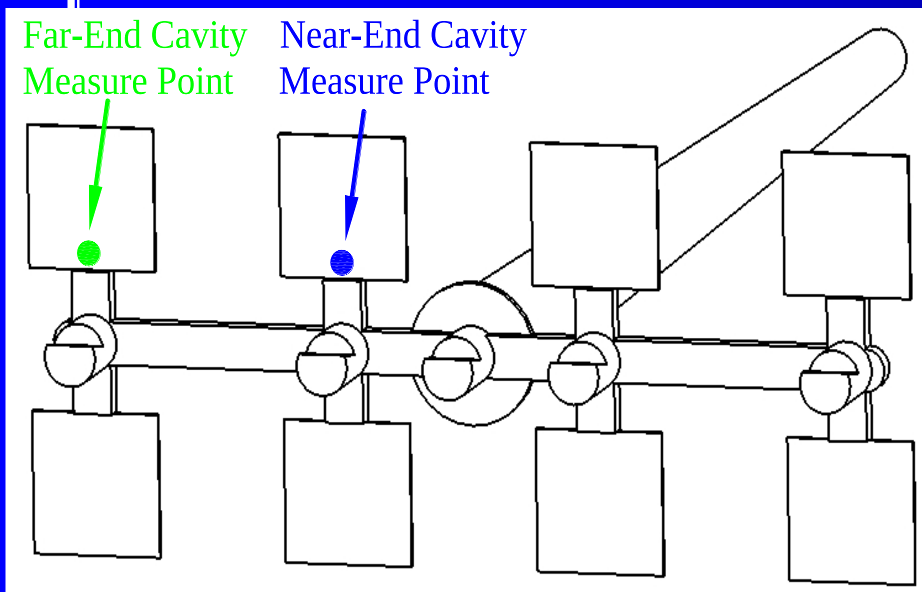
1. High Injection Rate
   - short heat transfer time
   - high shear-thinning
   - high shear-heating

2. High Mold Temperature
   - decrease heat flux between the boundary of mold and melt

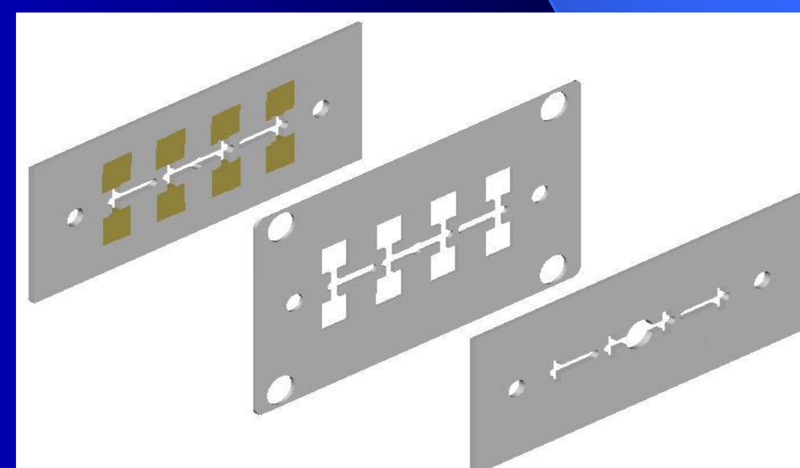


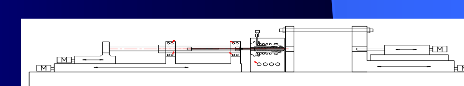
The Illustration of Molded Parts

Cavities: 5mm x 5mm square with thickness of 100μm and 250μm

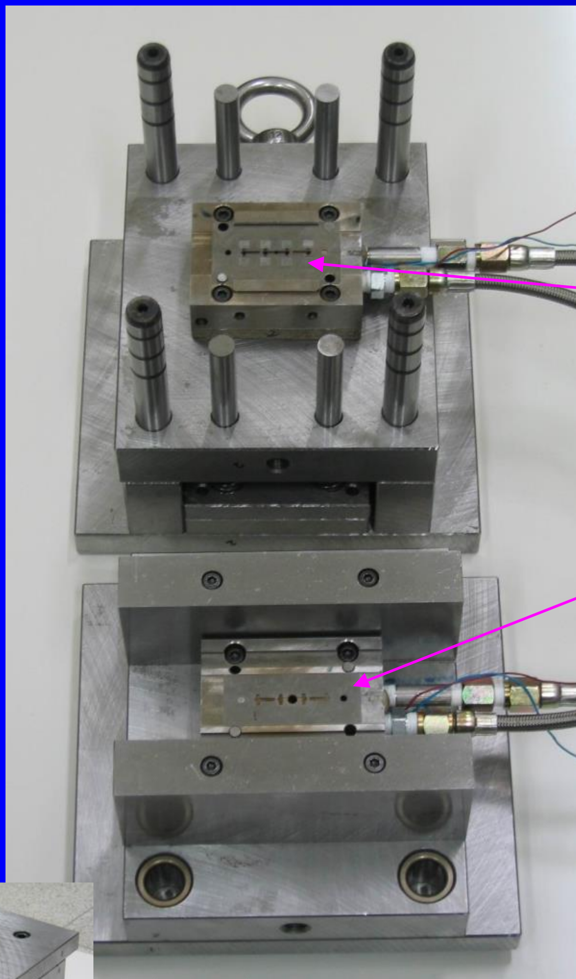


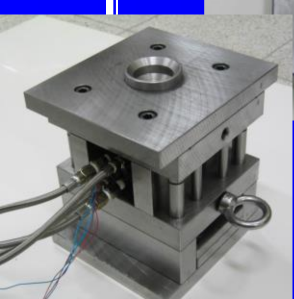
Runner: cavity thickness + 0.6mm

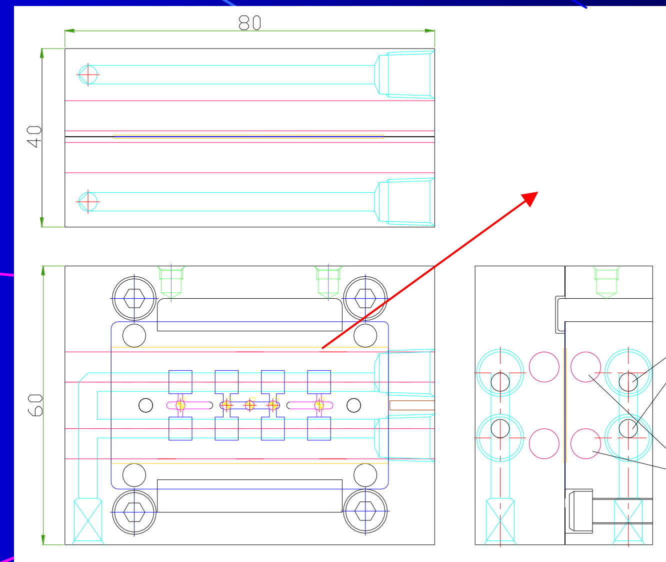




Mold Design



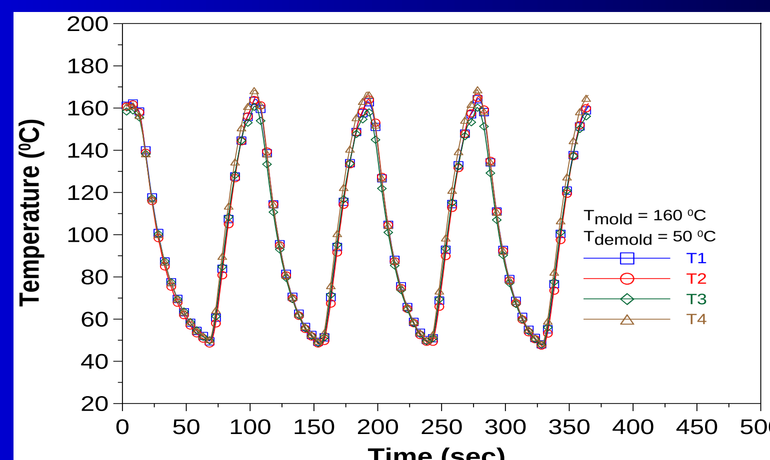




Rapid cooling / heating system

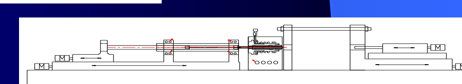
Cooling channel

Heater



Cooling 50sec

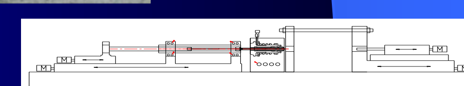
Heating 36sec



Injection Machine

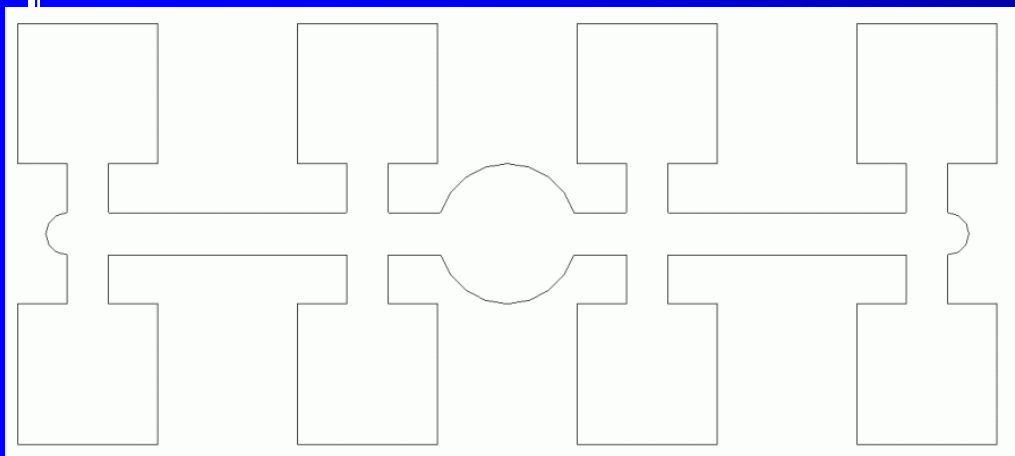
FANUC α-15iA

Clamping Force:15 tonf
Screw Diameter：16 mm
Max. Injection speed：200 mm/s
Max. Injection Pressure：220 MPa

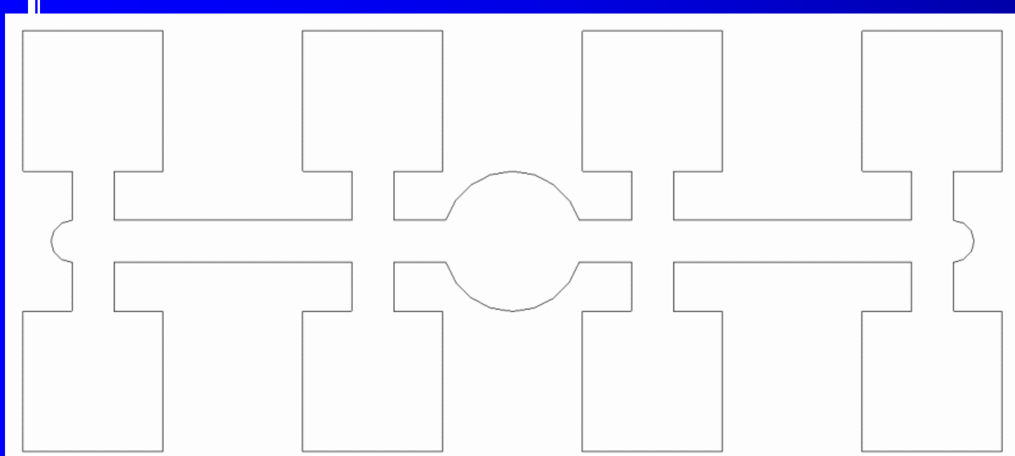


Cavities Filling Process

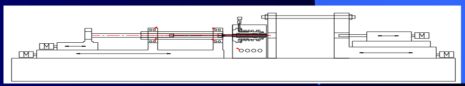
- The melt fronts are observed with short-shot samples



Cavity thickness 250μm
Runner thickness 850μm
Injection Speed=80mm/sec
Mold Temp.=80°C

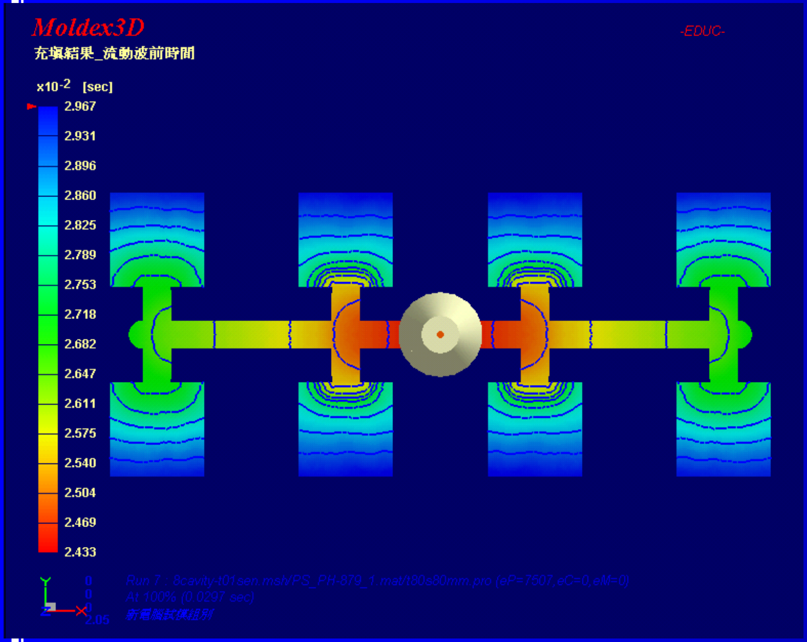


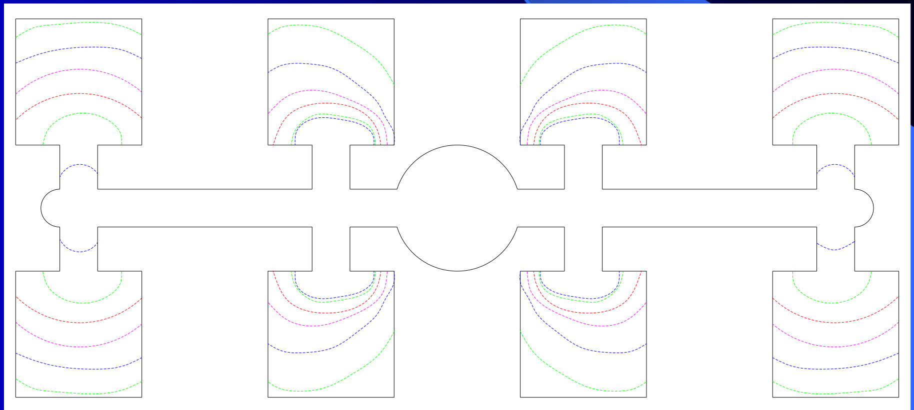
Cavity thickness 100μm
Runner thickness 700μm
Injection Speed=80mm/sec
Mold Temp.=80°C



Simulation

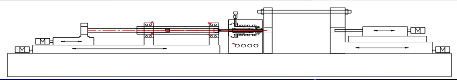
- Moldex 3D (Taiwain)
- Cavity thickness 100μm , Runner thickness 700μm)
- Speed=80mm/sec,Tmold=80°C



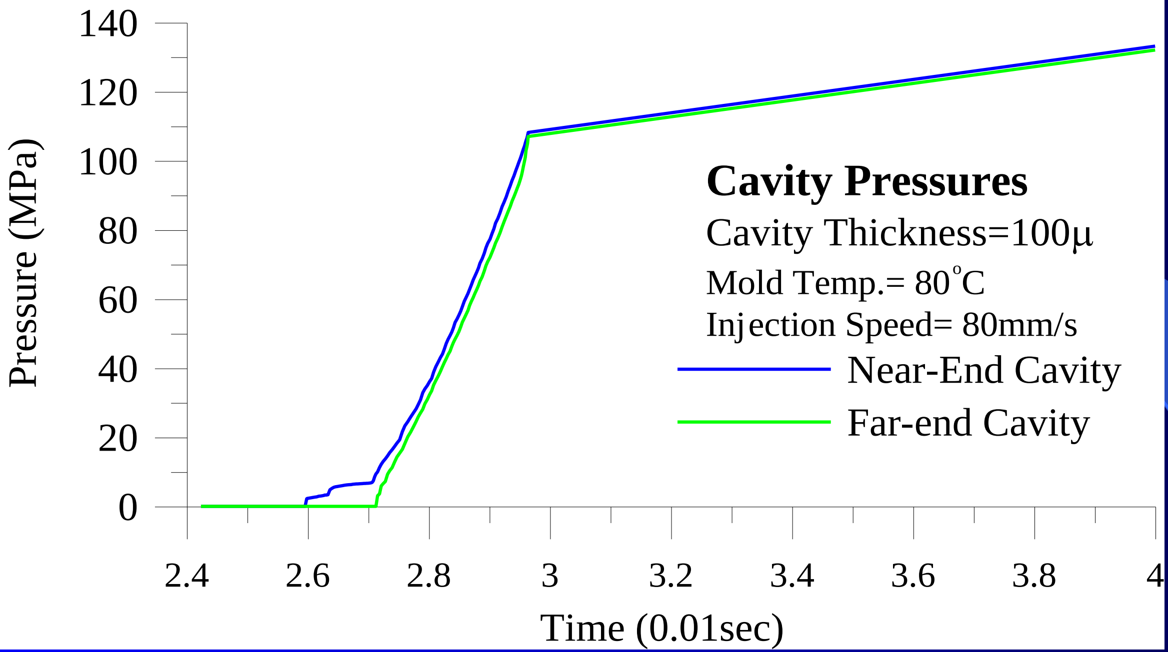


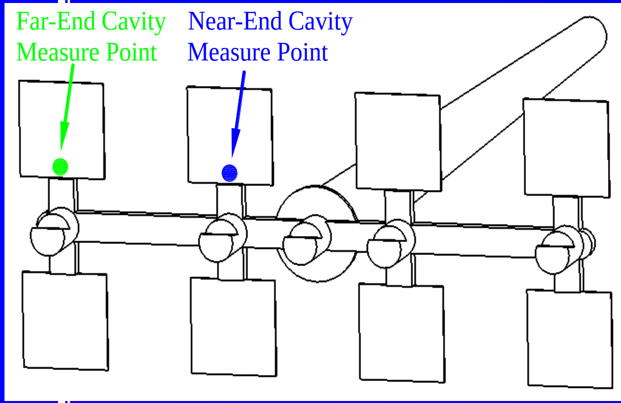
Experiment: Short-Shot Samples

Simulation: Melt Front

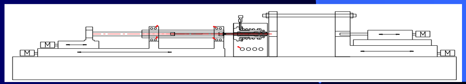


The Simulation Results of Cavities Pressure Variation During Filling Process

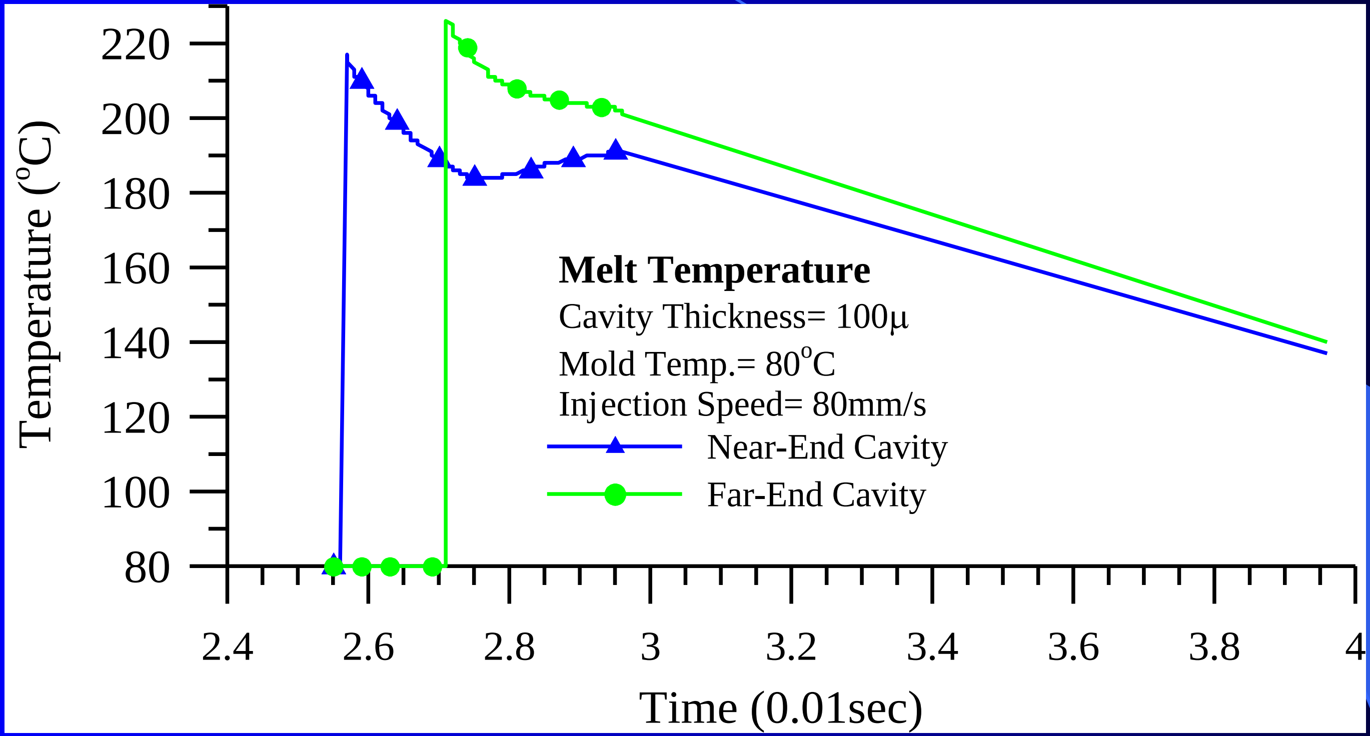




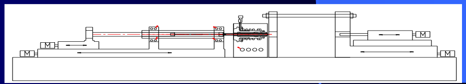
The pressure rise in the entrance of near-end cavities between 0.026 and 0.027 seconds is slow since the flow resistance to enter the cavity of 100μm thick is much larger than that to flow in runner leading to the far-end cavities.



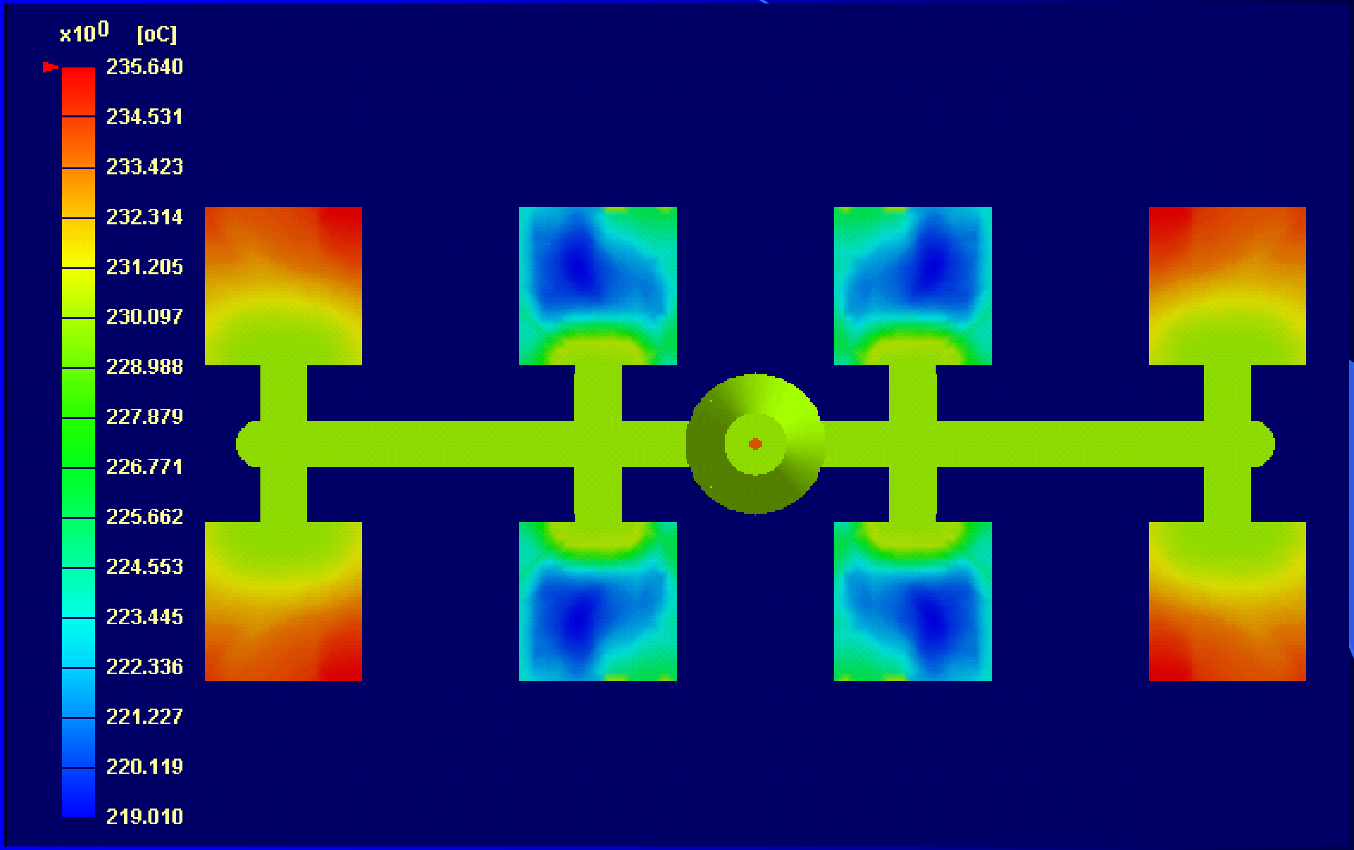
The Simulation Results of Melt Temperature During Filling Process



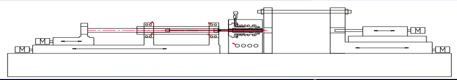
1. During the short interval of 0.1 ms (0.026 to 0.027 seconds) , the melt temperature in near-end cavity is cooled down from 206℃ to 189 ℃.
2. The decrease of melt temperature and flow speed causes the increase of melt viscosity which will result in the lag of the melt-front advancement.



The Simulation Results of Melt Front Temperature During Filling Process



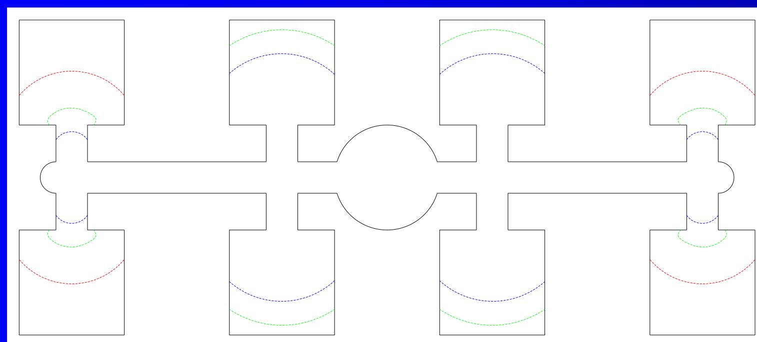
The far-end cavities are filled under higher temperature than the near-end cavities



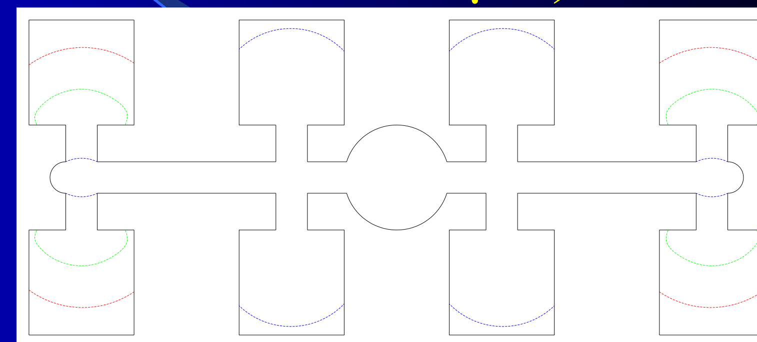
250μm Cavities Filling Process under Various Operating Parameters

- The melt fronts are observed with short-shot samples (Cavity thickness 250μm , Runner thickness 850μm)

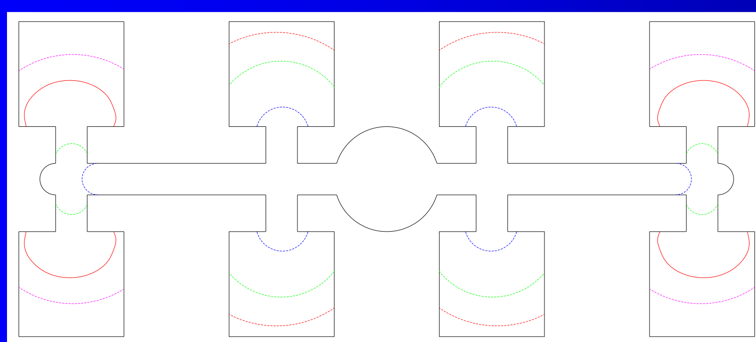
Mold Temp.



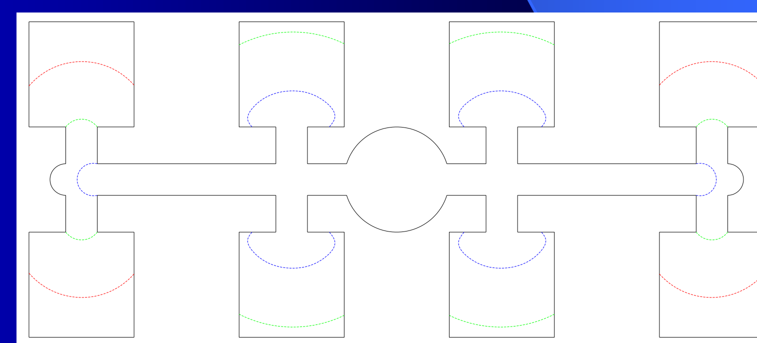
Speed=80mm/sec,T_{mold}=140°C



Speed=160mm/sec,T_{mold}=140°C

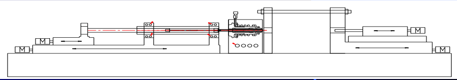


Speed=80mm/sec,T_{mold}=80°C



Speed=160mm/sec,T_{mold}=80 °C

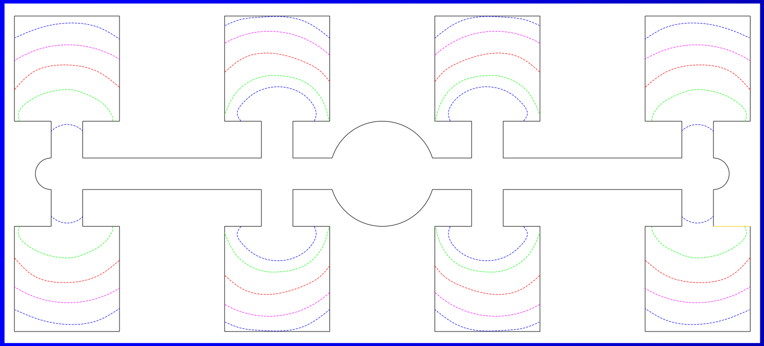
Injection speed



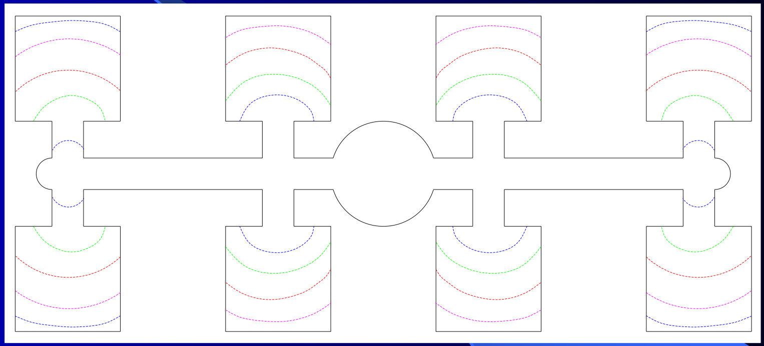
100μm Cavities Filling Process under Various Operating Parameters

- Cavity thickness 100μm , Runner thickness 700μm

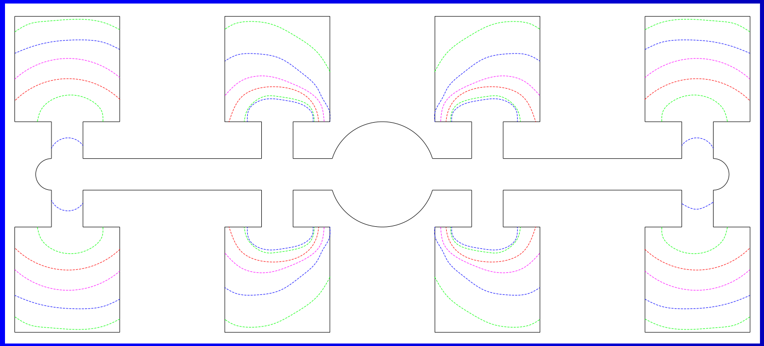
Mold Temp.



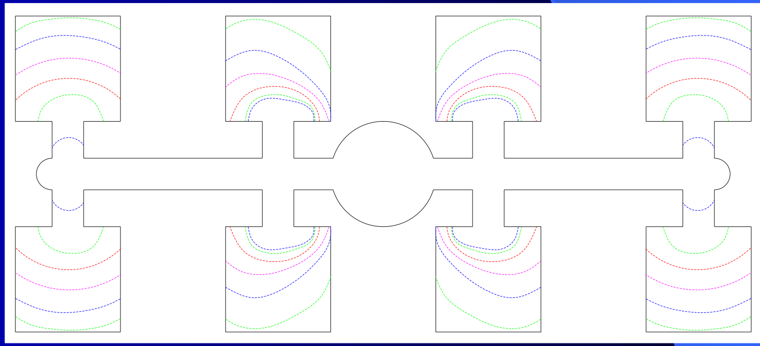
Speed=80mm/sec,T_{mold}=140°C



Speed=160mm/sec,T_{mold}=140°C

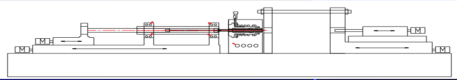


Speed=80mm/sec,T_{mold}=80°C



Speed=160mm/sec,T_{mold}=80 °C

Injection speed



Conclusion

1. The flow hesitation will occur in near-end cavity when the cavity thickness is extremely thin compared to the runner dimensions.
2. The pressure arising speed of near-end cavity is slow when the melt is flowing in the runner leading to the far-end cavities. Consequently, this causes the melt temperature which in the near-end cavities are rapidly cooled down.
3. The decrease of melt temperature and flow speed causes the increase of melt viscosity which will result in the lag of the melt-front advancement.
4. Mold temperature is a critical processing parameter. High mold temperature can retard the effect of hesitation.