

การประยุกต์ใช้ แม่พิมพ์ระบบทางวิ่งร้อน
เพื่อเพิ่มผลผลิต ในกระบวนการฉีดพลาสติก

Apply hot runner system
for
Increase productivity



PHAISAL KASIKUM, PDT/KMITNB

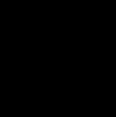
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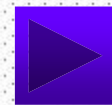
วันศุกร์ที่ 21 กันยายน 2561





เมื่อไร? เราจึงจะใช้ระบบ Hot Runner

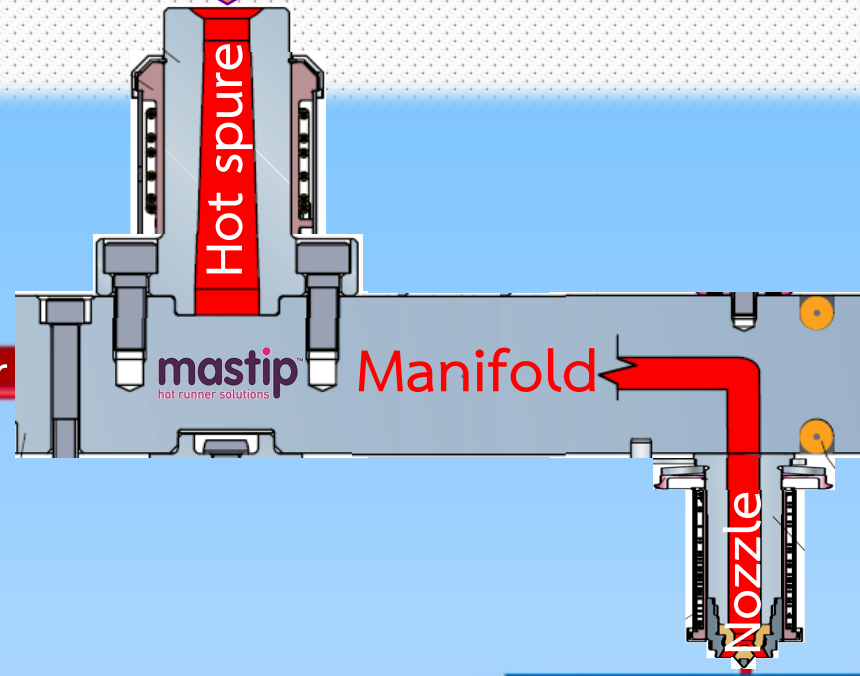
1. ชิ้นงานที่มีน้ำหนักน้อยแต่จำนวน Cavity มากๆ
2. ชิ้นงานที่ใช้พลาสติกทางวิศวกรรมซึ่งฉีกยากและมีราคาสูง
3. ชิ้นงานที่มีผนังบางมาก
4. ชิ้นงานที่มีผนังหนา
5. ชิ้นงานที่ต้องการลดตำหนิที่ทางเข้า (Gate)
6. ชิ้นงานที่มีปริมาณการผลิตสูง
 - ต้องการลดส่วนที่เป็น Runner
 - ต้องการลดรอบการผลิตจาก
Mold Open & Close and Cooling Runner
7. เมื่อคำนวณแล้วมีจุดคุ้มทุนในระยะเวลาที่เทียบกับปริมาณการผลิตตลอดการใช้งานของแม่พิมพ์นั้น



Structure of Hot Runner



From Injection Machine



Sub - Runner

Main Runner

Hot spure

mastip
hot runner solutions

Manifold

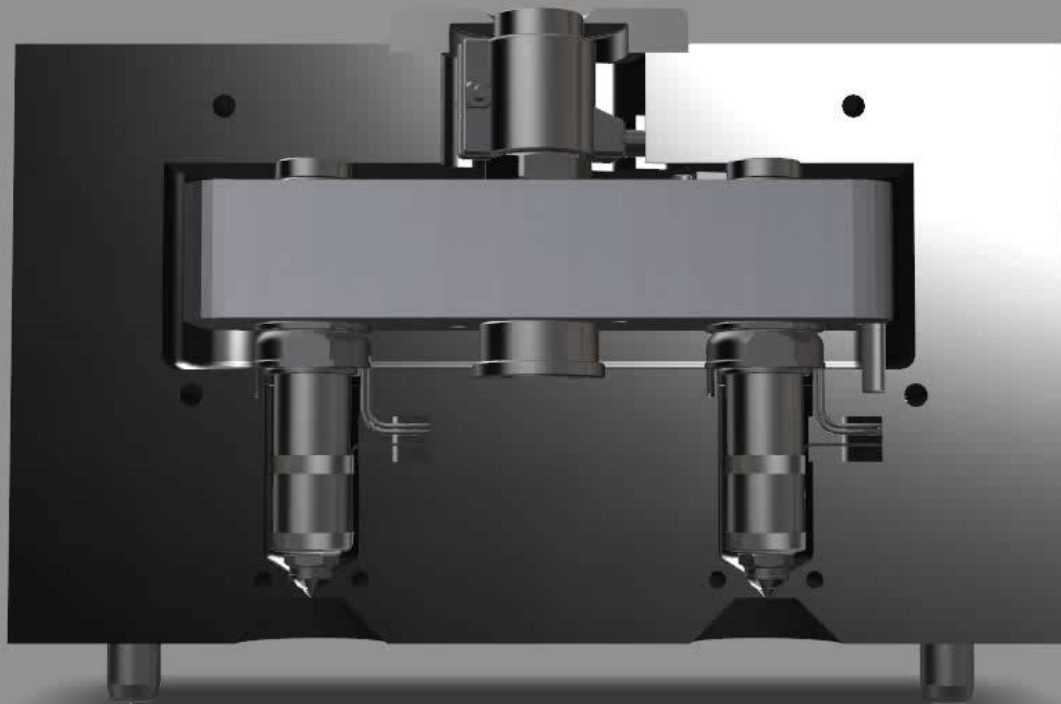
Nozzle





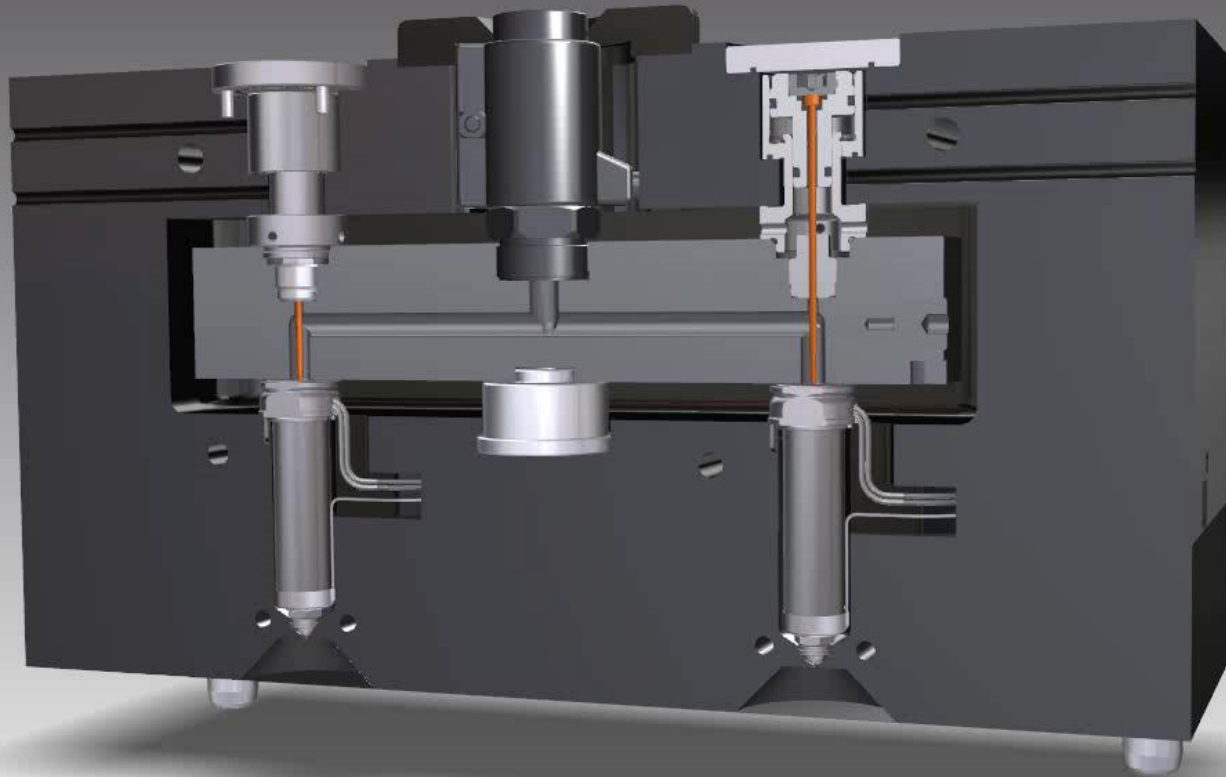
Structure of Hot Runner with Normal Gate

mastip[™]
hot runner solutions

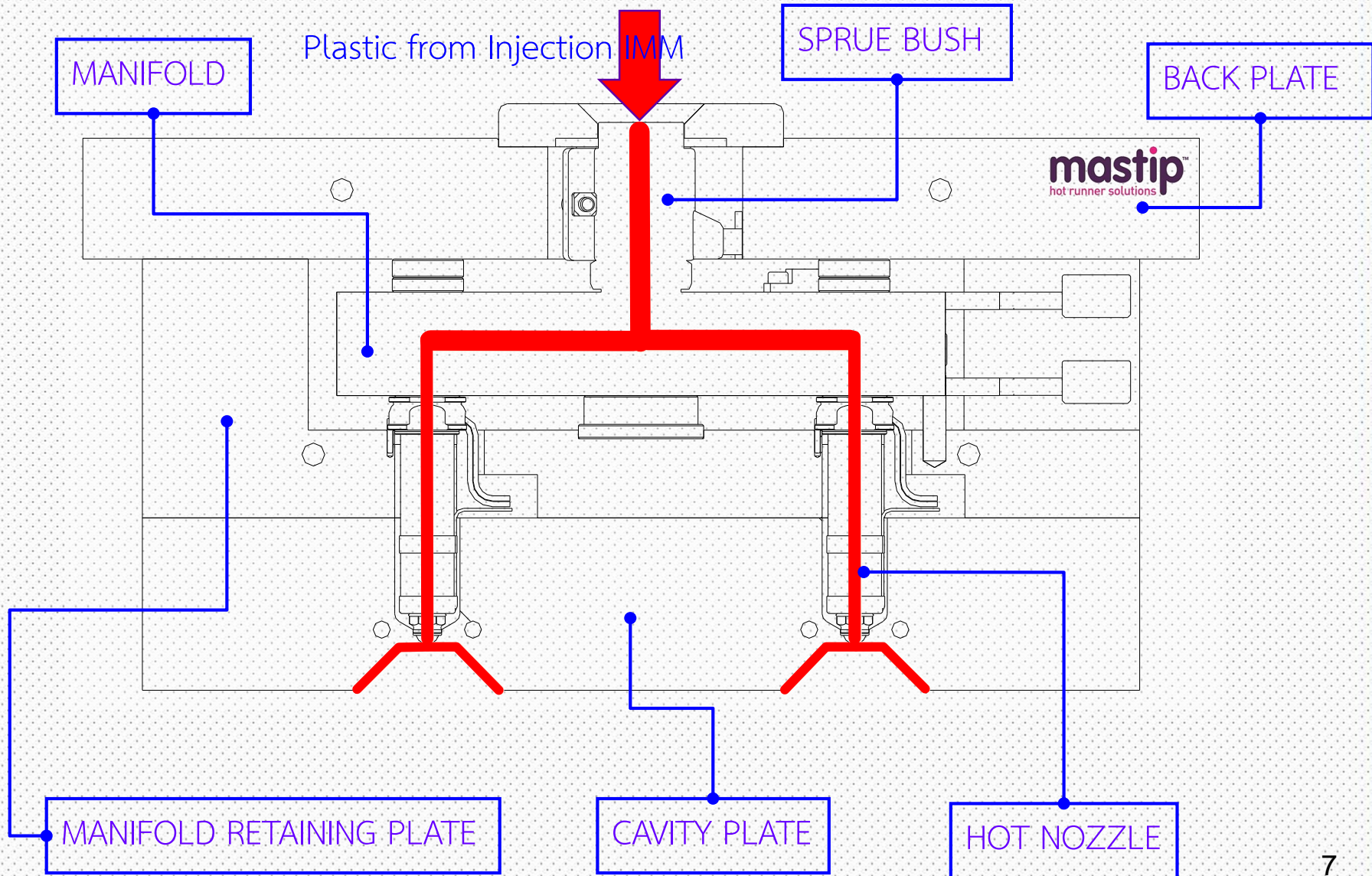


Structure of Hot Runner with Valve Gate

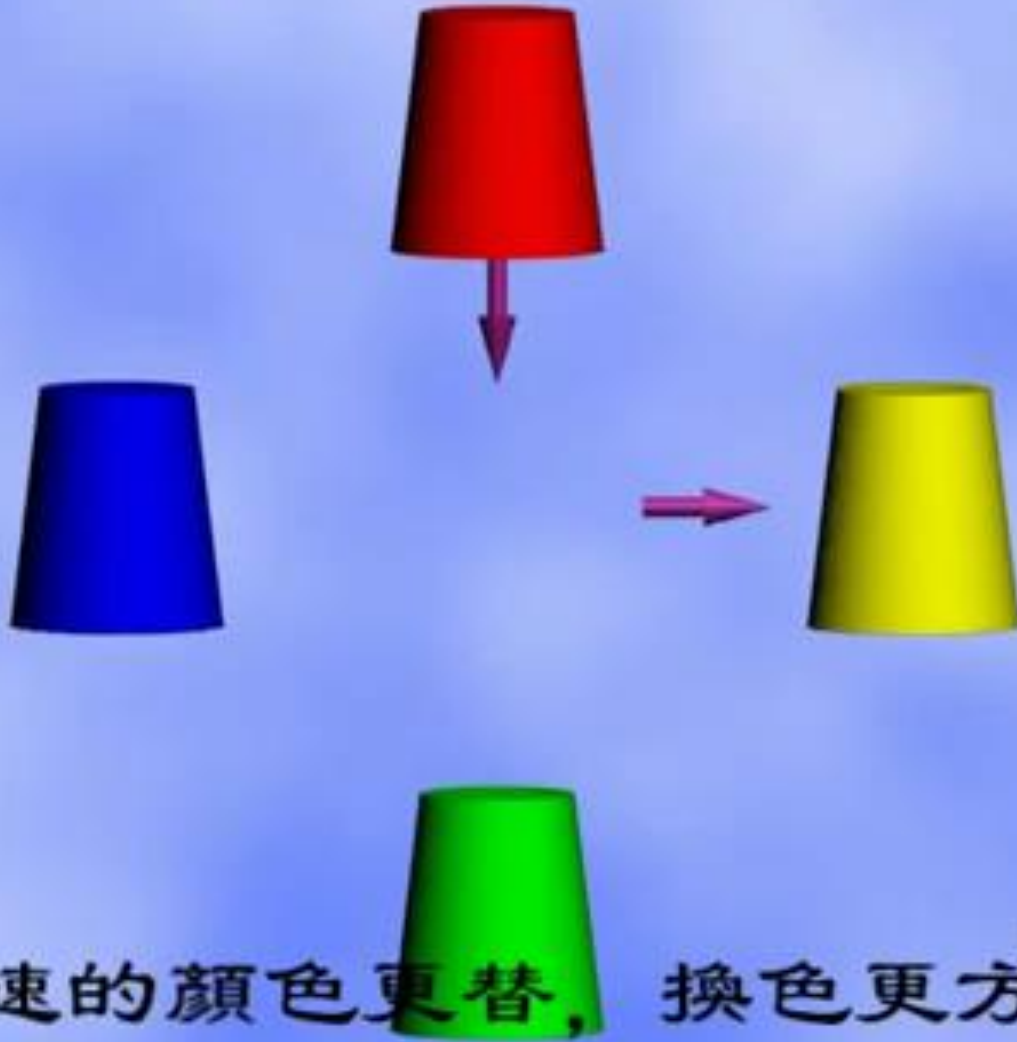
mastip[™]
hot runner solutions



การทำงานระบบ Hot Runner (Multi Cavity)



Hot Runner System (Multi Cavity)



快速的顏色更替，換色更方便

Qui



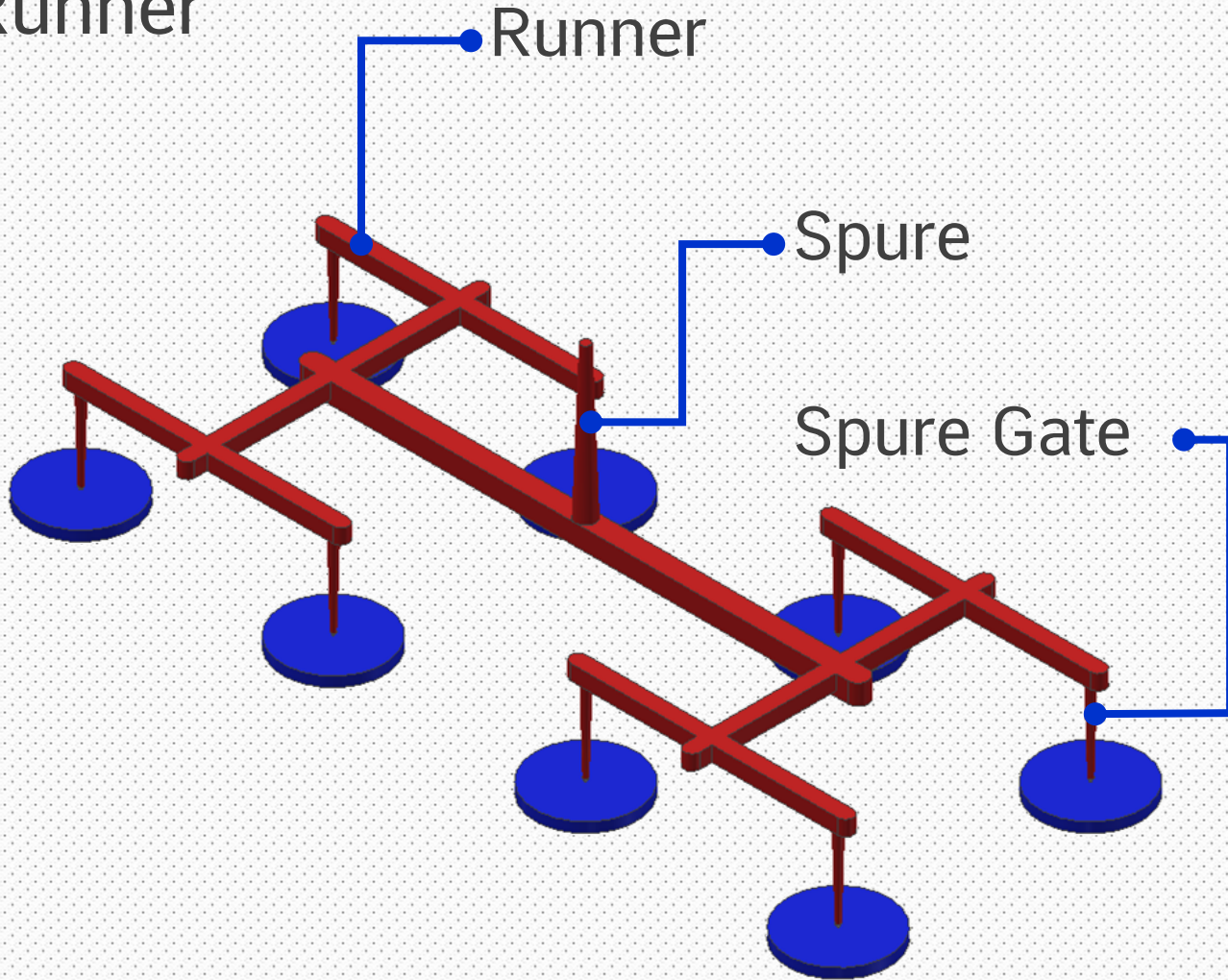
熱流道系統結構演示

INSTALLATION SHOW OF HOT RUNNER SYSTEM



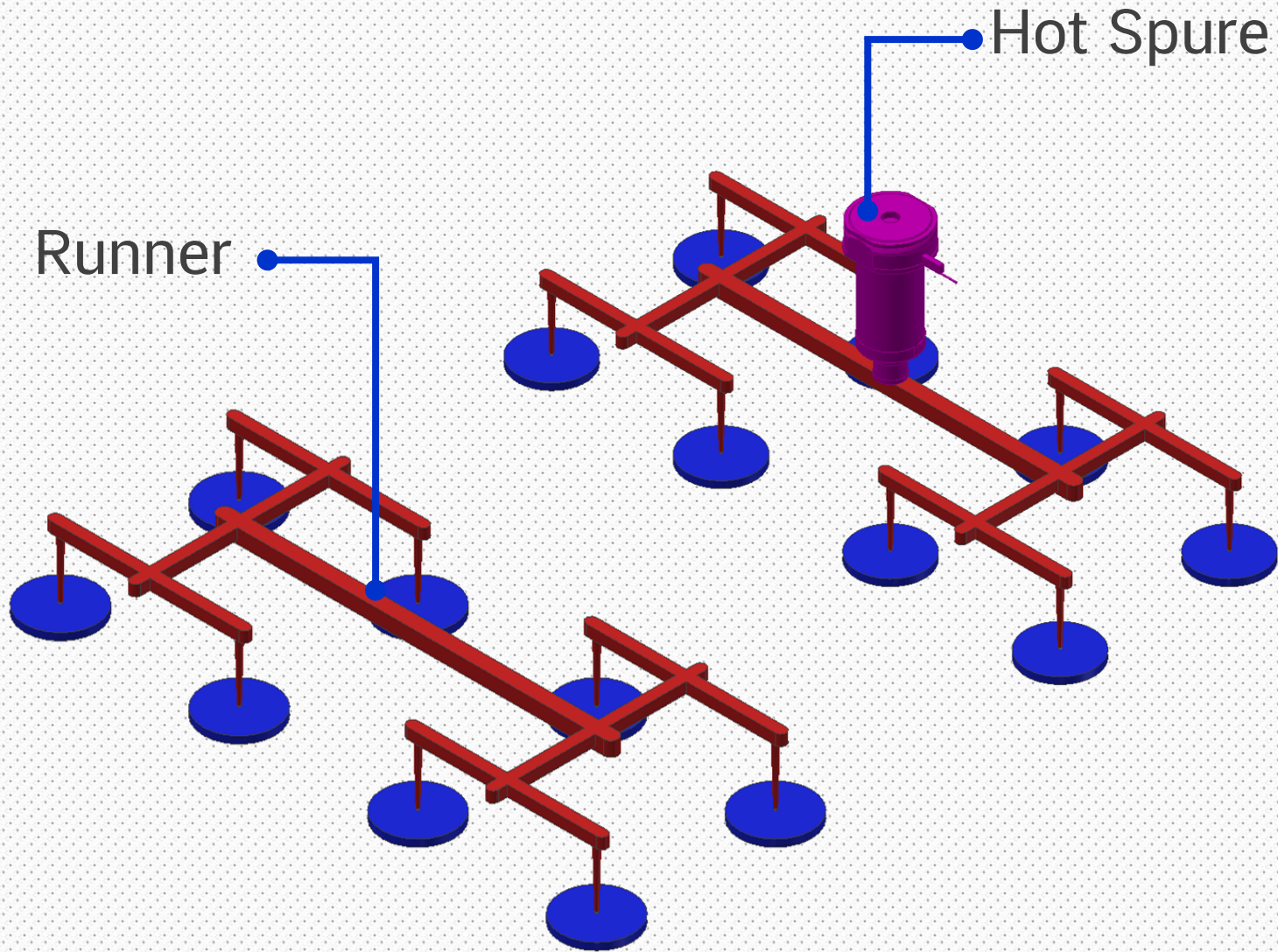
Type of Hot Runner

Cold Runner

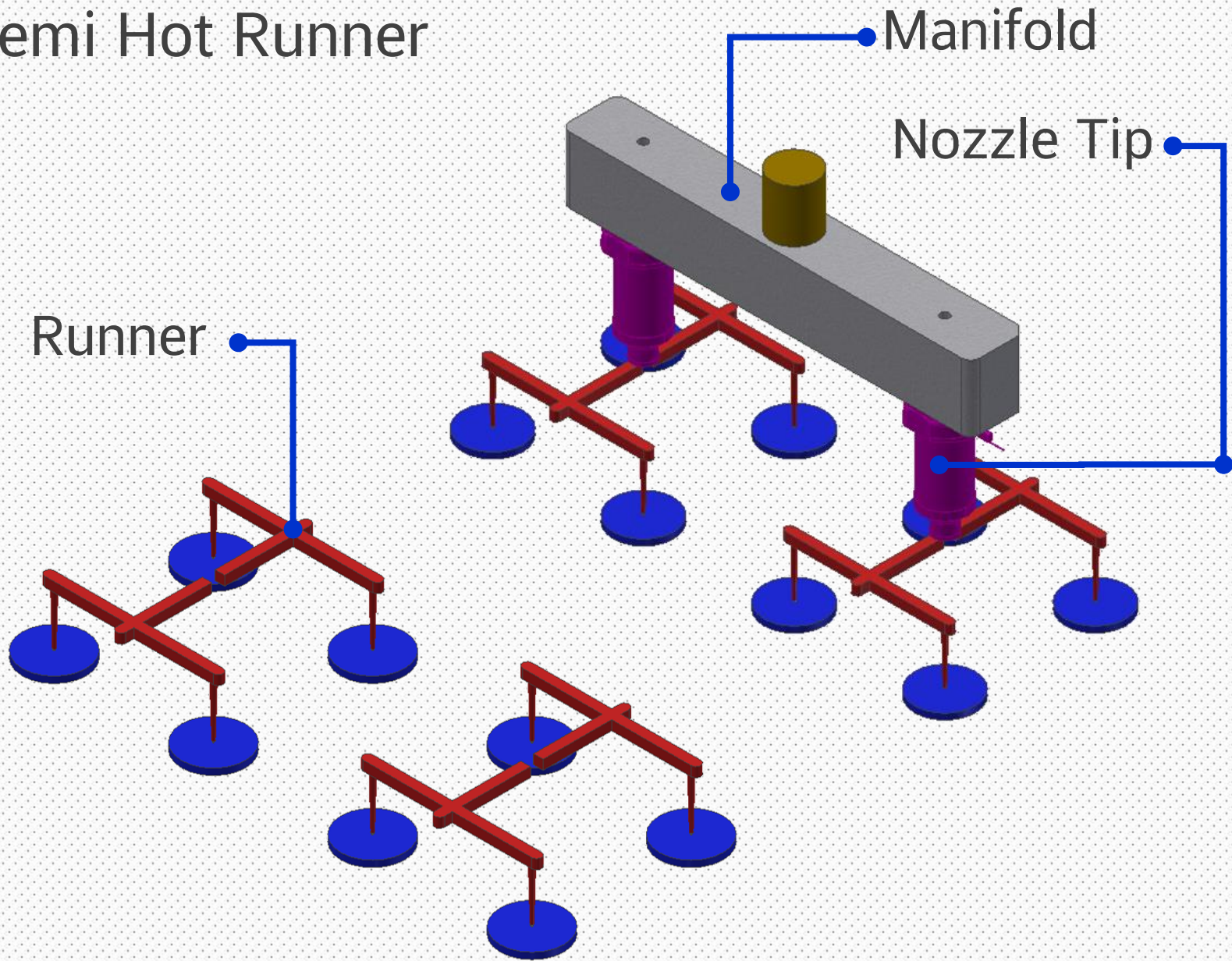




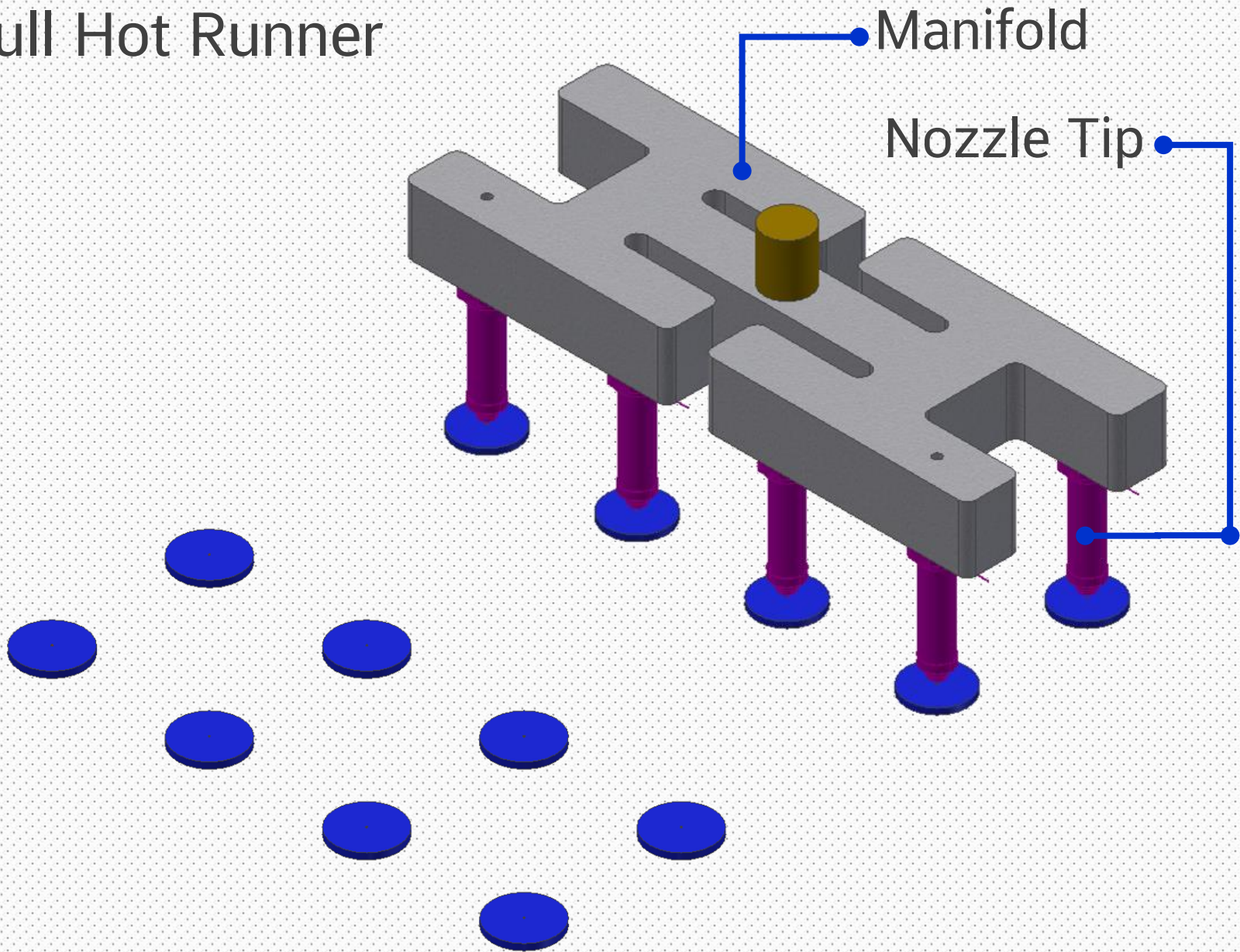
Hot Spure



Semi Hot Runner

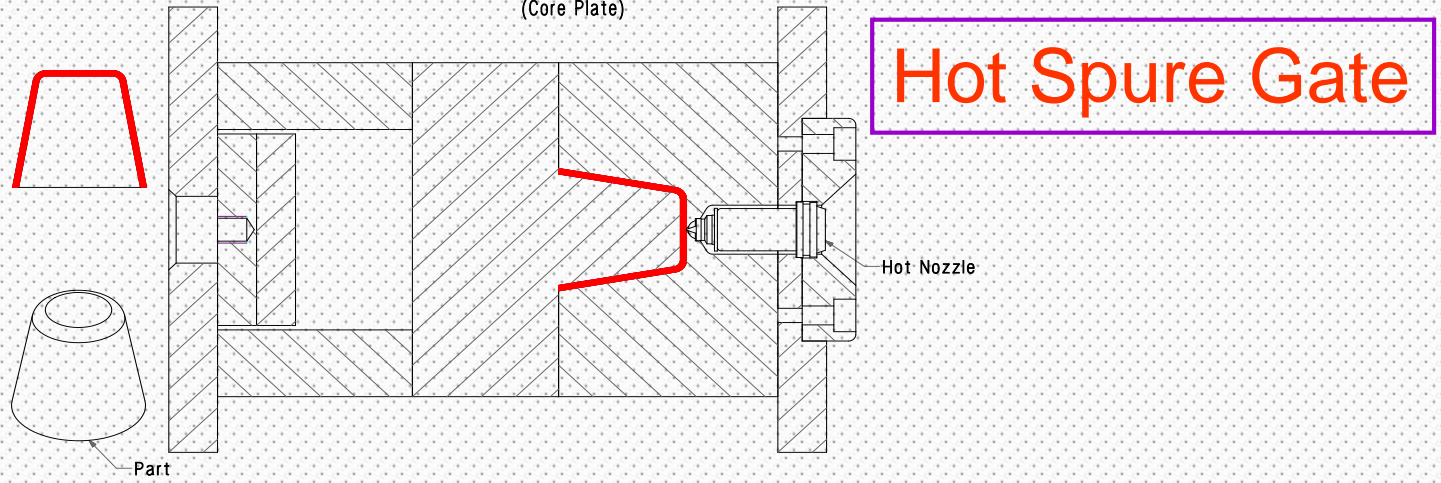
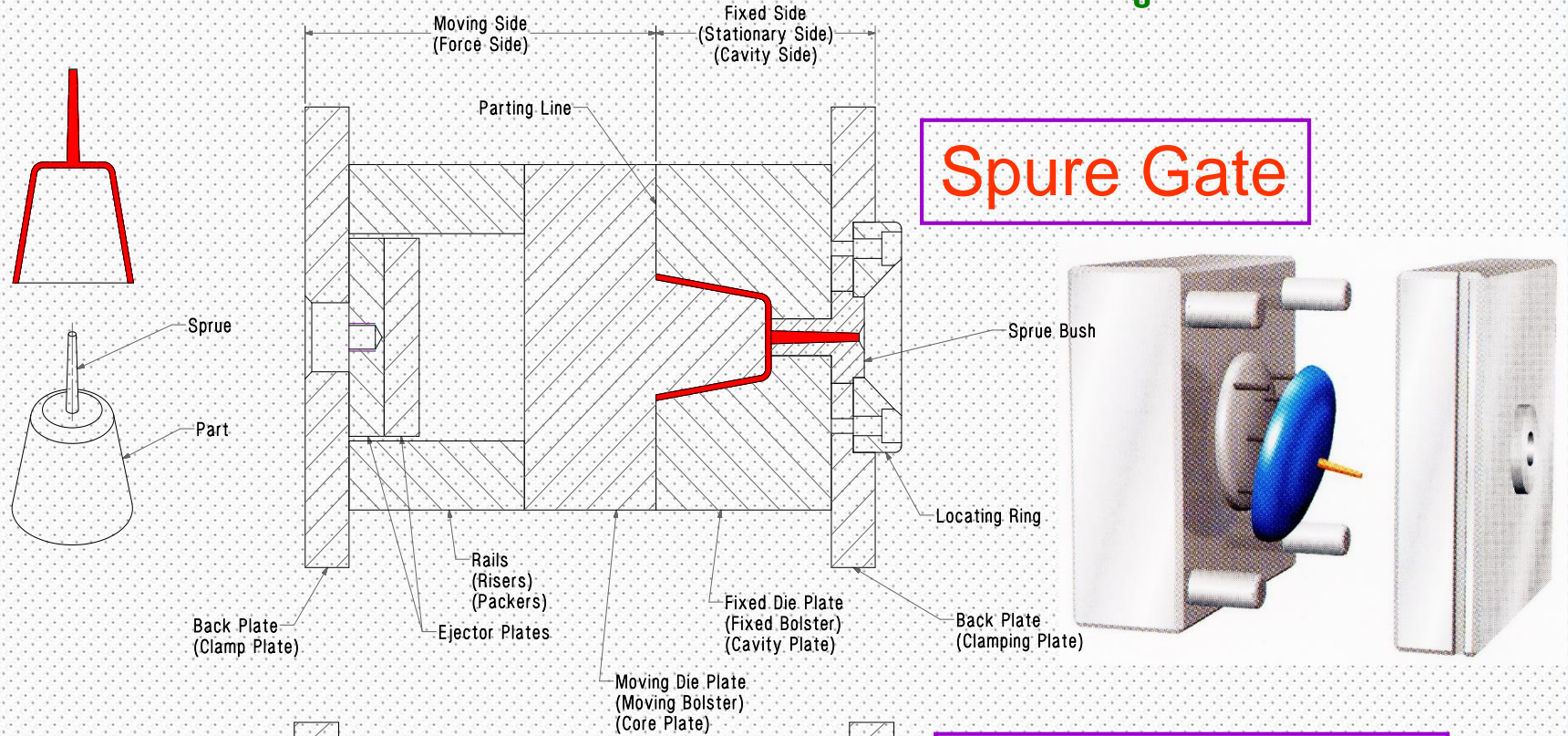


Full Hot Runner

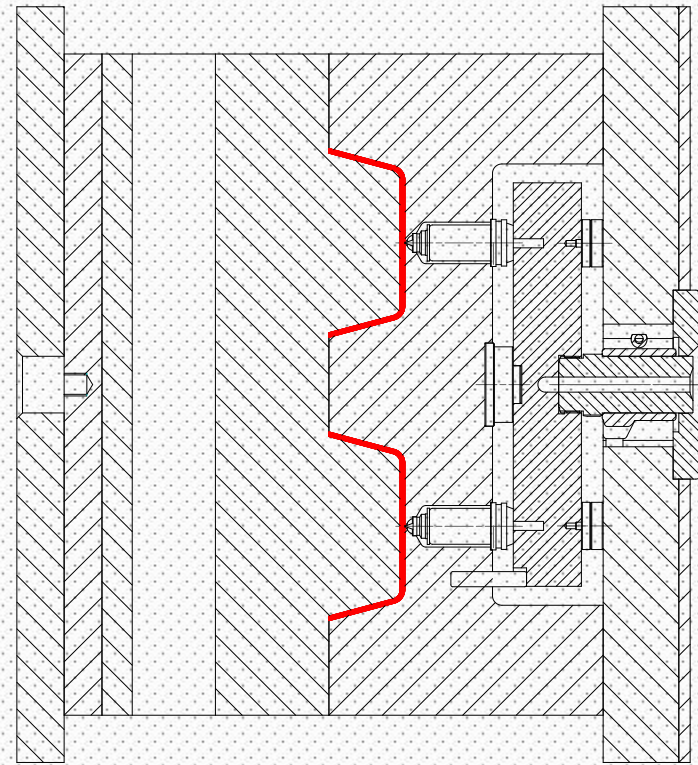
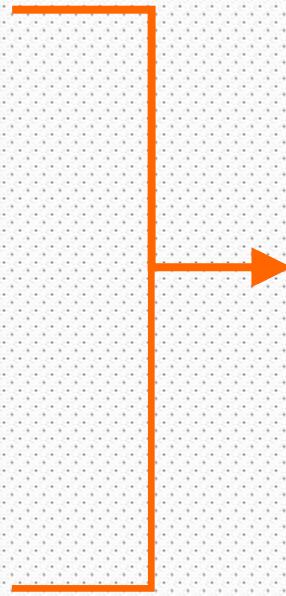
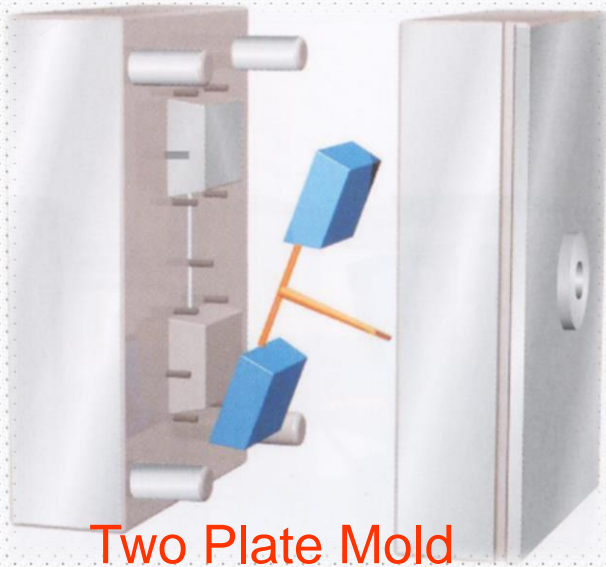
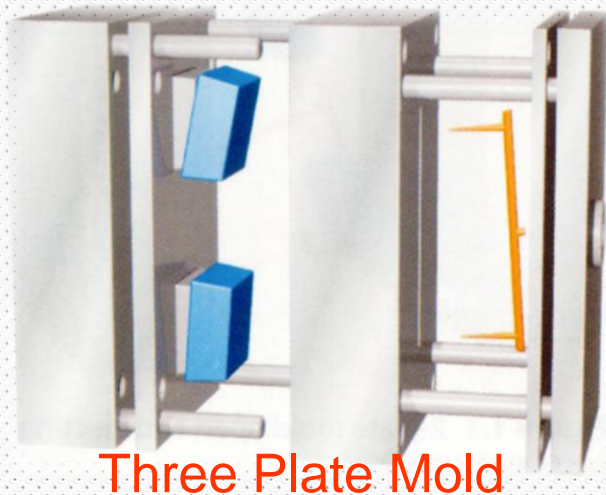




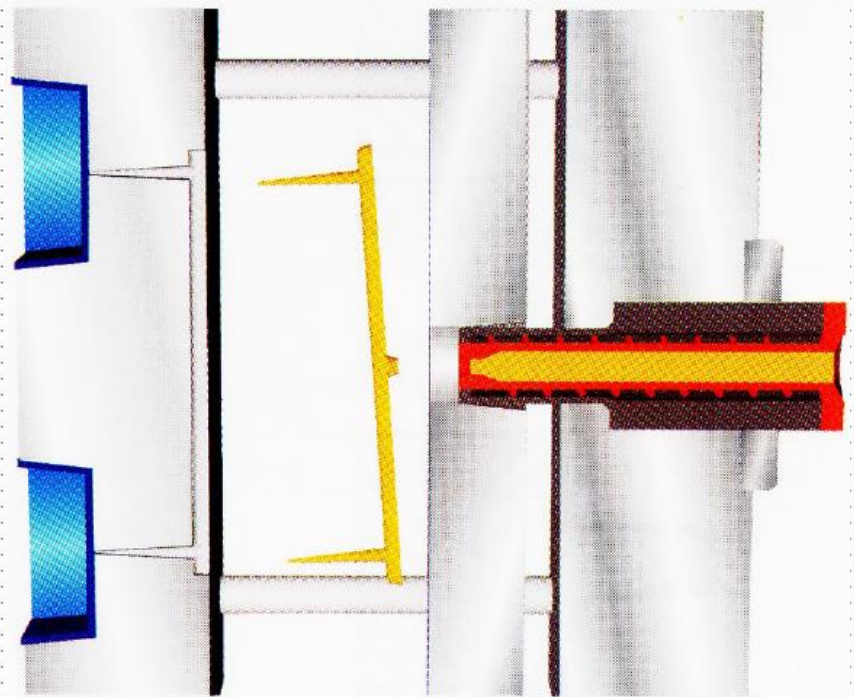
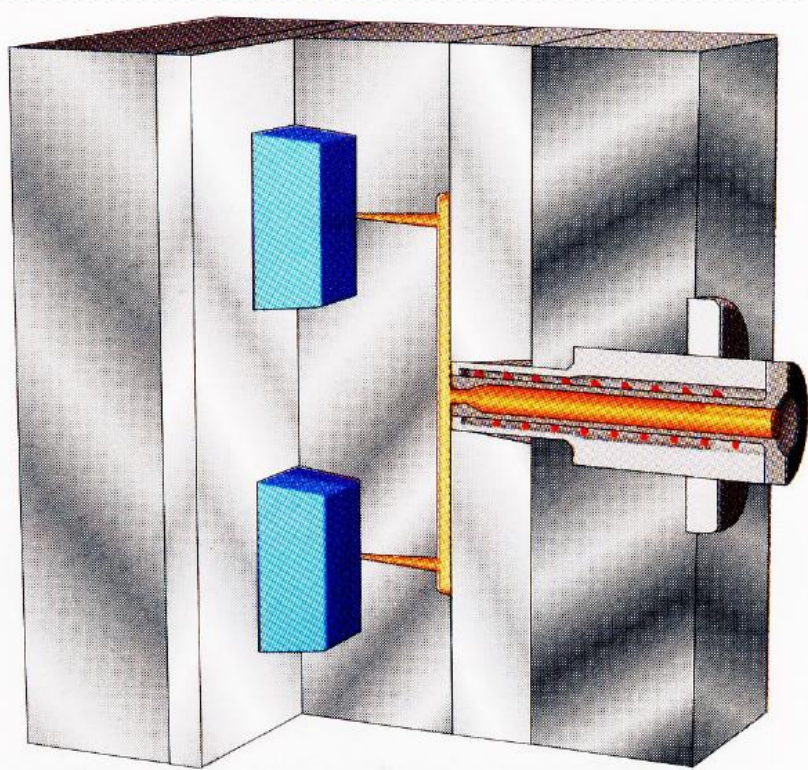
การปรับเปลี่ยนแม่พิมพ์ ระบบ Cold Runner สู่ Hot runner



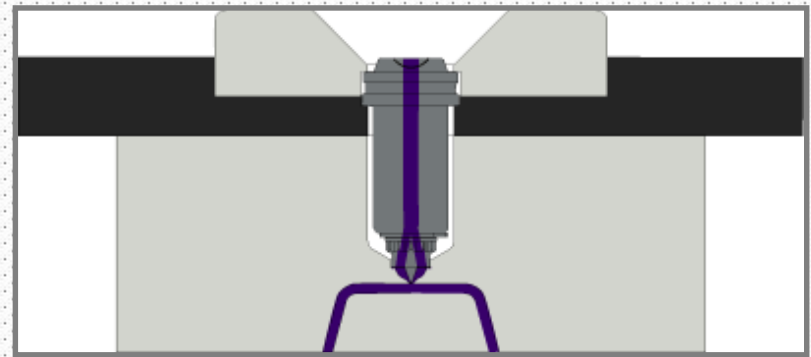
การปรับเปลี่ยนแม่พิมพ์ ระบบ Cold Runner สู่ Hot runner



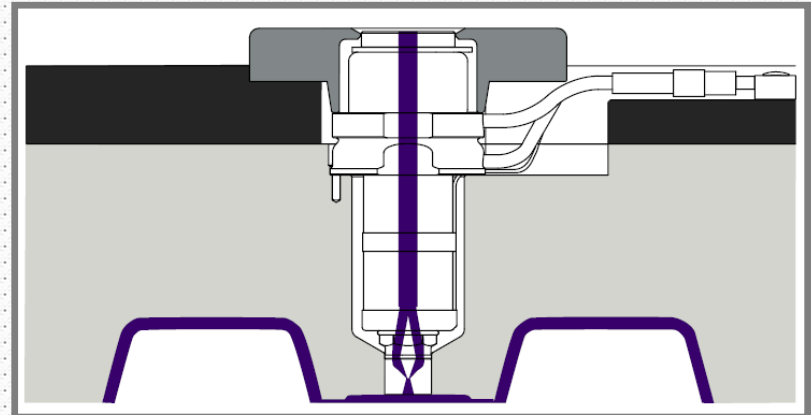
การปรับเปลี่ยนแม่พิมพ์ ระบบ Cold Runner สู่ Hot runner



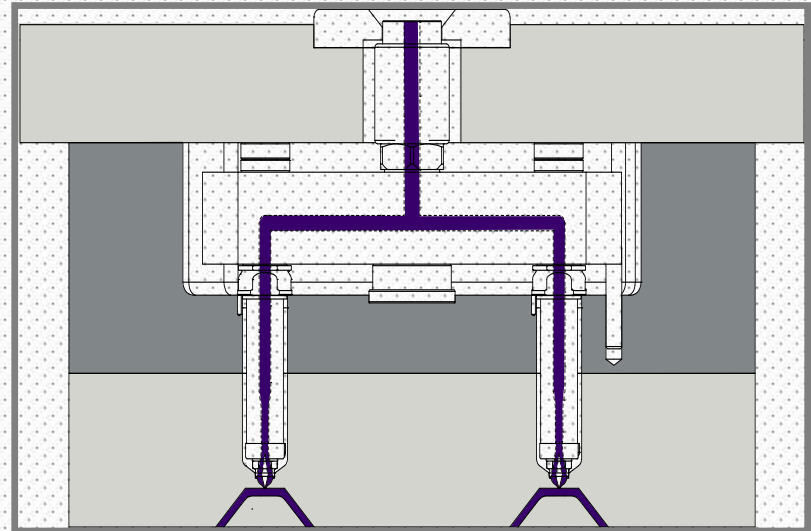
1 Cavity 1 Drop



2 Cavity 1 Drop



2 Cavity 2 Drop





Cycle Time for Injection Moulding

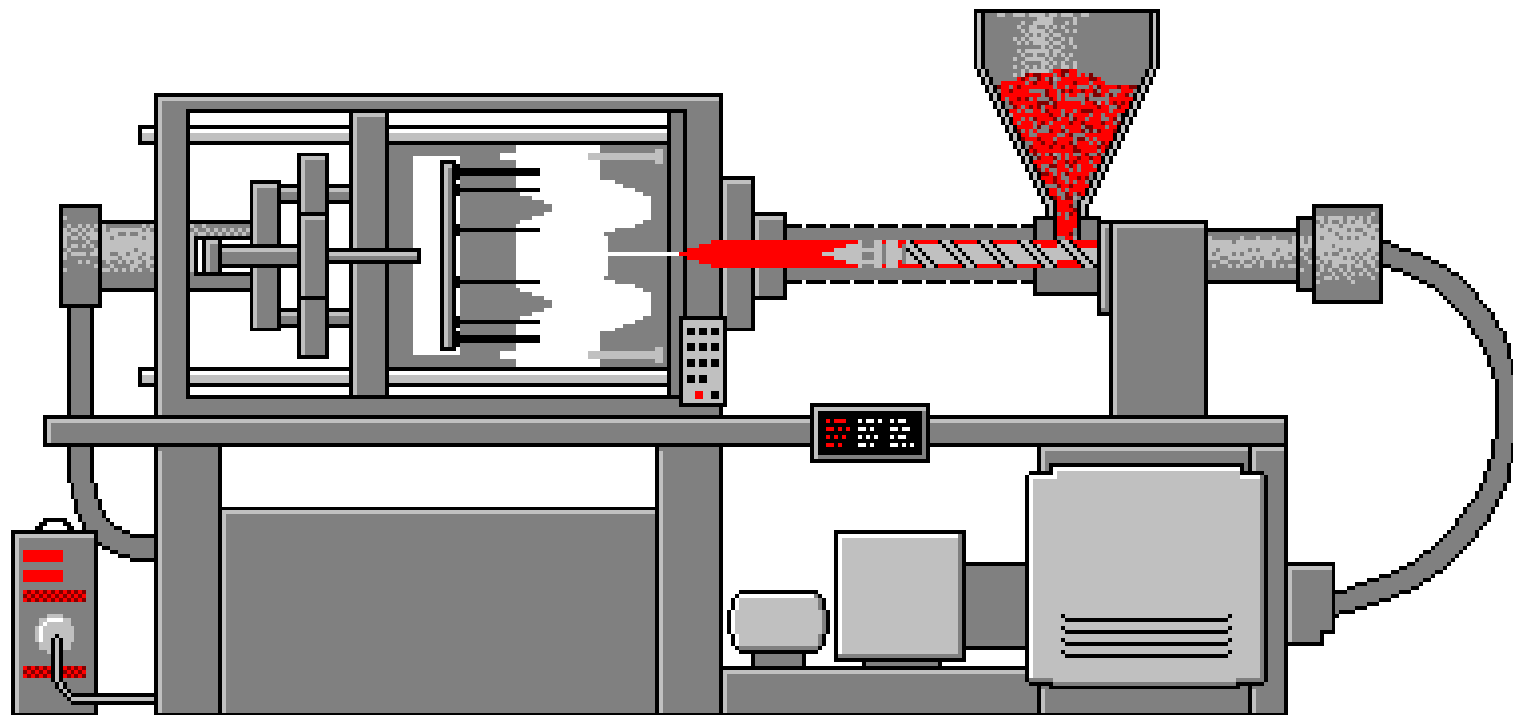


Cycle Time

	Cold Runner	Hot Runner	Time Reduce
Mold Close	2.50 Sec		
Fill Time	0.50 Sec		
Packing Time	1.00 Sec		
Cooling Time	8.72 Sec		
Mold Open	2.50 Sec		
Ejector Time	1.50 Sec		
	16.72 Sec		

Cycle Time

Clamping Injection Cooling Ejection



Injection Molding Machine





การคำนวณหาเวลาที่คุ้มทุน

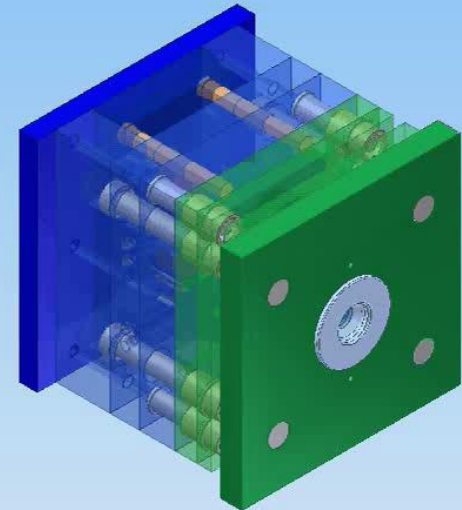
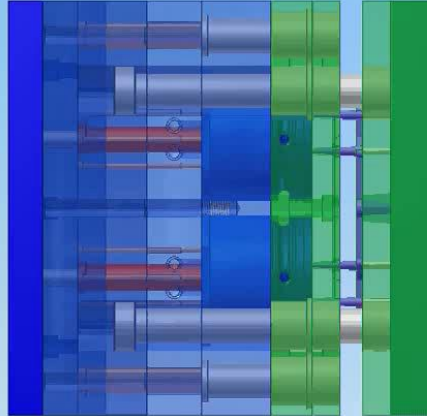
จากการลดเวลาในการปิด-เปิด แม่พิมพ์



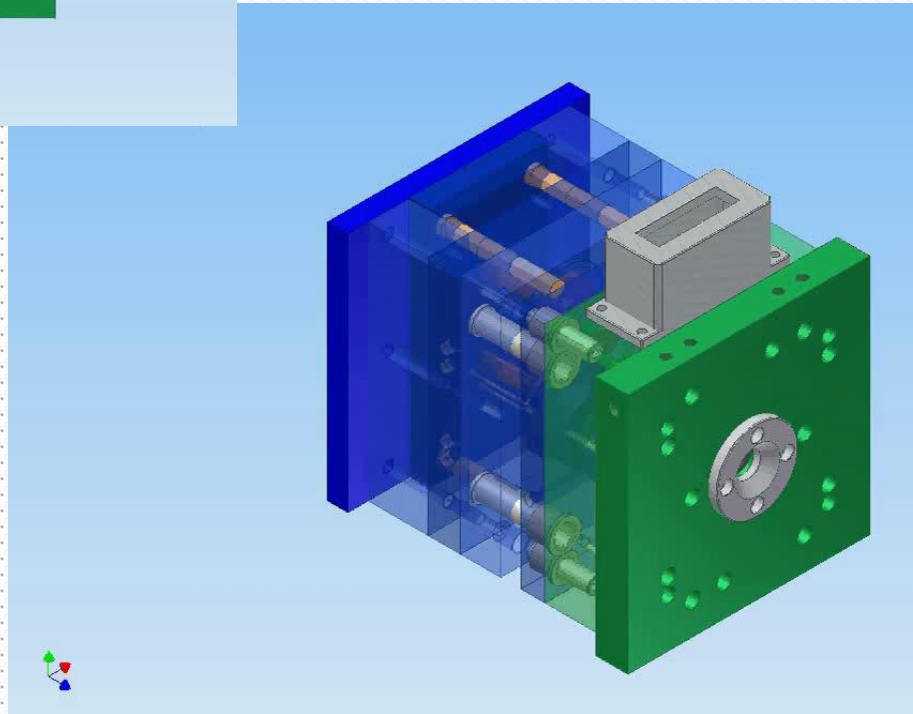
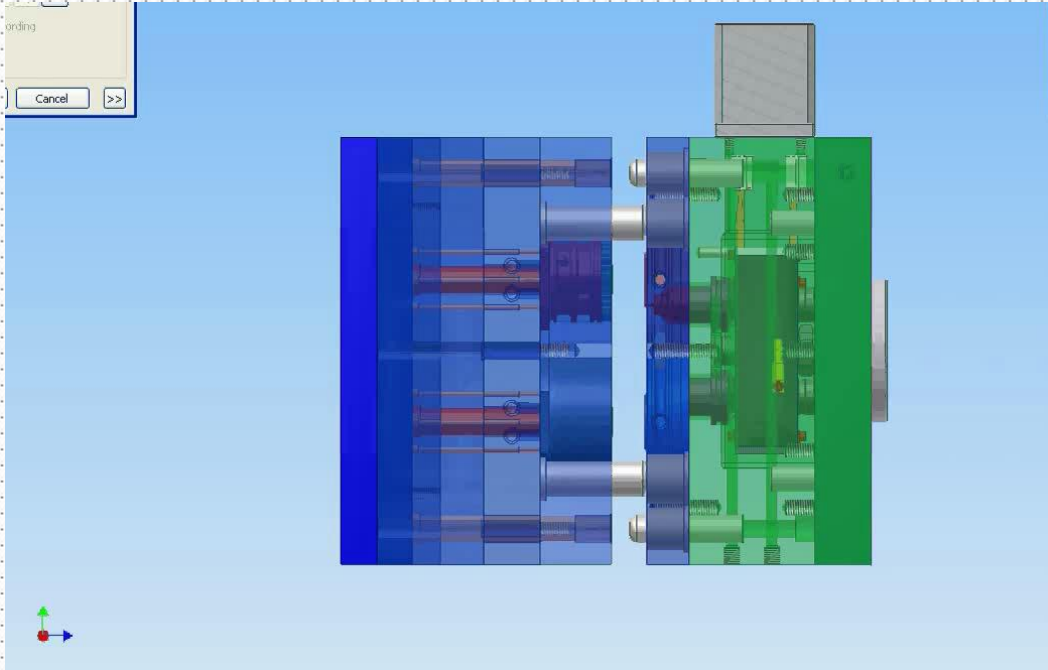
Cycle Time Comparison Table for Mold Open and Mold Close

	Cold Runner	Hot Runner	Time Reduce
Mold Close	2.50 Sec	1.50 Sec	????????????
Fill Time	0.50 Sec		
Packing Time	1.00 Sec		
Cooling Time	8.72 Sec		
Mold Open	2.50 Sec	1.50 Sec	????????????
Ejector Time	1.50 Sec		
	16.62 Sec		

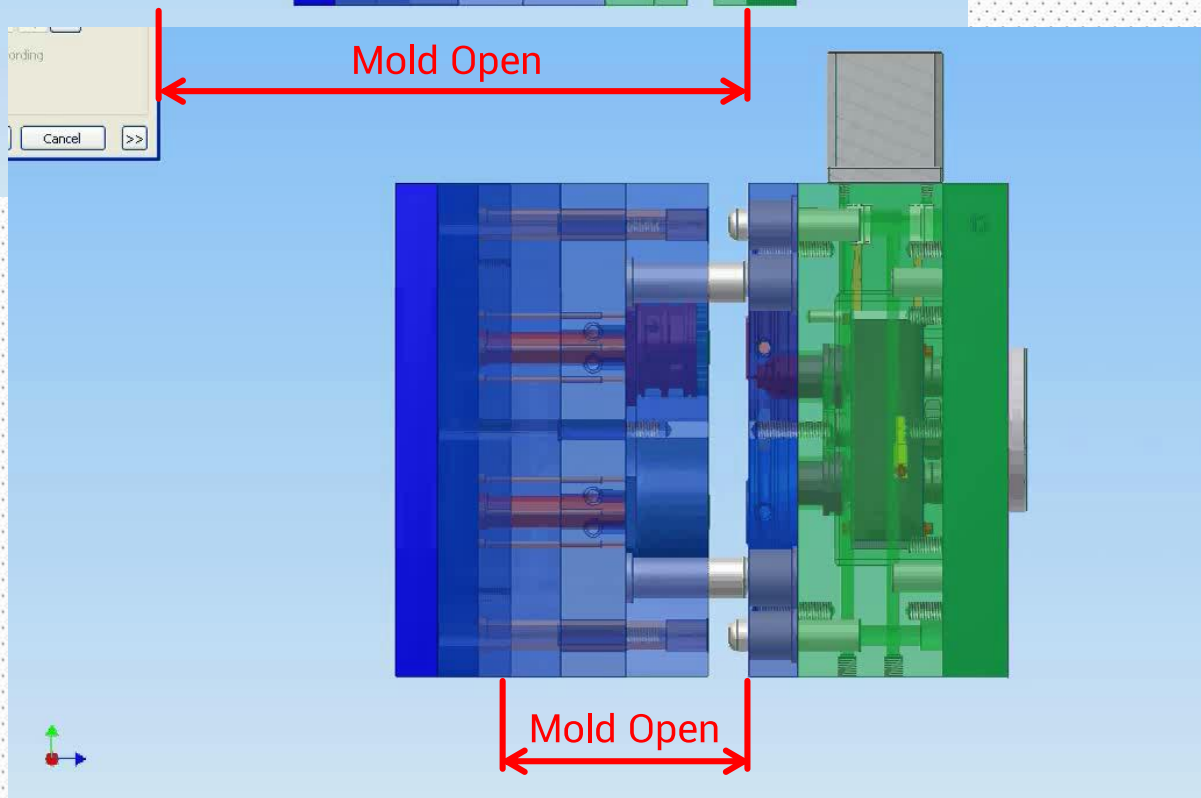
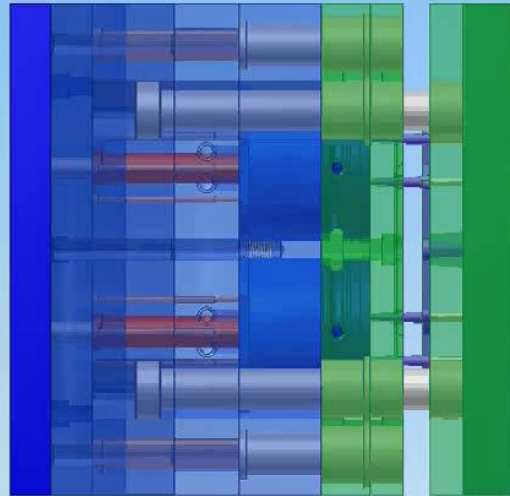
การทำงานของแม่พิมพ์ระบบ Cold Runner



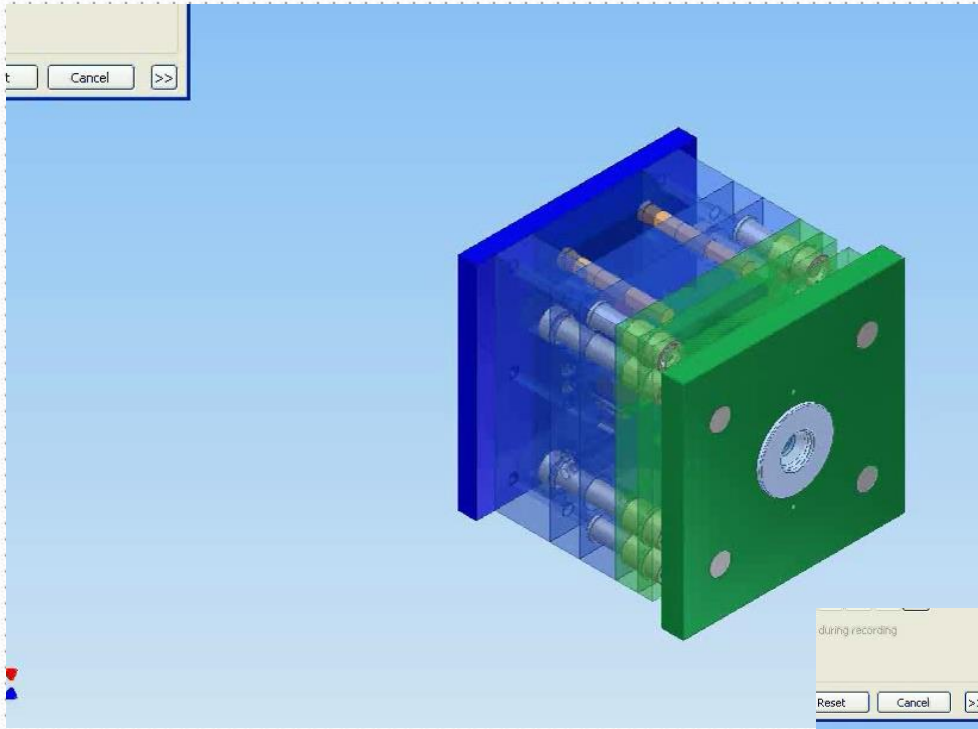
การทำงานของแม่พิมพ์ระบบ Hot Runner



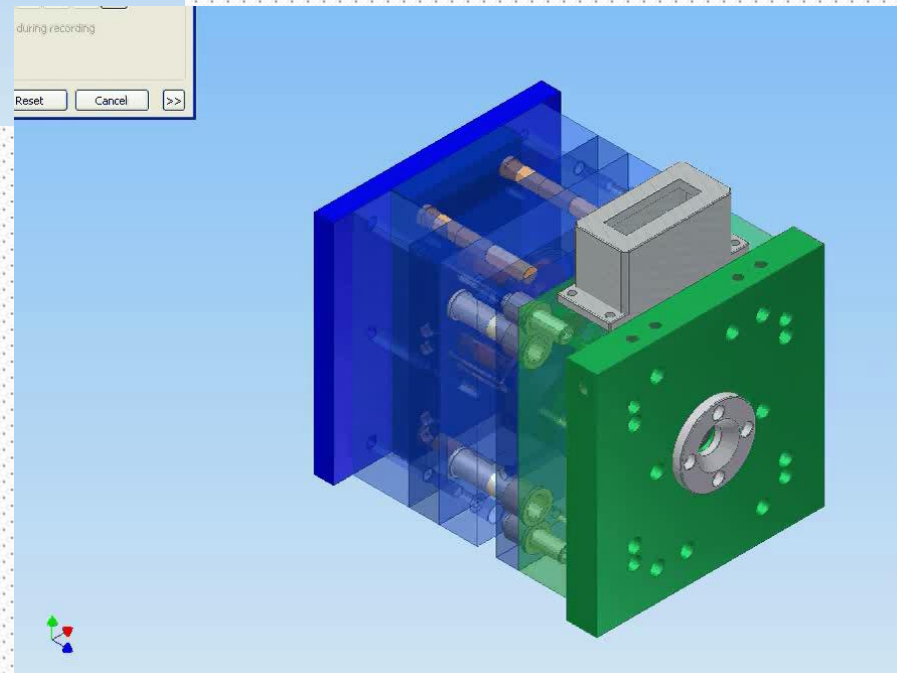
Mold Opening Cold Runner & Hot Runner



Cold Runner with Pin Point Gate



Hot Runner System





การคำนวณหาเวลาที่คุ้มทุน
จากการลดเวลาในการหล่อเย็น

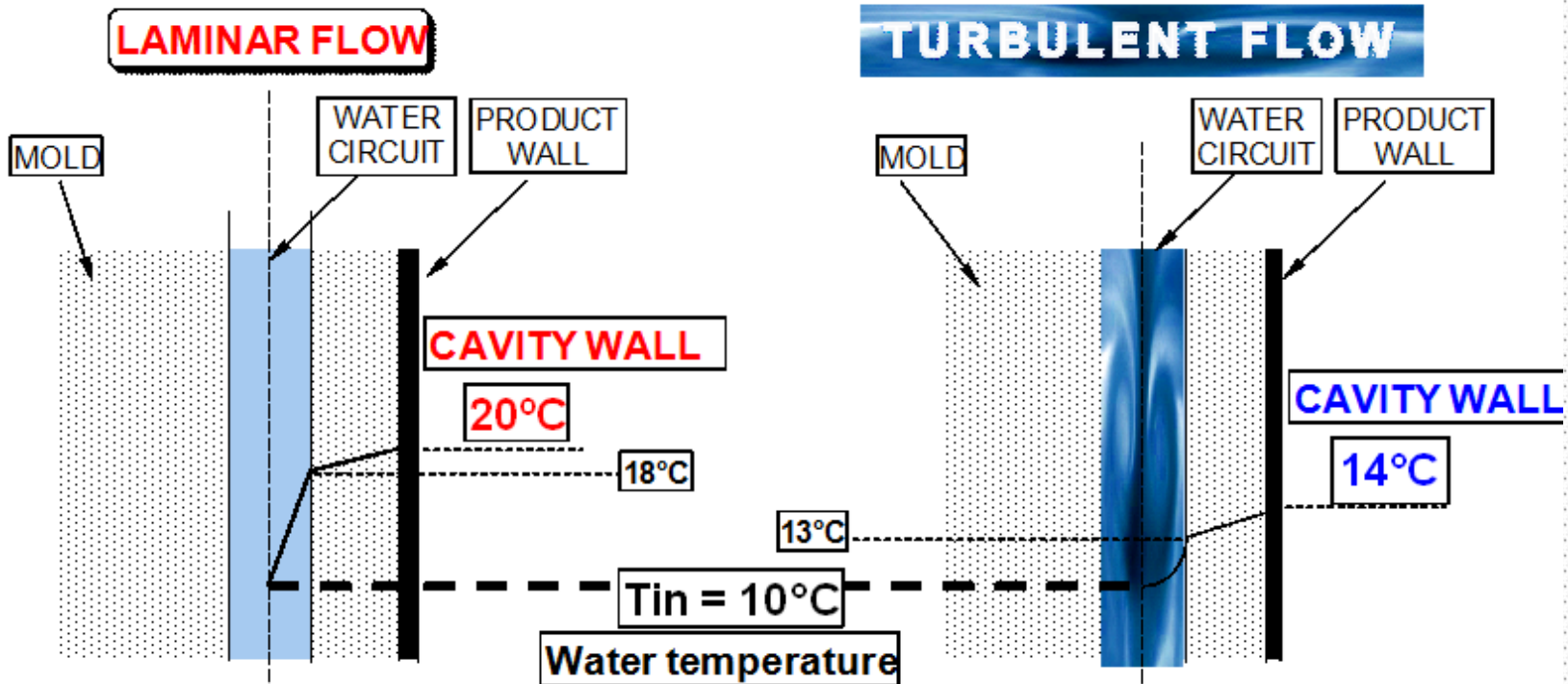


Cycle Time Comparison Table for Mold Cooling

	Cold Runner	Hot Runner	Time Reduce
Mold Close	2.50 Sec	1.50 Sec	
Fill Time	0.50 Sec		
Packing Time	1.00 Sec		
Cooling Time	8.62 Sec	2.64 Sec	???????????
Mold Open	2.50 Sec	1.50 Sec	
Ejector Time	1.50 Sec		
	16.62 Sec		

ประสิทธิภาพในการหล่อเย็น (Cooling Performance)

High Flow = Turbulent Flow = Shorter Cooling Time



การไหลของน้ำในระบบการหล่อเย็น (Water Flow)

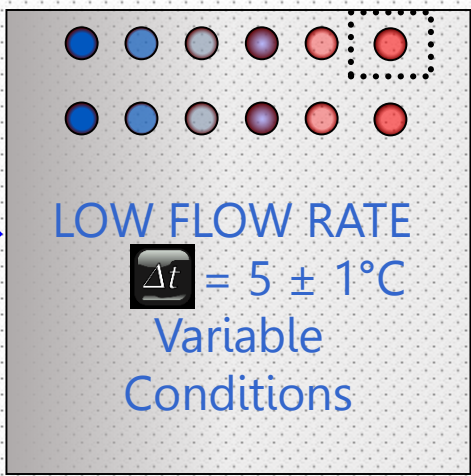


ประสิทธิภาพในการหล่อเย็น (Cooling Performance)

Shorter Cooling Time + Better Mold Symmetry

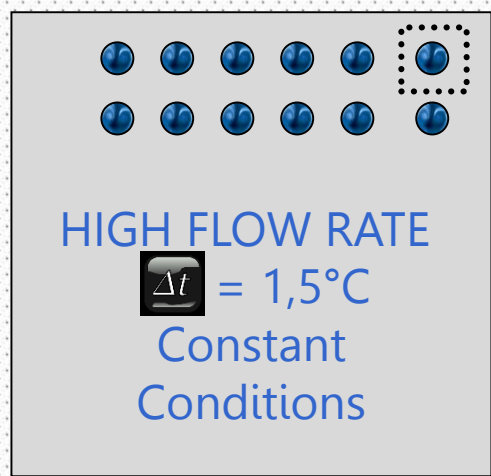
Inefficient Mold
Central Cooling

Same temp.
for all molds



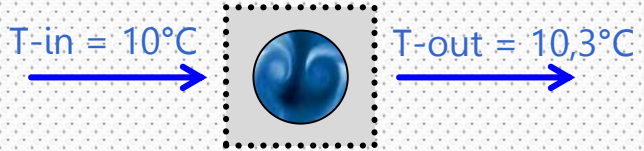
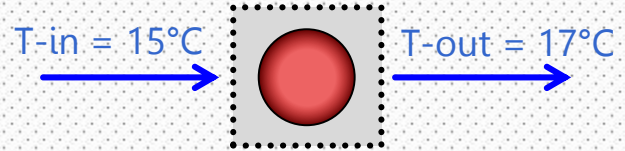
Highly Efficient Mold
Dedicated Cooling

Dedicated
temp. per mold



Last Cavity Average Temp $\approx 15.60^\circ\text{C}$

Last Cavity Average Temp. $\approx 10.00^\circ\text{C}$



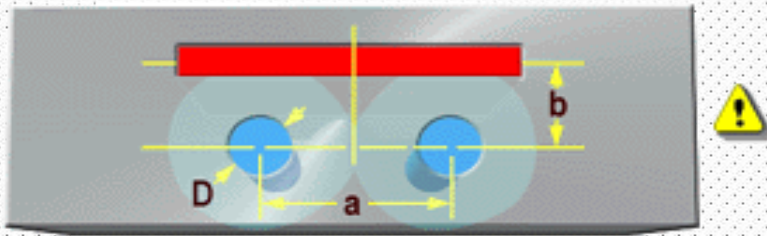
Consistent Cycle Time 15 SEC

Consistent Cycle Time 12.5 SEC

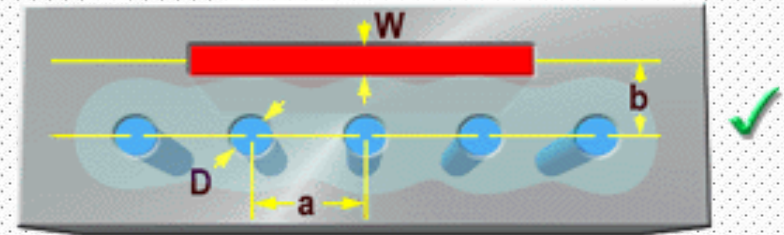
Productivity +20 %

การคำนวณขนาดและตำแหน่งของน้ำหล่อเย็น

NON-UNIFORM
HEAT REMOVAL



MORE UNIFORM
HEAT REMOVAL



Large spacing $>a<$

+ small spacing $>b<$

+ large channel diameter $>D<$

Part thickness $>W<$

$< 2 \text{ mm}$

$< 4 \text{ mm}$

$< 6 \text{ mm}$

Channel Diameter $>D<$

8 Mm - 10 mm

10 mm - 12 mm

12 mm - 15 mm

Spacing $>b<$ = 2-3 X channel diameter $>D<$

Spacing $>a<$ = max 3 X channel diameter $>D<$



การคำนวณหาเวลาที่คุ้มทุนจากการลดเวลาในการหล่อเย็น

ข้อมูลที่ต้องการ

- Mold Lay-Out

- Cavity Number = 4 Cavity

- Runner Length

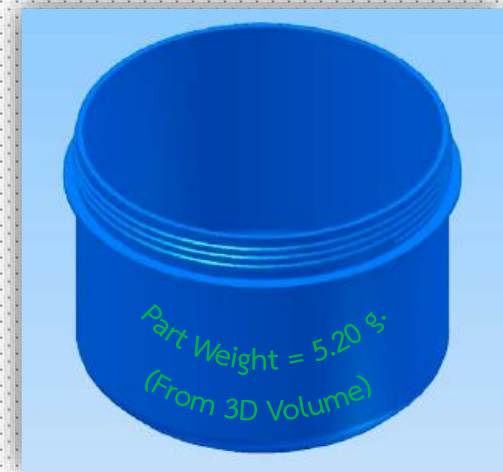
*** For Calculate Size of Runner ***

- Plastic Type = >PP<

- Part Weight = 7.60 g.

- Part Thickness = 1.00 mm.

- Length of Runner = See Mold Lay-Out



คำนวณหาขนาด Runner

- Mold Lay-Out

Cavity Number = 4 Cavity

L = Runner Length

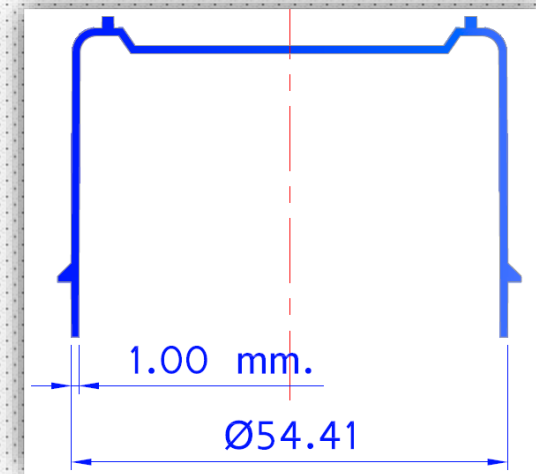
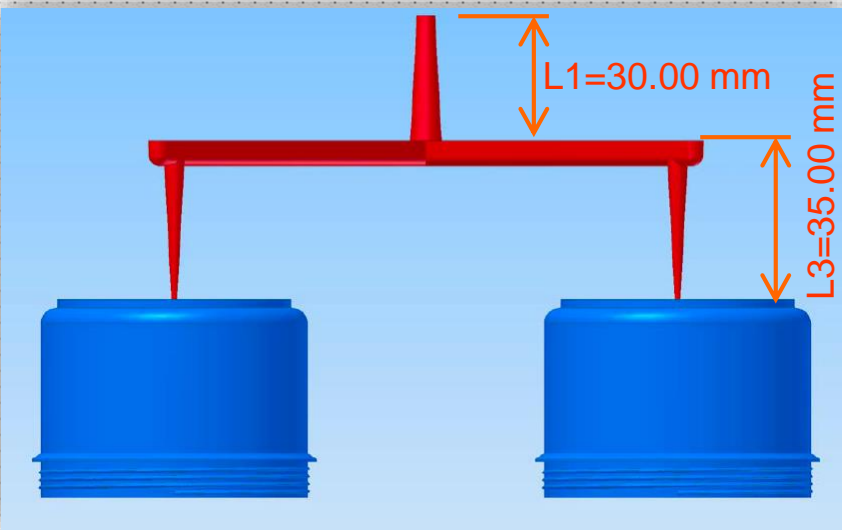
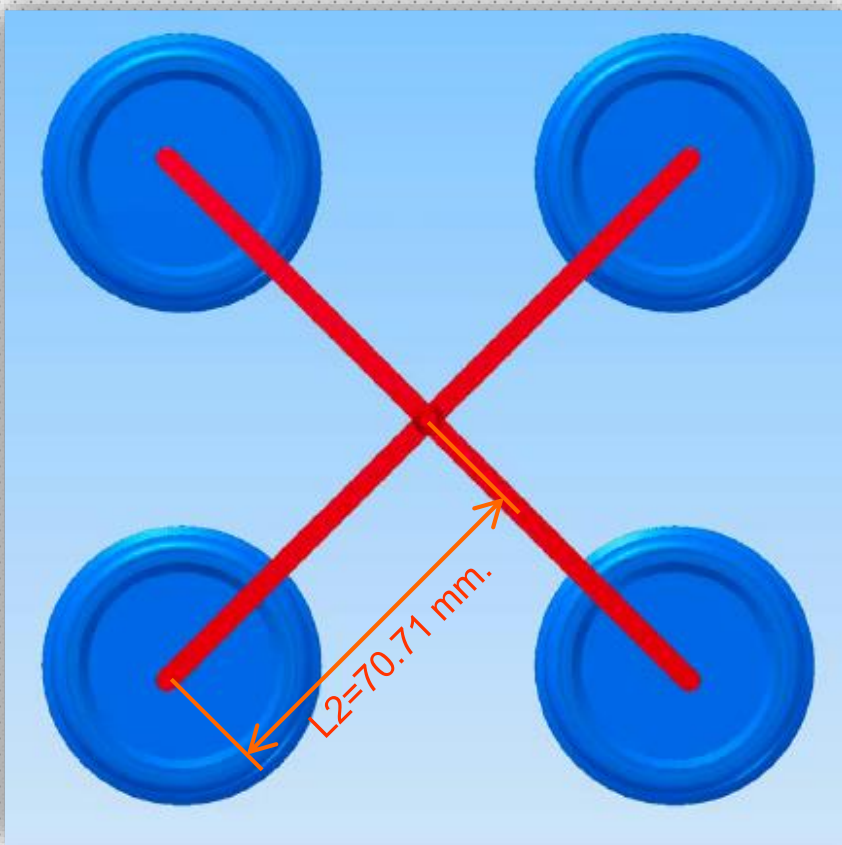
$L = L1+L2+L3$

$L = 30+70+35 = 135 \text{ mm.}$

- Plastic Type = >PP<

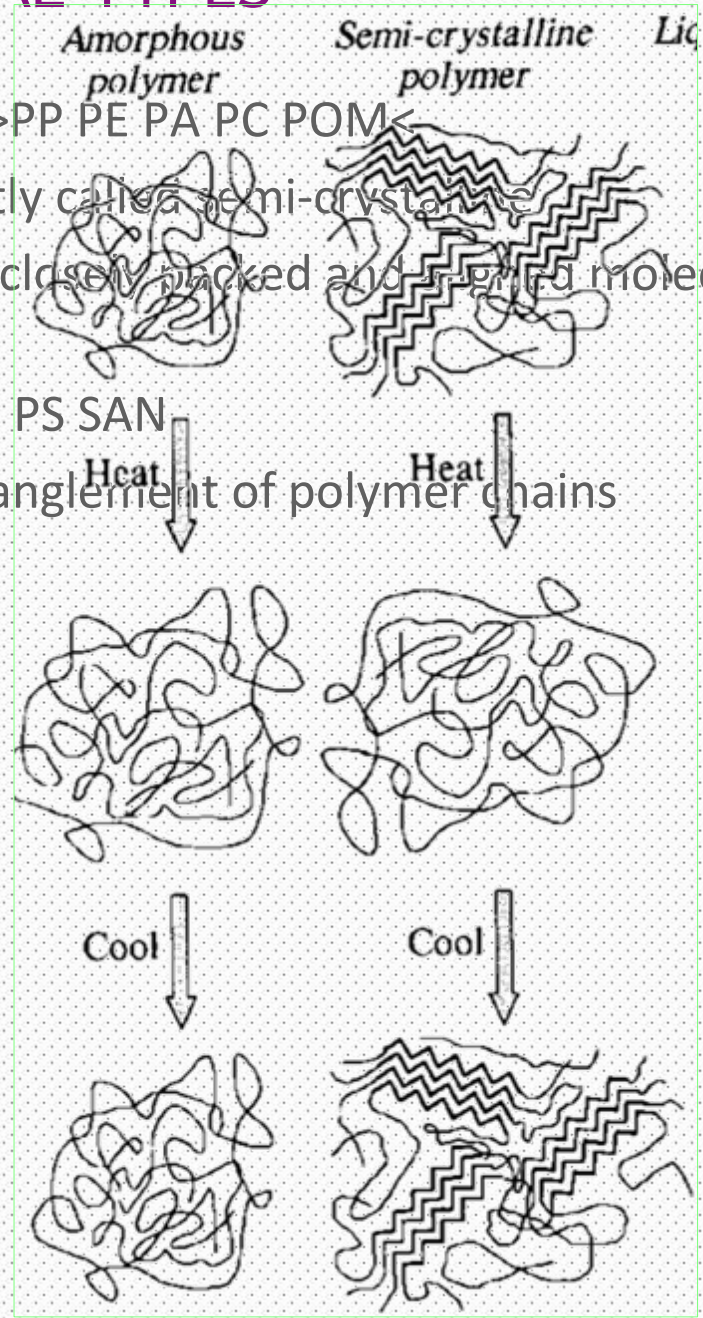
- Part Weight = 7.60 g.

- Part Thickness = 1.00 mm.



PLASTIC MATERIAL TYPES

- Semi Crystalline > PP PE PA PC POM
 - More correctly called semi-crystalline
 - Has areas of closely packed and aligned molecular chains
- Amorphous > ABS PS SAN
 - Random entanglement of polymer chains



PLASTIC MATERIAL TYPES

- Crystalline

- Narrow moulding window
- Rapid change of viscosity
- Requires good temperature control

- Amorphous

- Wide moulding window
- Slow change of viscosity
- Requires high level of cooling

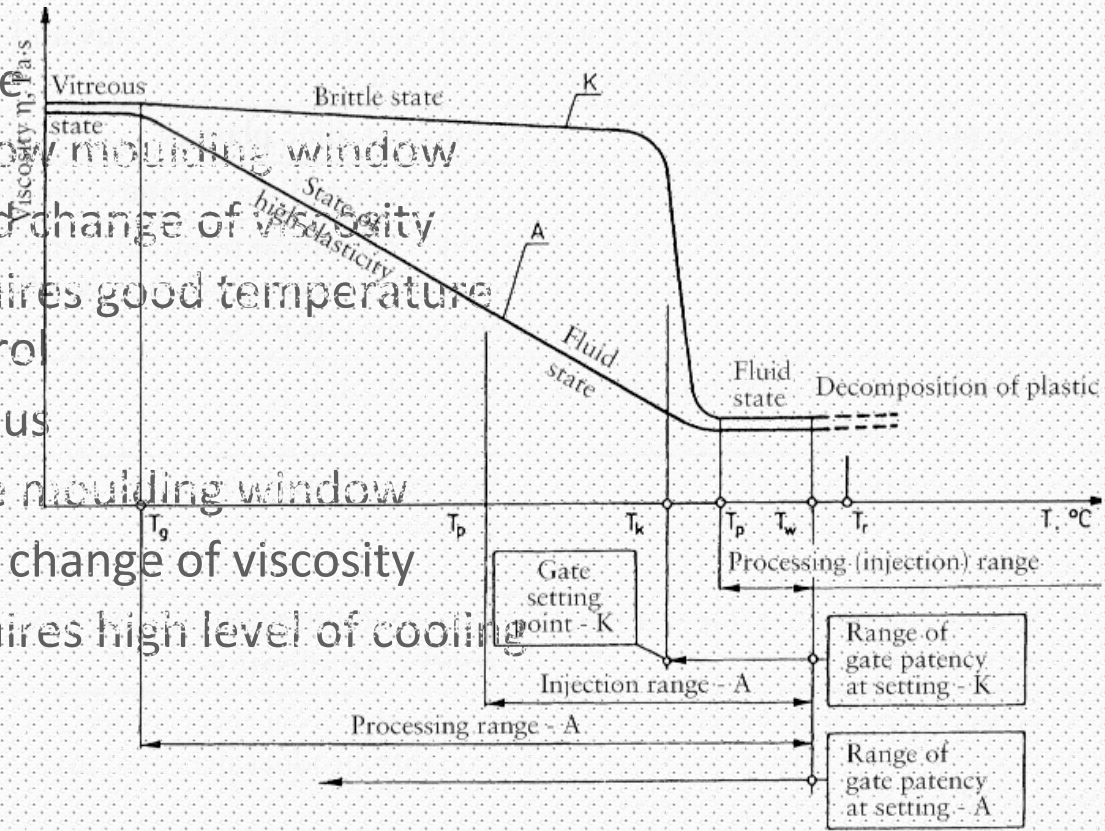
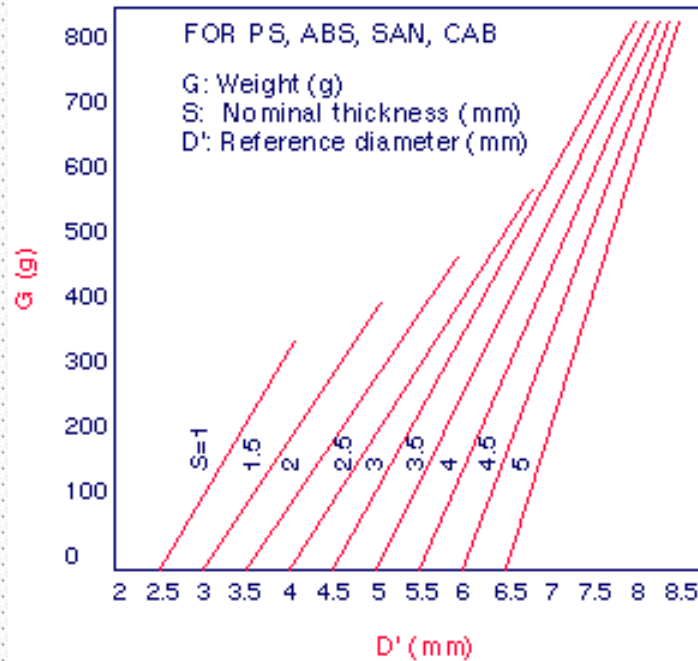


Figure 3.3 Change in state of plastic depending on temperature and characteristic temperature ranges

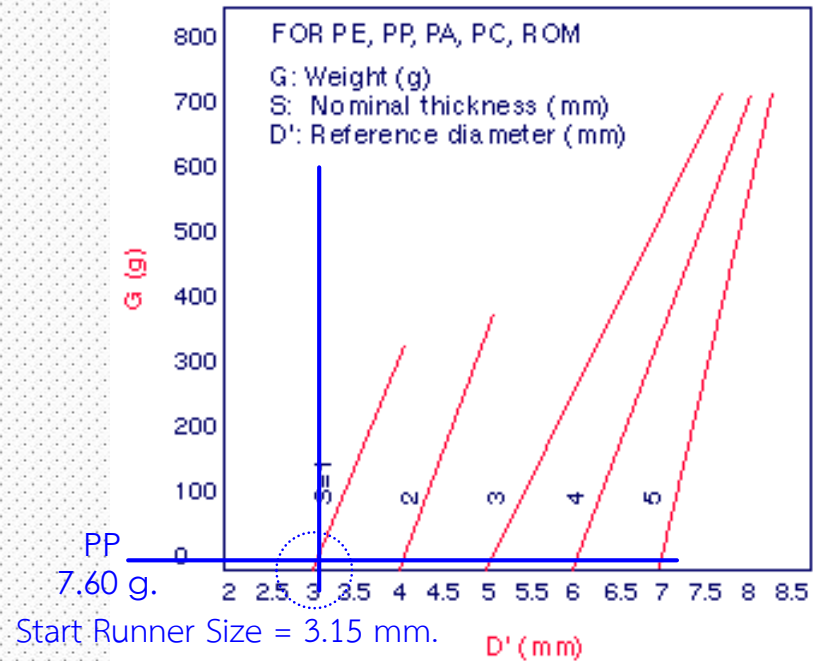
A - amorphous plastic; K - semi-crystalline plastic; T_g - glass transition temperature; T_c - crystallisation temperature during cooling; T_w - injection temperature; T_r - decomposition temperature; T_p - flow temperature (melting of crystallites - for a semi-crystalline plastic $T_p \approx T_c$)



Amorphous Polymer



Semi-Crystalline Polymer



Example

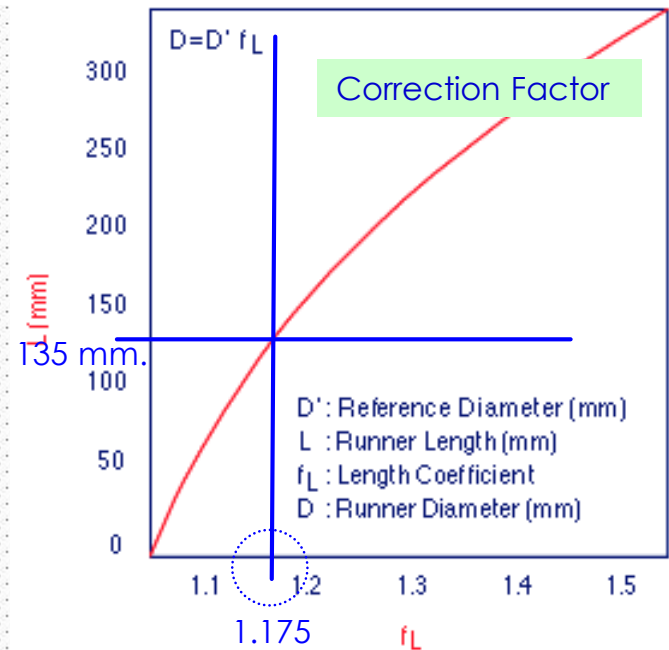
Plastic = >PP<
 Weight = 7.60 g.
 Thickness = 1.00 mm.
 Runner Length = 135 mm.

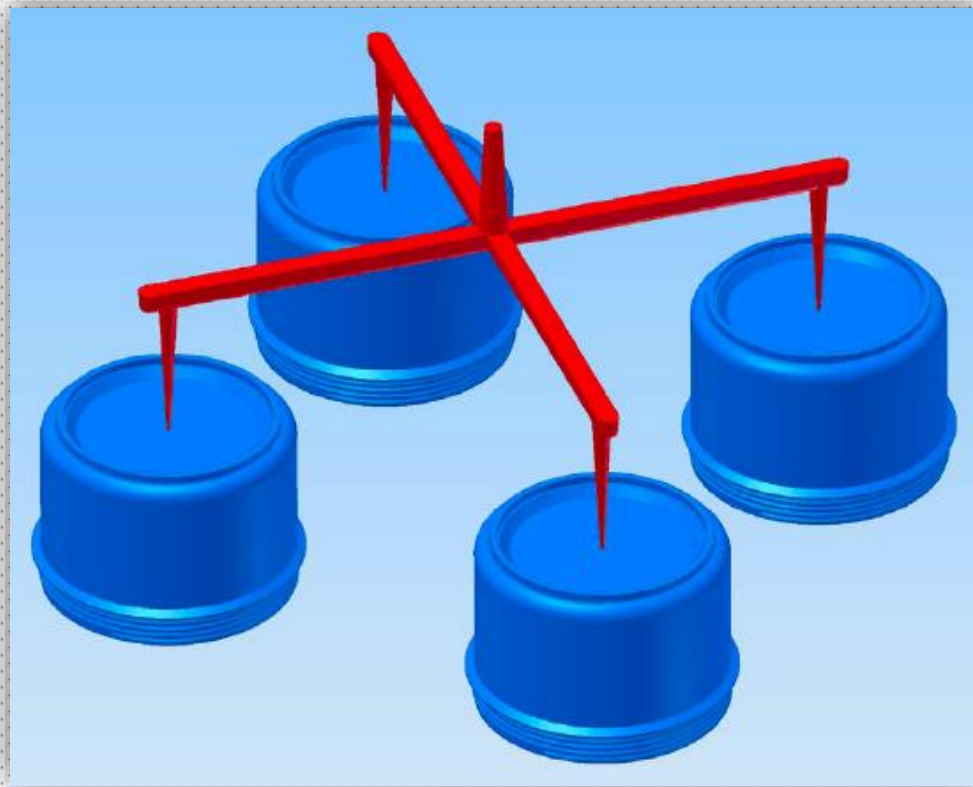
Take from Table

Runner Start = 3.15 mm.

Correction Factor = 1.175

Calculate = 3.15 mm. x 1.175
 = 3.70 mm.
 Runner Diameter ~ 4.00 mm.





Size of Runner = 4.00 mm.

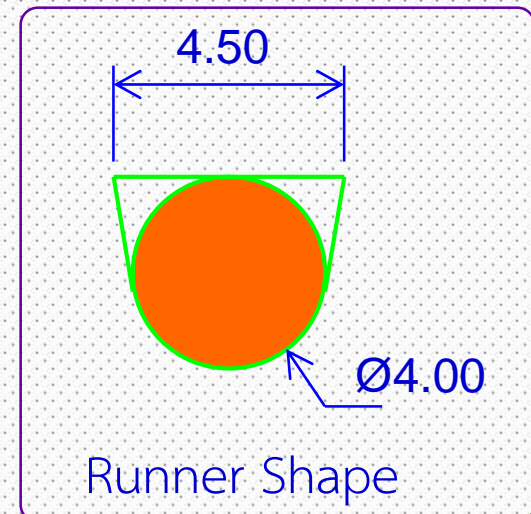
(at Round Shape)

- Plastic >PP<

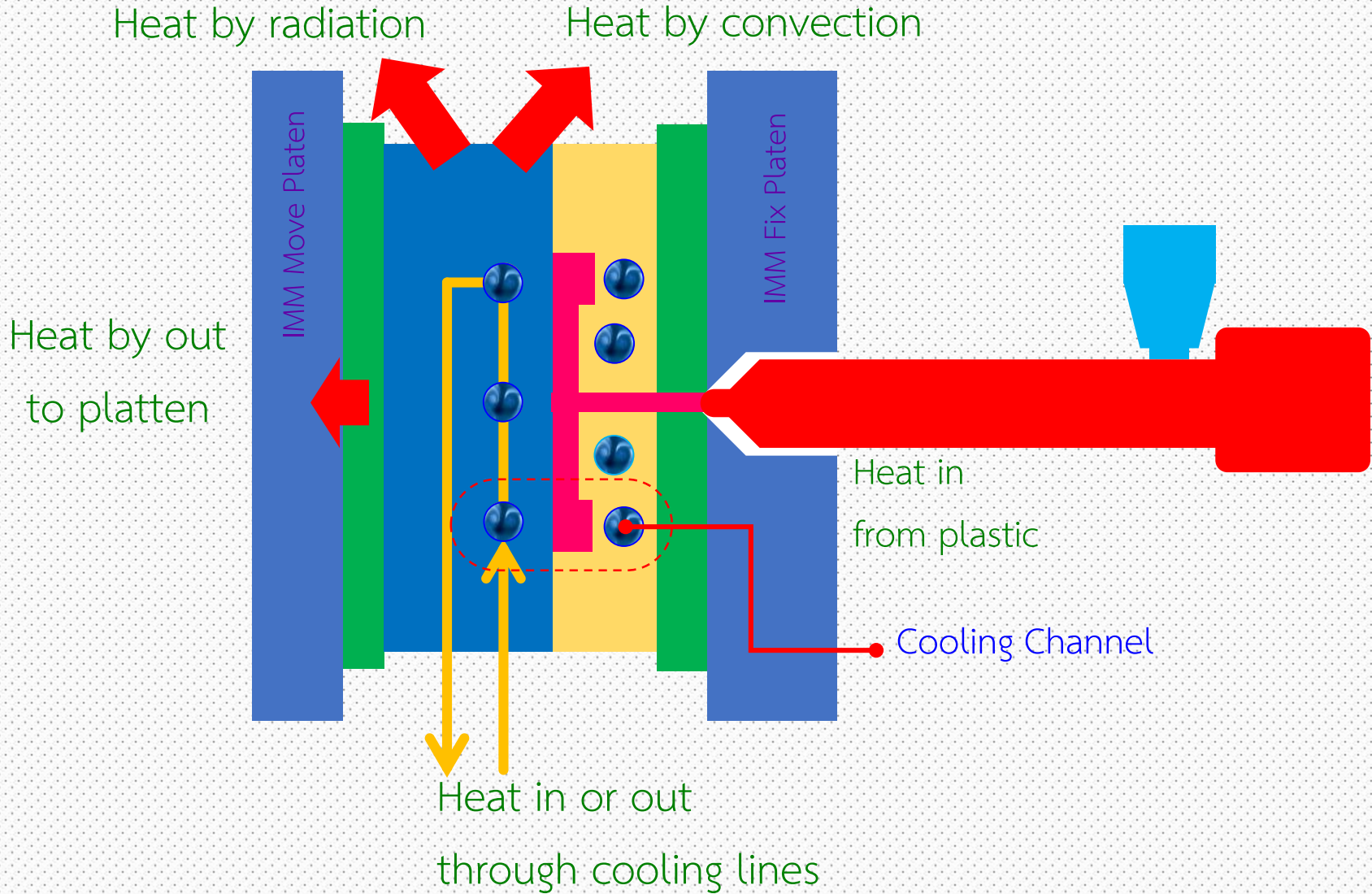
- Part Weight = 7.60 g.

- Runner weight = 5.20 g.

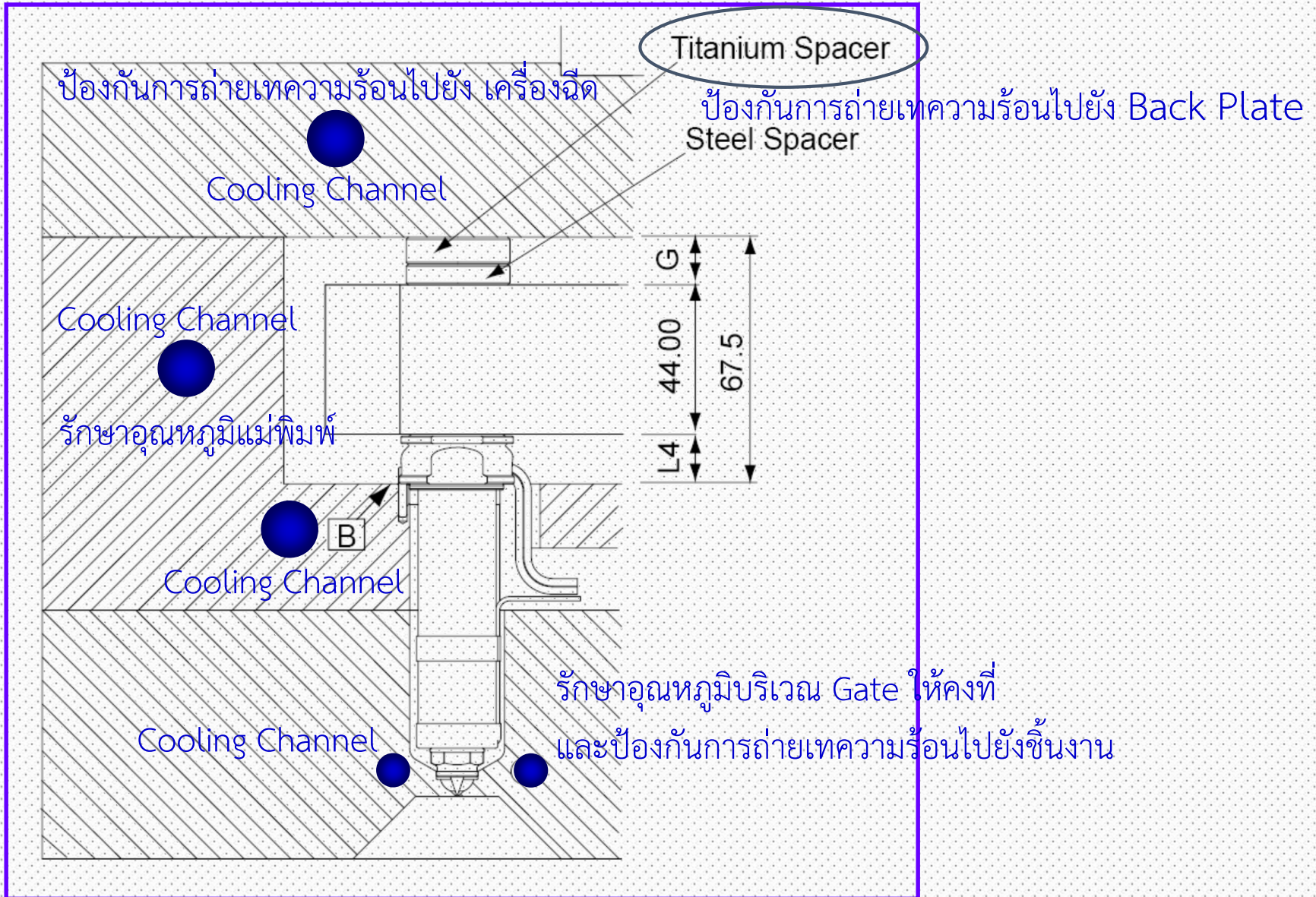
- Total weight = 35.60 g.



การถ่ายเทความร้อน จากแม่พิมพ์ Cooling time



การรักษาอุณหภูมิในระบบ Manifold By Cooling.





GATE COOLING

- Temperature control is critical for
 - Cosmetic gates
 - Maintaining gates live
 - Semi-crystalline materials
- For quickest cycle time individual gate cooling per cavity is required



GATE COOLING

- Too much cooling can cause starting problems
 - Glass filled material
 - Semi-crystalline materials
 - Depends on cycle time
- Always need to be able to control the cooling



Gate Temperature Control (Cooling)

- Over cooling gates
 - High vestige gates
 - Prevents gate operating

- Pictures PA + GF
 - Long pack time

- Potential cures
 - Higher mould temp
 - Insulate gate area

80C mold 310C nozzle

140C mold 310C nozzle

Cooling Time for Runner with Cold Runner

เวลาของหล่อเย็น

(Runner)

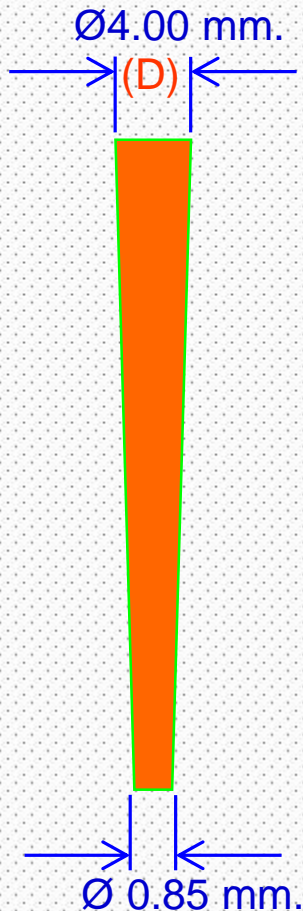
$$= 0.1729 \cdot \frac{r^2}{a_{\text{eff}}} \cdot \ln \left[1.6023 \left(\frac{T_{\text{melt}} - T_{\text{mold}}}{T_g - T_{\text{mold}}} \right) \right] \text{ Sec.}$$

$$= 0.1729 \times \frac{2.00^2}{0.067} \cdot \ln \left[1.6023 \left(\frac{220 - 40}{165 - 40} \right) \right]$$

$$= 10.322 \times \ln 2.307$$

$$= 10.322 \times 0.836$$

$$= 8.62 \text{ Sec.}$$



>PP< Specification

Melt temp = 220 °C (T_{melt})

Mold Temp = 40 °C (T_{mold})

Eject Temp = 80 C (T_{mold})

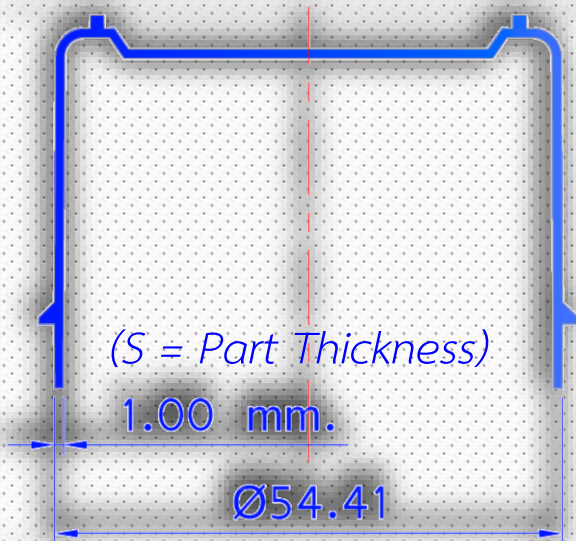
Glass Transition Temp = 165°C (T_g)

$a_{\text{eff}} = 0.067$

Cooling Time for Part with Hot Runner



เวลาของหล่อเย็น (Part)



>PP< Specification

Melt temp = 220 °C (T_{melt})

Mold Temp = 40 °C (T_{mold})

Eject Temp = 80 C (T_{mold})

$a_{eff} = 0.067$

$$= \frac{s^2}{\pi^2 \cdot a_{eff}} \ln \left[\frac{4}{\pi} \left(\frac{T_{melt} - T_{mold}}{T_{eject} - T_{mold}} \right) \right] \text{ Sec.}$$

$$= \frac{1.0^2}{\pi^2 \cdot (0.067)} \ln \left[\frac{4}{\pi} \left(\frac{220 - 40}{80 - 40} \right) \right]$$

$$= \frac{1.0^2}{\pi^2 \cdot (0.067)} \ln 5.729$$

$$= 1.51 \times 1.745$$

$$= 2.64 \text{ Sec.}$$





คำนวณหารอบการผลิต

Cycle Time Comparison Table

Process	Cold Runner	Hot Runner	Time Reduce
Mold Close	2.50 Sec	1.50 Sec	↓ 1.00
Fill Time	0.50 Sec	0.50 Sec	
Packing Time	1.00 Sec	1.00 Sec	
Cooling Time	8.62 Sec	2.64 Sec	↓ 5.98
Mold Open	2.50 Sec	1.50 Sec	↓ 1.00
Ejector Time	1.50 Sec	1.50 Sec	
	16.62 Sec	8.64 Sec	↓ 7.98

Cycle Time Reduce = 48.01%



คำนวณหากำลังการผลิตที่เพิ่มขึ้น

Productivity Add Up Comparison Table

	Cold Runner	Hot Runner	Remark
Cycle Time	16.62 Sec	8.64 Sec	
1 Hours	866 Pcs	1,666 Pcs	
1Day	20,794 Pcs	40,000 Pcs	24 Hours
1 Month	540,649 Pcs	1,040,000 Pcs	26 Days

Productivity Ad Up = 48.01%



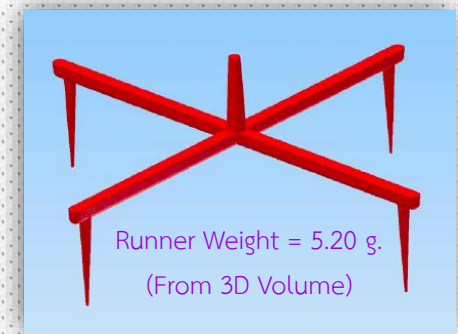
คำนวณหาปริมาณทางวิ่งที่ไม่ต้องสูญเสีย

Runner Loss Comparison Table

	Cold Runner	Hot Runner	Remark
Short Number	216 Short	416 Short	/ Hours
1 Hours	1.12 Kg.	0.00 Kg.	
1Day	26.95 Kg.	0.00 Kg.	24 Hours
1 Month	700.87 Kg.	0.00 Kg.	26 Days
Save Money	35,043.00	Baht/Month	

- Runner weight**
- Cold Runner = 5.20 g.
 - Hot Runner = 0.00 g.

Plastic Price = 50.00 Baht/Kg. (Estimate)





คำนวณหาปริมาณการใช้พลังงานไฟฟ้าในการหลอมละลาย

Electrical Power Required Comparison Table

	Cold Runner	Hot Runner	Remark
Weight/Short	9.33 (262 Short x 35.60 g.)	12.64 (416 Short x (7.60x4) g.)	Kg./Hour
1 Hours	1,400.00 (9.33 x 150)	1,896.00 (12.46 x 150)	Watts/Hour
Production	1,048.00	1,664.00	Pcs/Hours
1 Pcs Use	1.34 (1,400.00 x 1,048.00)	1.14 (1,896.00 x 1,664.00)	Watts/Pcs
Power Save	0.20 1.34-1.14 = 0.20 Watts	Watts/Pcs	
	99.20 0.20 x 496 (1896-1400) = 99.20 watts	Watts/Hour	
	2,182.40	Watts/Day	
	56,742.40	Watts/Month	

Plastic 1 Kg. = 150 Watts/Hour ~5 Baht/Kg.

HOT RUNNER SYSTEM

Manifold and Nozzle

Connecting Plug

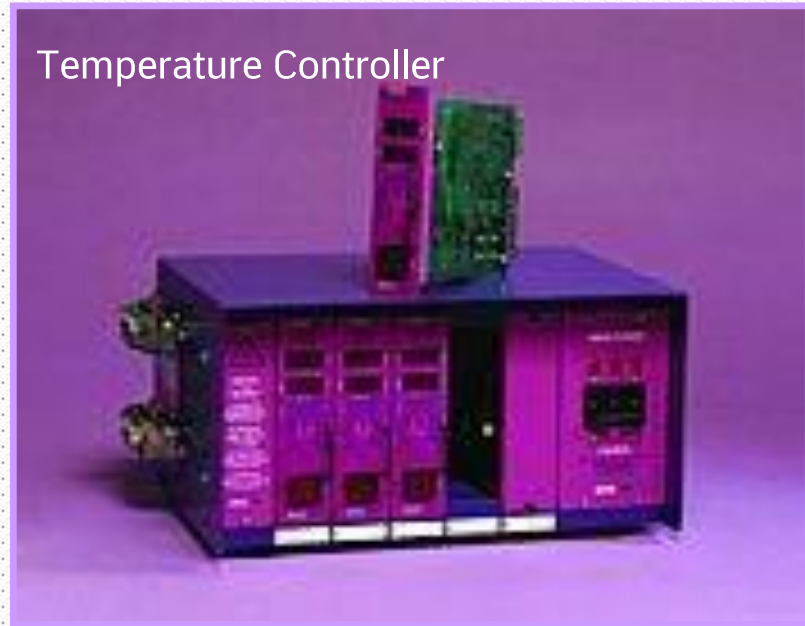
Terminal & Mounting Box



Mold Power-Thermocouple Cable

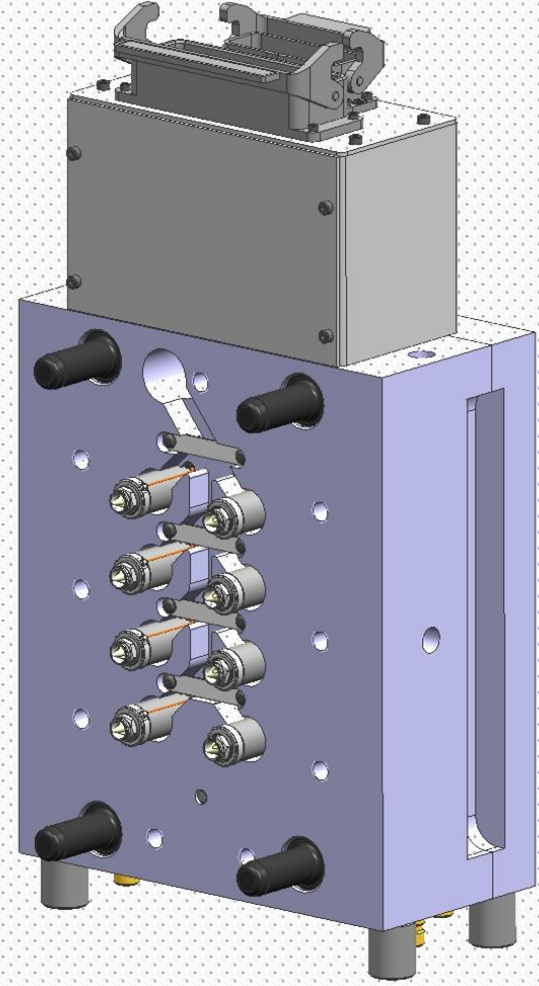
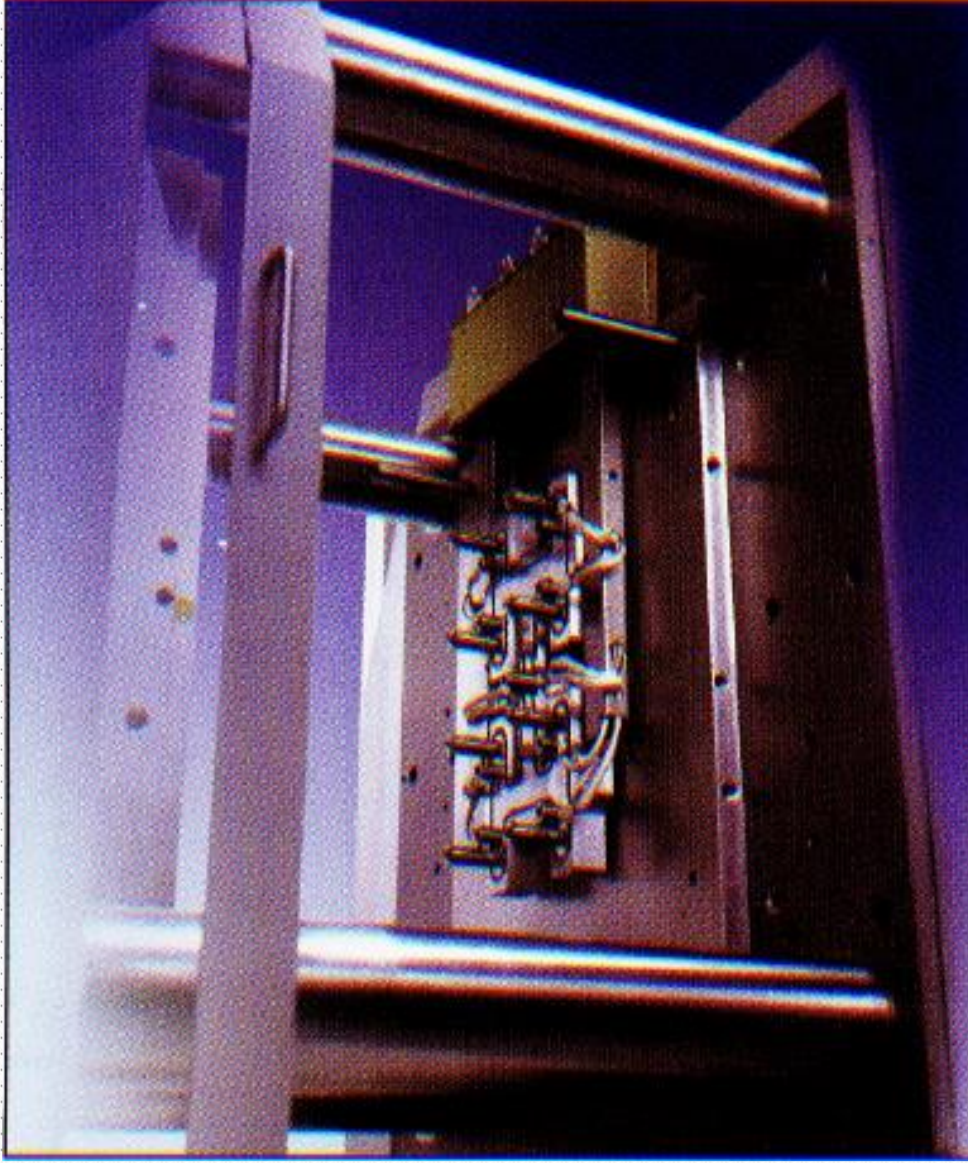


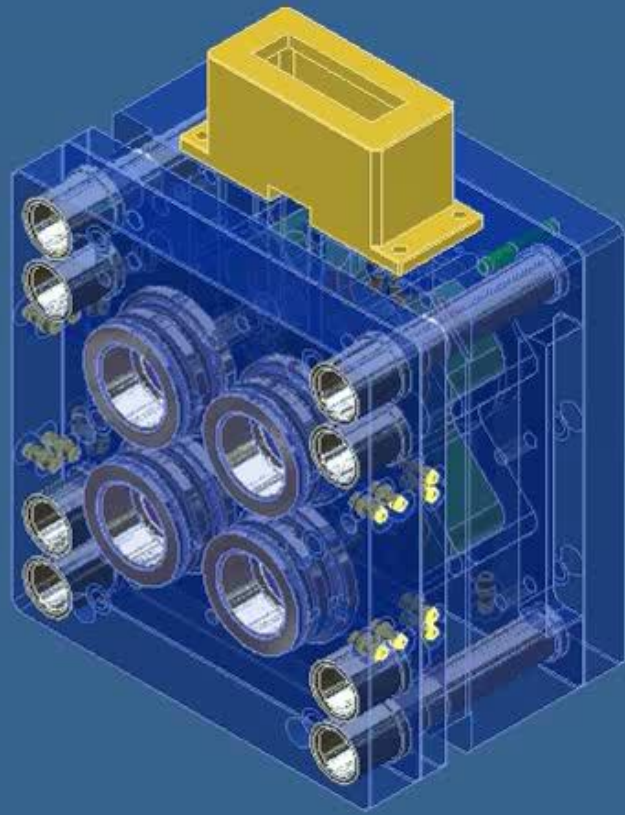
Temperature Controller

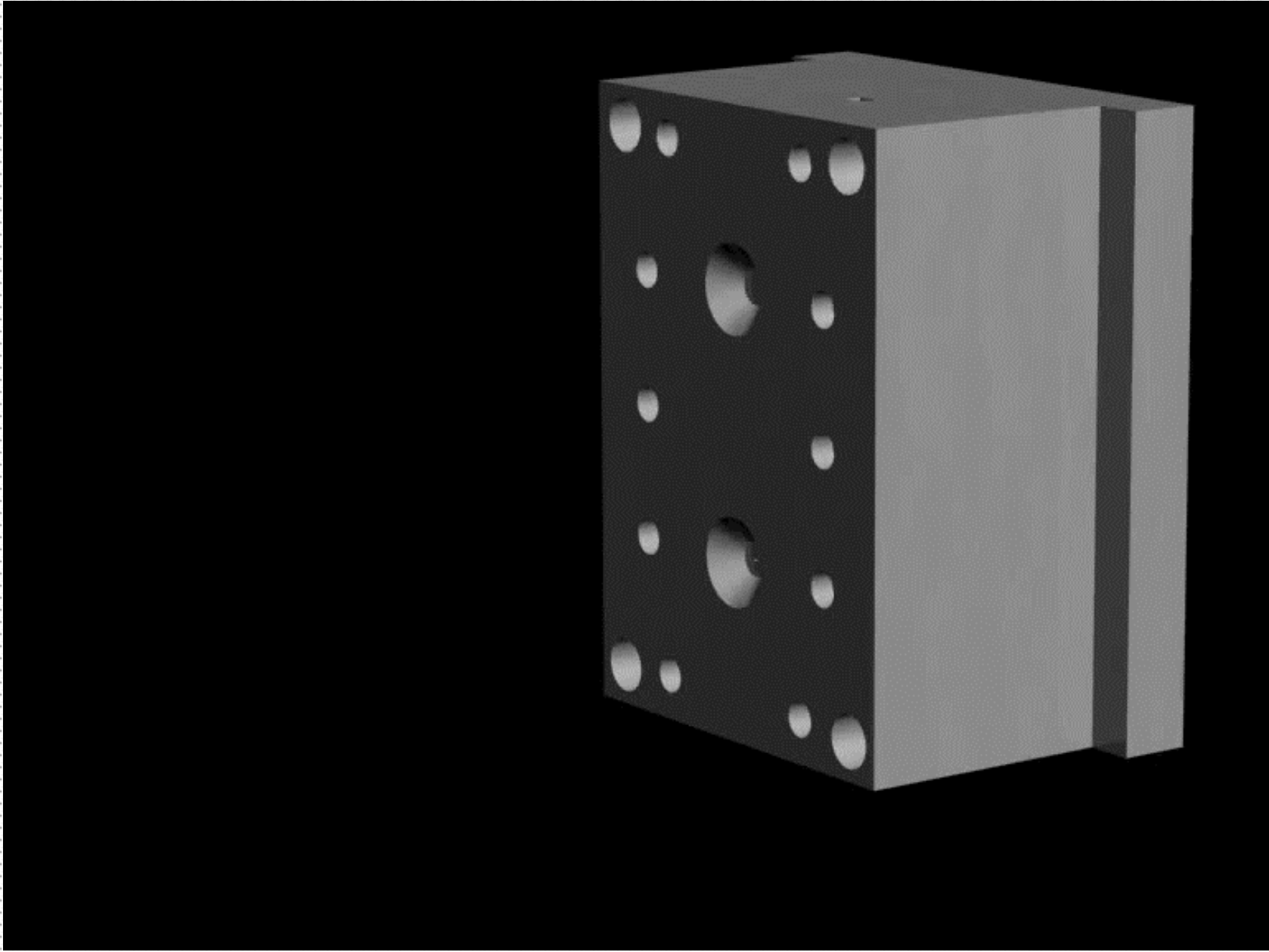


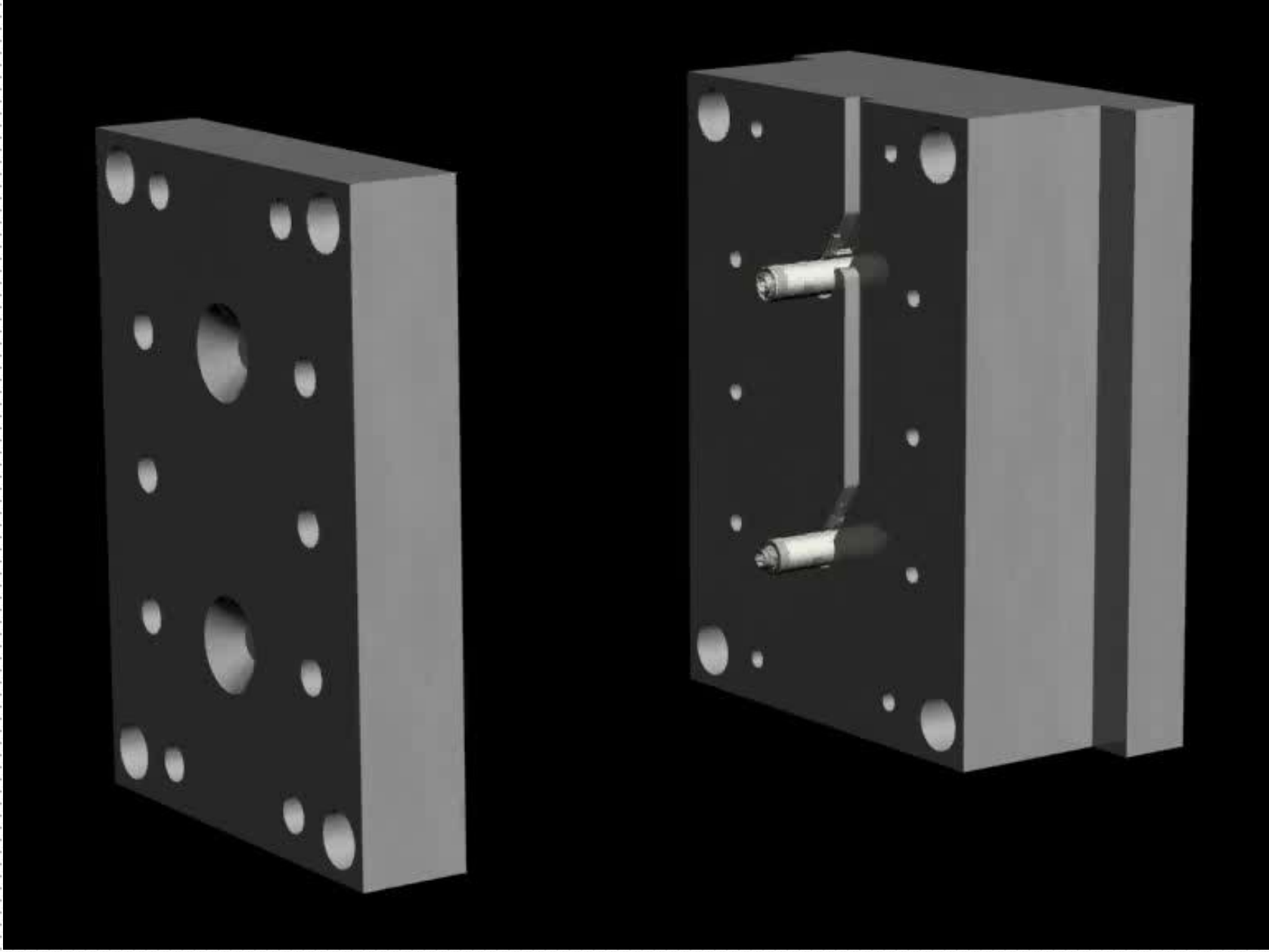


ADVANCE FOR HOT HALF CONCEPT







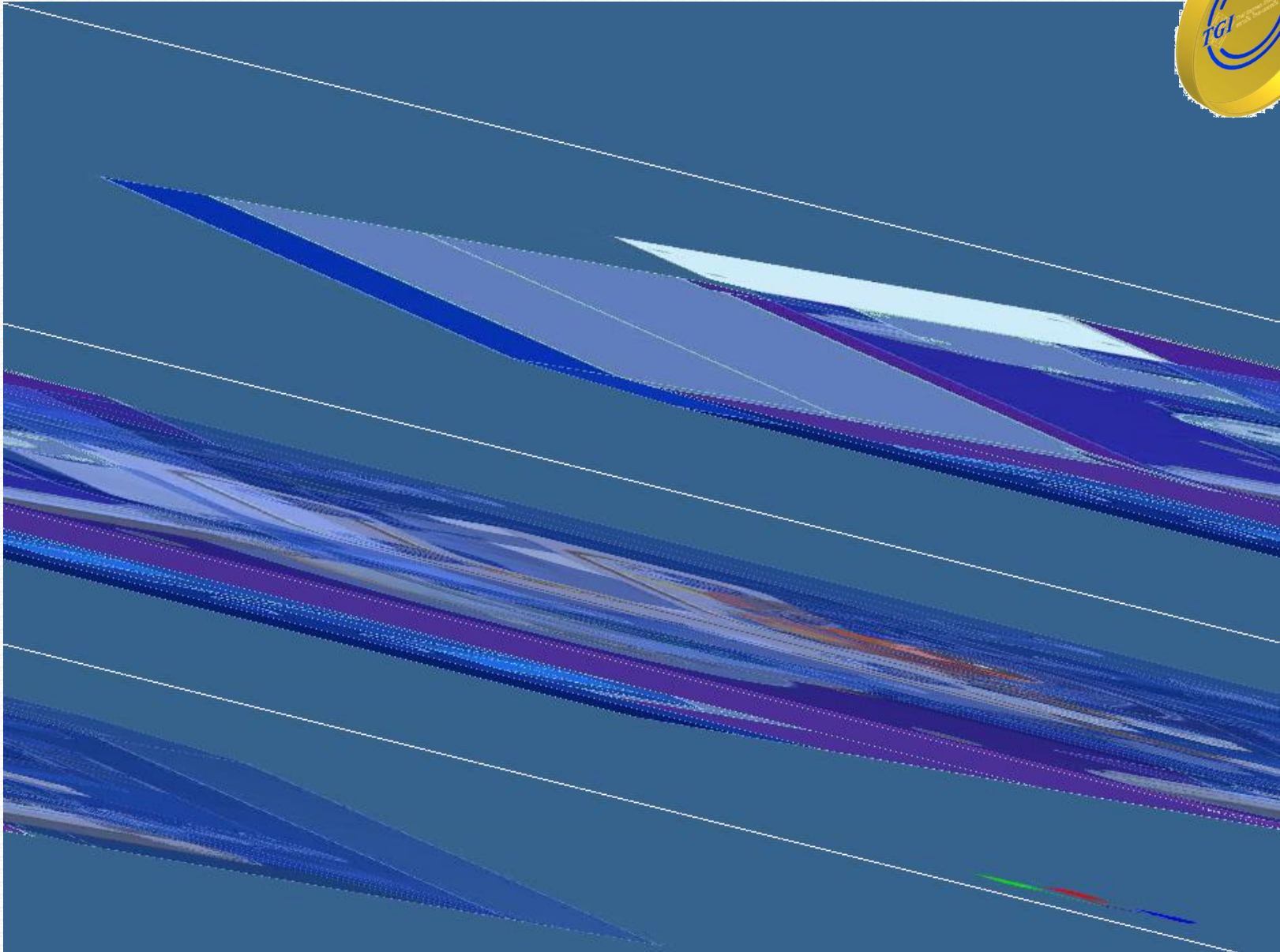




ADVANCE FOR MOLD 2K // TGI

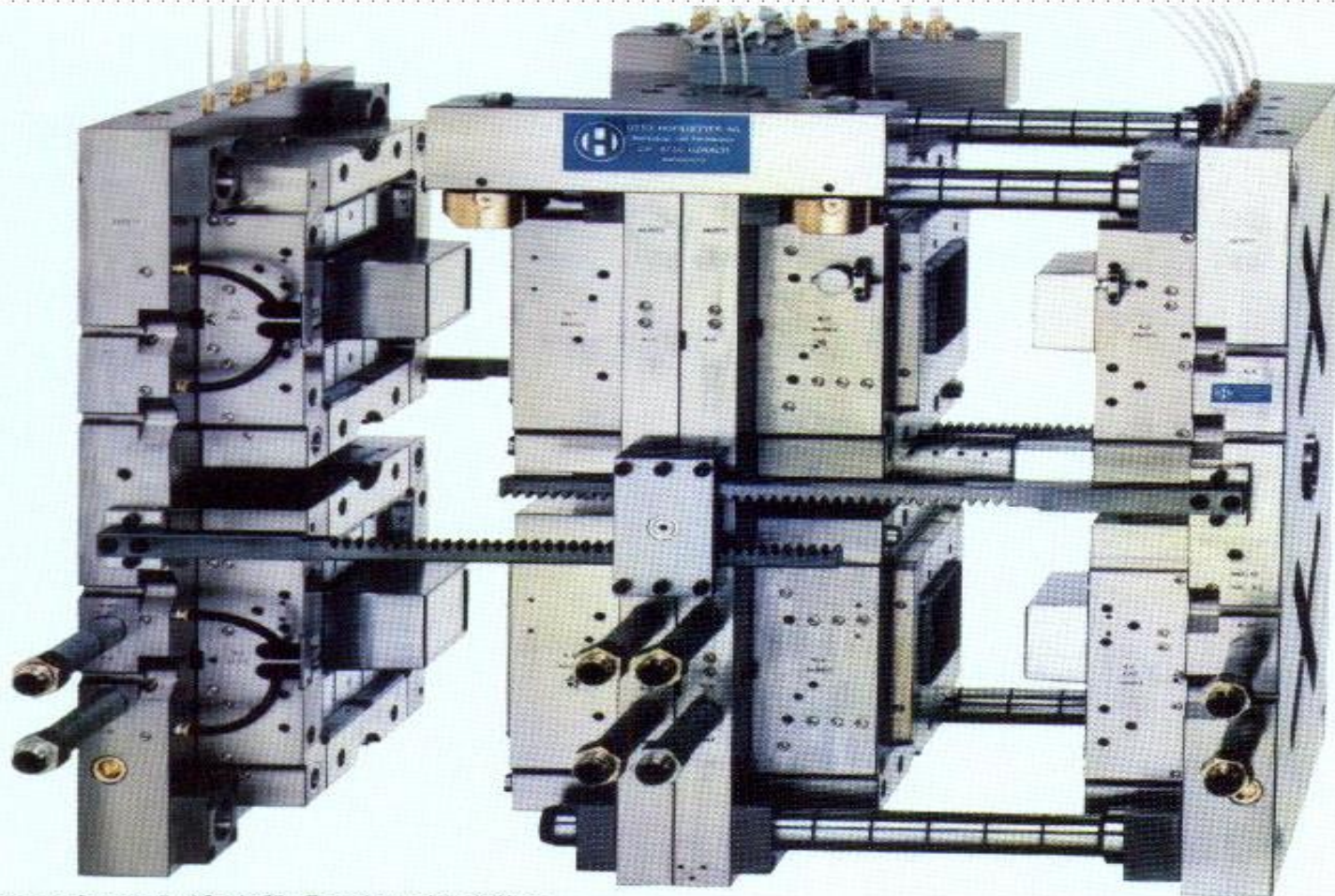


MOLD 2K // TGI





ADVANCE FOR STACK MOLD



*OH-Etagenwerkzeug 2+2fach für Feuchttuchbehälter
Moule à étages OH, 2+2 empreintes, pour serviettes humides
OH 2+2 cavity stack mould for moist tissues*

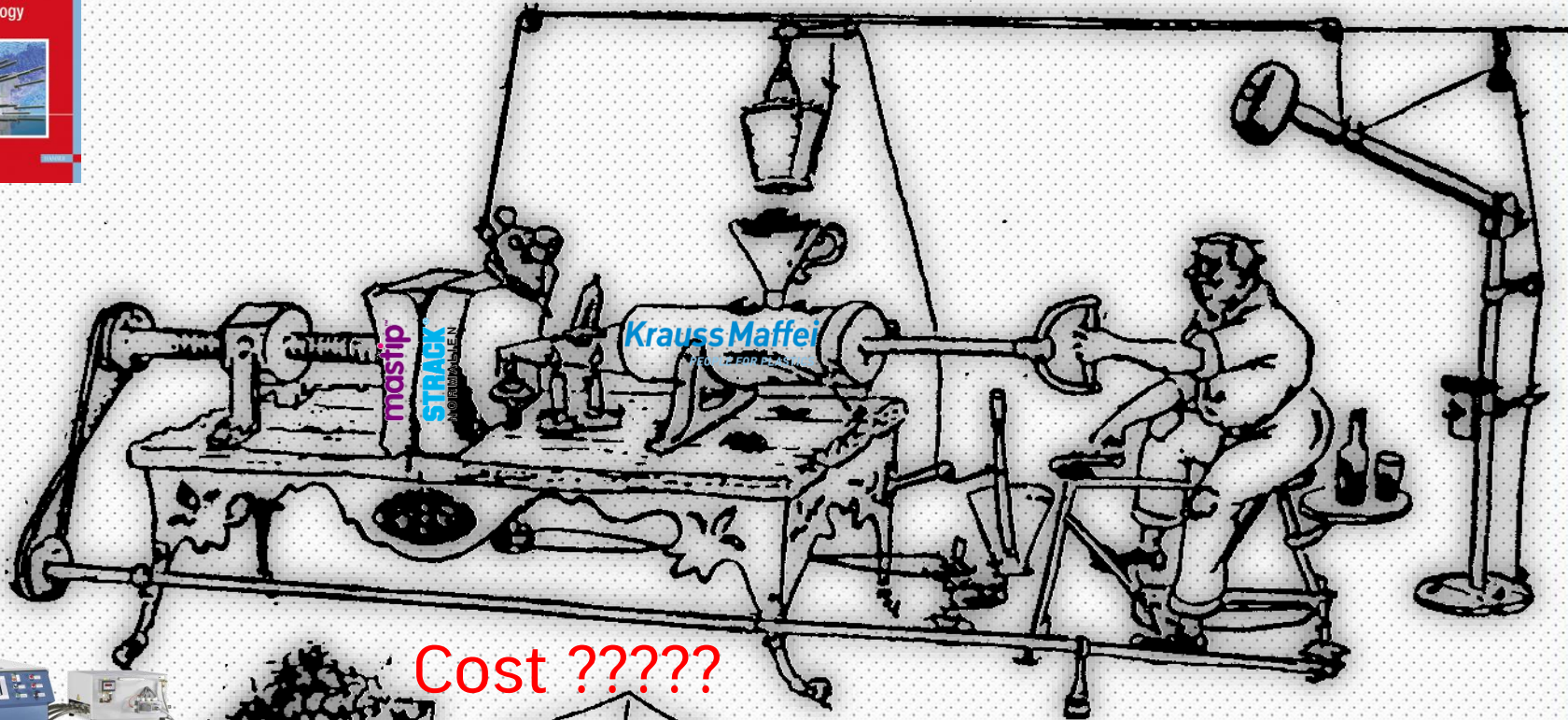


Stack Mold
Animation

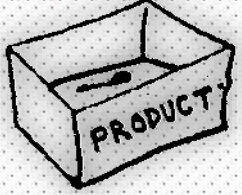
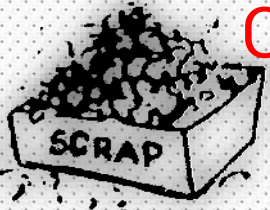
<http://www.hotrunner.com.tw>



THANK YOU FOR YOUR ATTENTION



Cost ?????



Temperature Controller

Advise and Training for
Improvement Mold and Molding Process