Module 3. Injection Molding

Cost	Rate	Quality	Flexibility
low	fast	high	→ low

bran

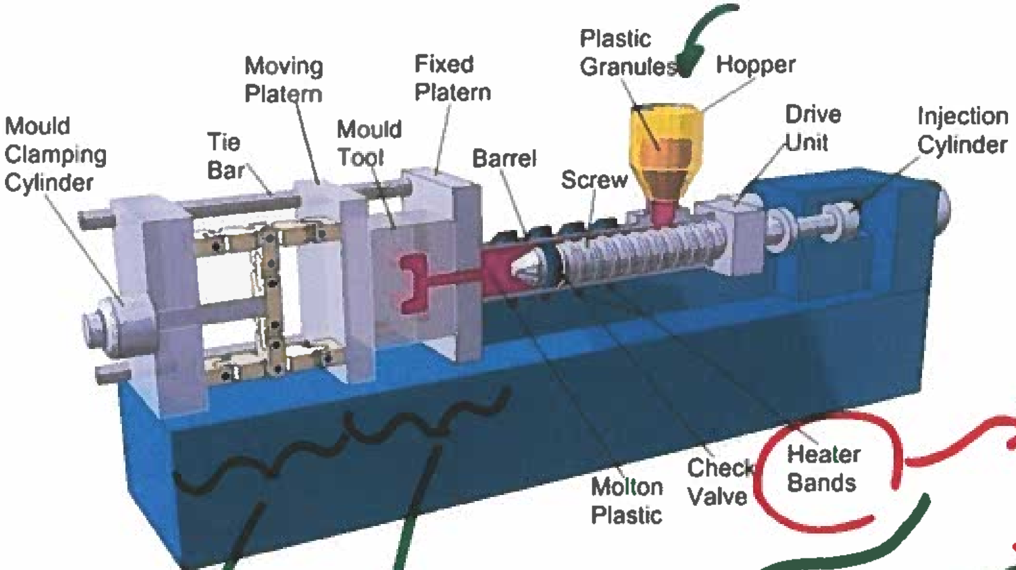
bran insert

insert molding

soft

hard plastic

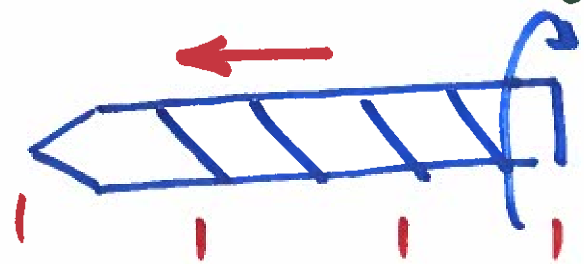
over molding



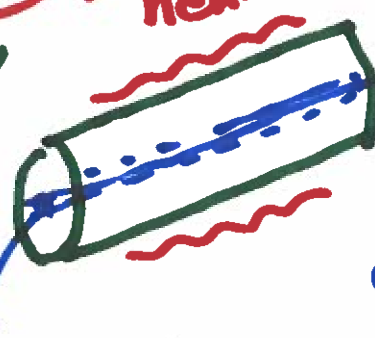
clamp

mold

feeder



heat



solidify

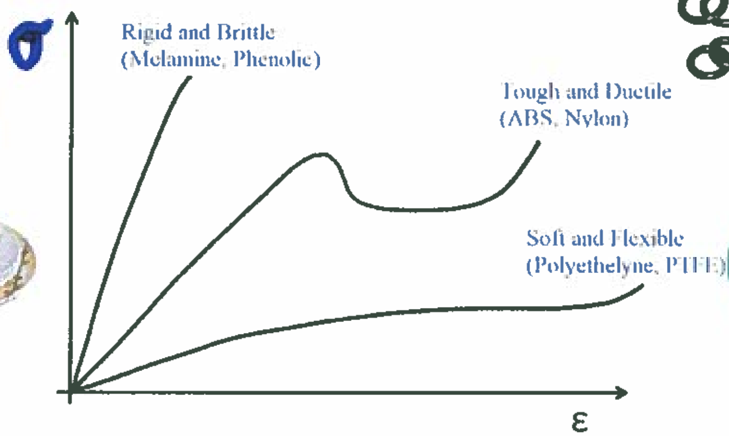
Polymer = poly + mer

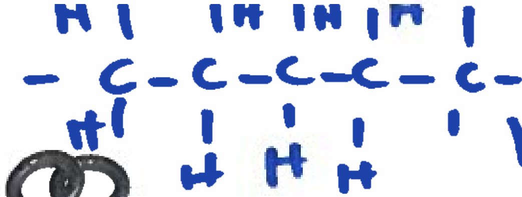
many struct

ethylene C_2H_4

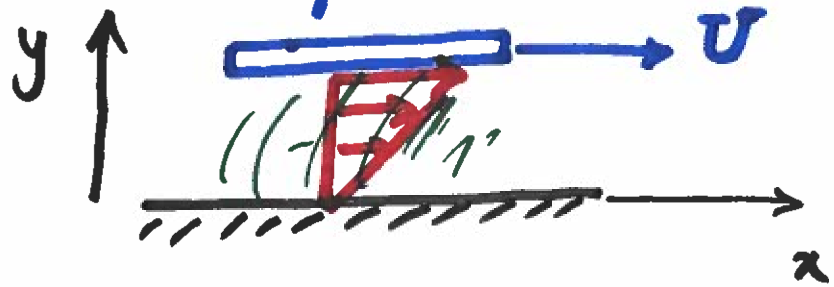
$$H_2C{=}CH_2 \xrightarrow[\text{pressure}]{\text{heat}} -\left[CH_2-CH_2\right]_n-$$

Mechanical Properties:





Viscosity:



$$\tau = \mu \frac{\partial u}{\partial y}$$

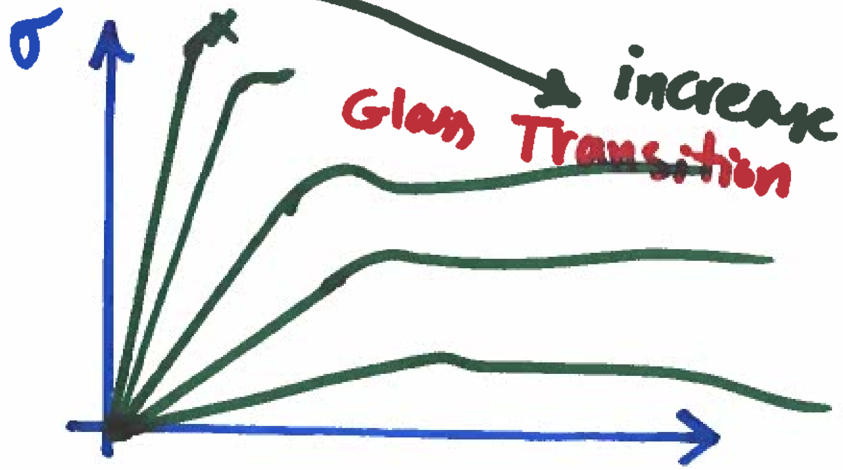
↓ Viscosity

Pa.s

oil: 0.1

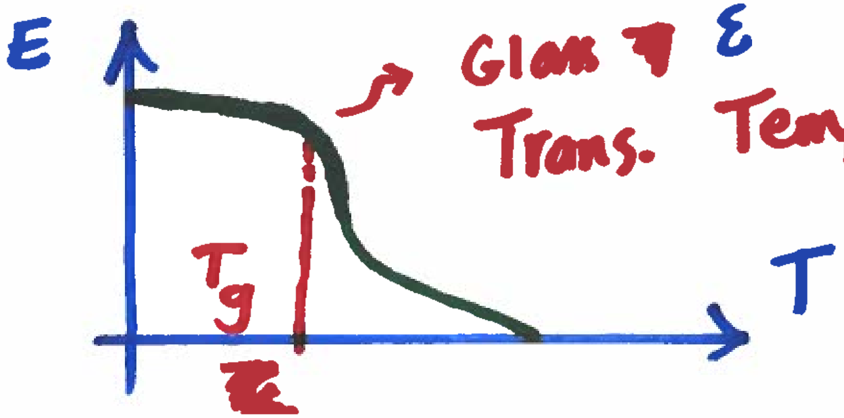
honey: 10

plastic: 100

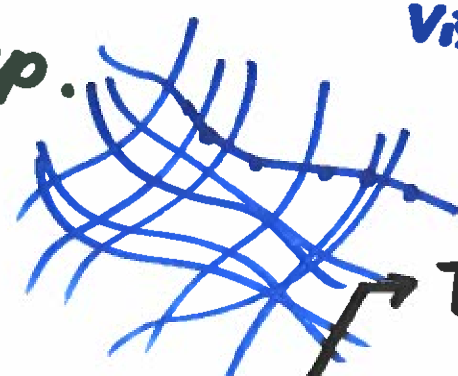


increase Temp.

Glass Transition

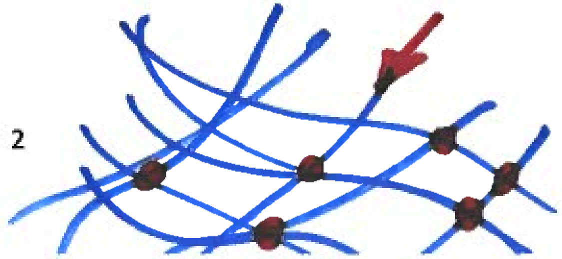


Glass Trans. Temp.

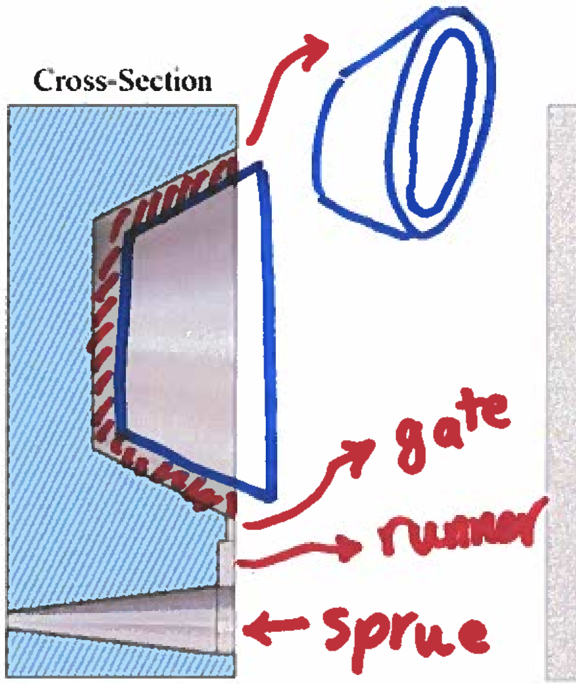


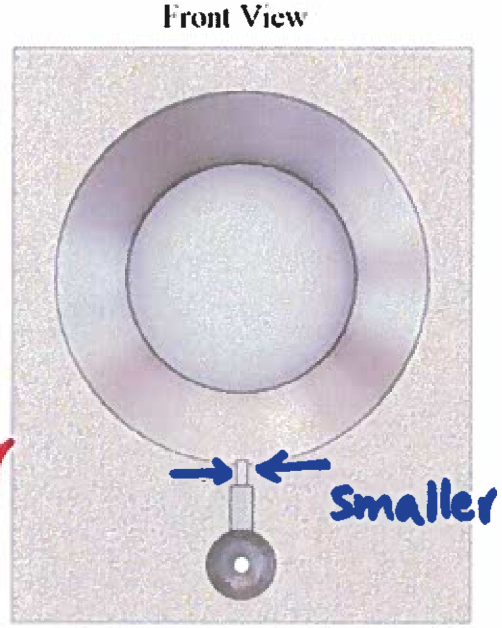
plastics → Thermoplastic → recycle → remelt → reshape

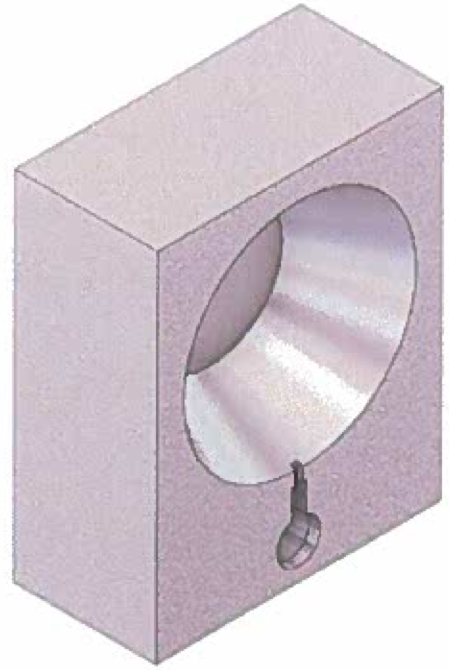
plastics → thermoset

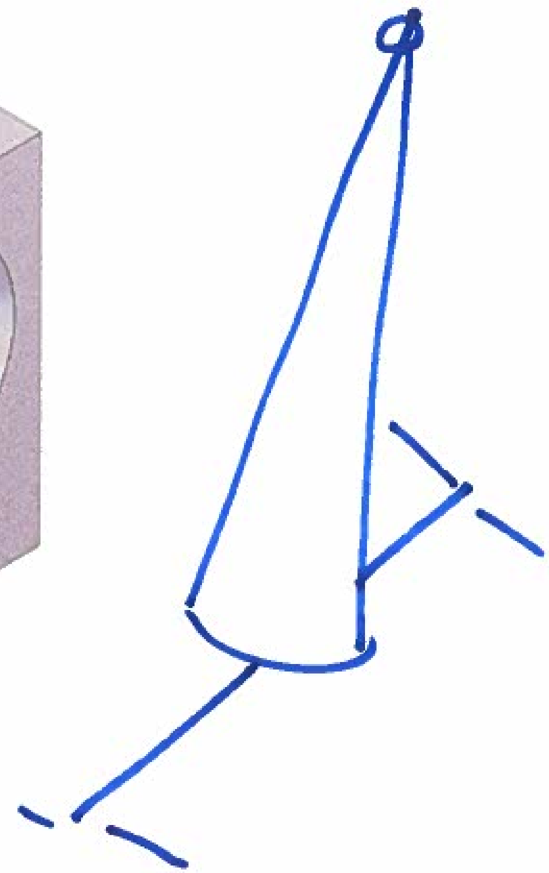


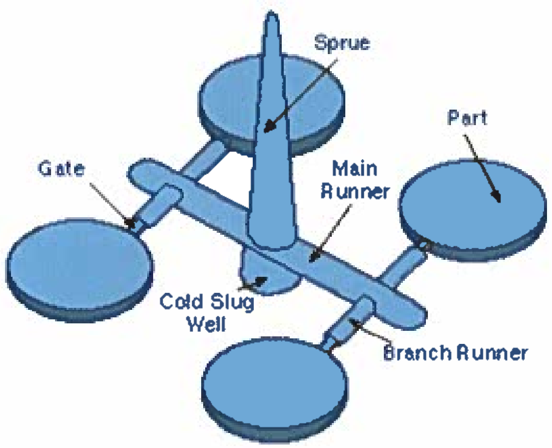
The features of the injection mold tool:

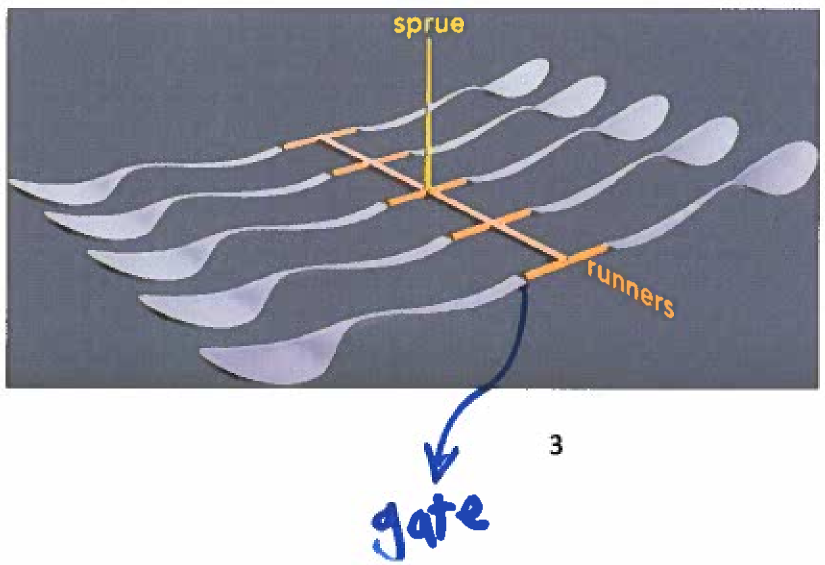




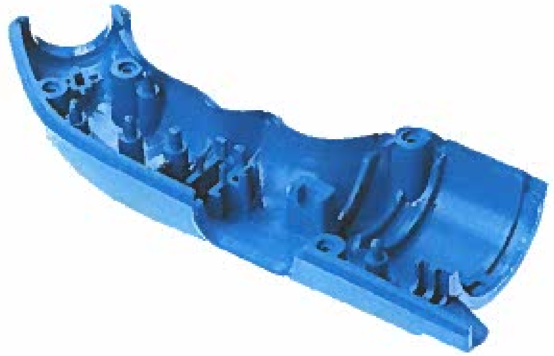


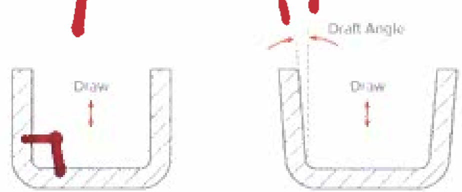




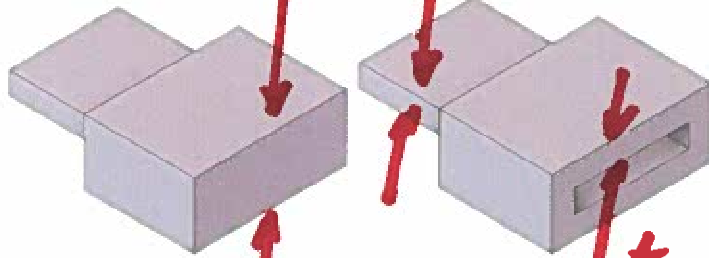


Design for Moldability:





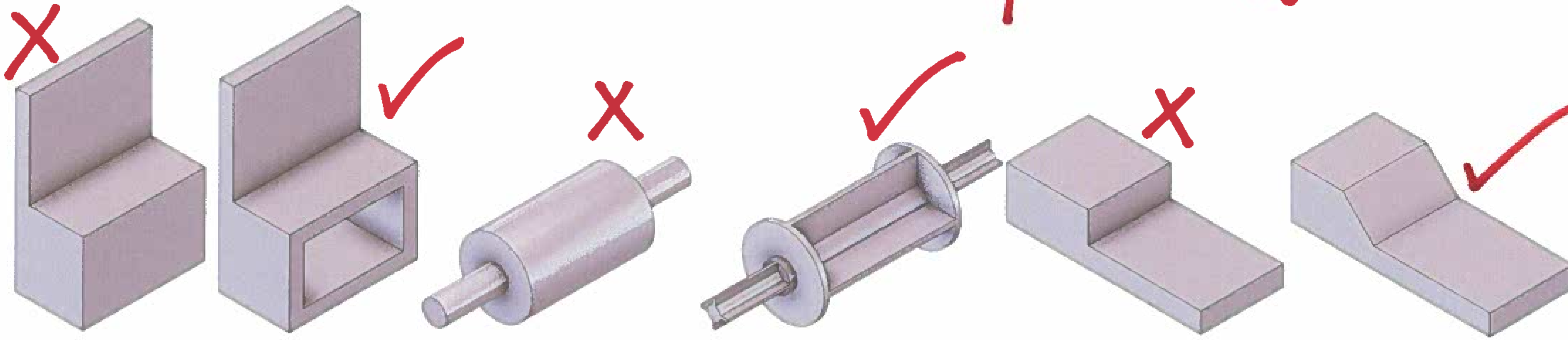
thickness

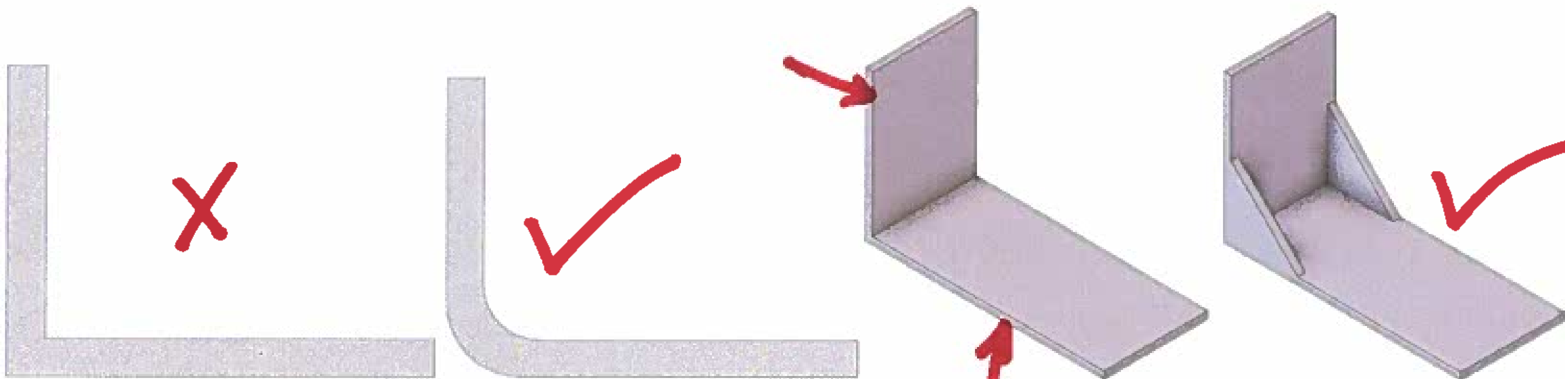


t

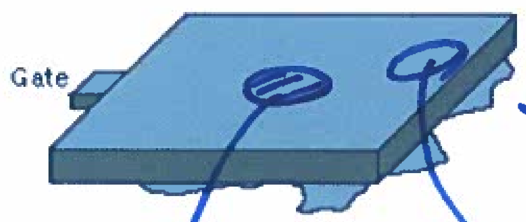
t

uniform thickness





Defect in Injection Molding Parts:



Flash

low clamping force

too much volume

dark

burning

high T

void

not enough

material

Control parameters:

V ① shot size

(1% shrinkage)

F ② Clamping force

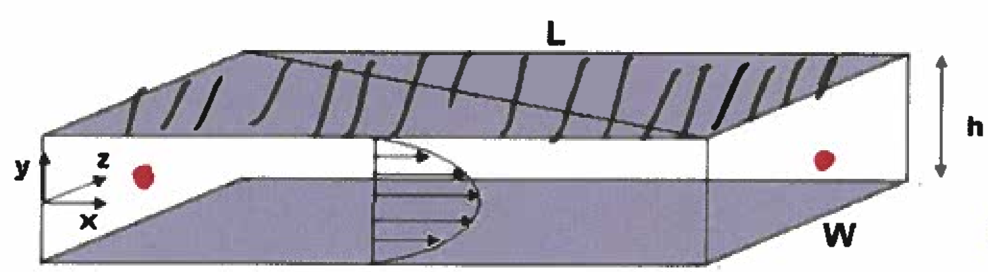
t_{cool} ③ Cooling time

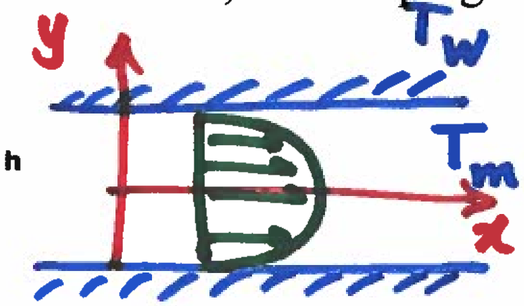
p ④ pressure

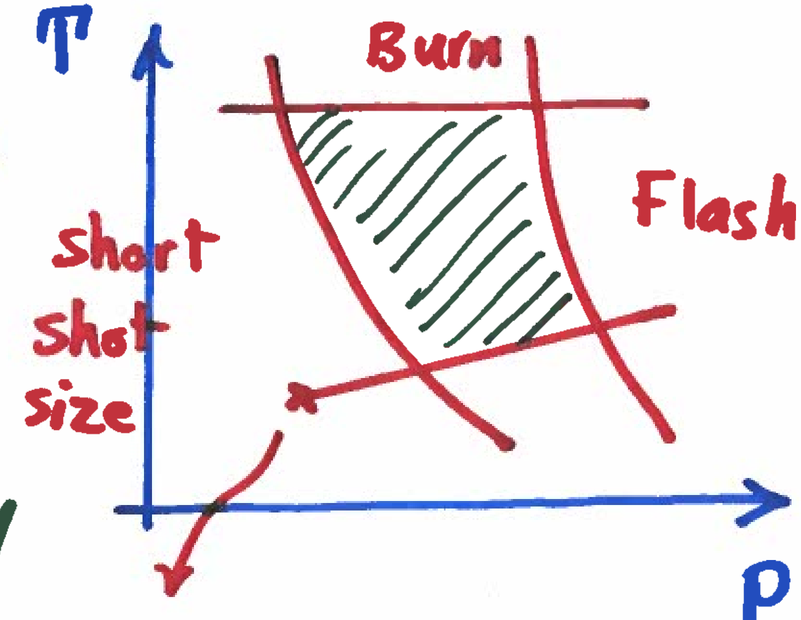
Engineering analysis of Injection Molding:

T_e : the temp. after ejection

Parameters: 1. Shot Size, 2. Required Time to Fill in a Mold, 3. Clamping Force, 4. Cooling Time







→ Q flow rate

$$\boxed{t_{fill} = \frac{Lwh}{Q}}$$

Navier-stock eq.

$$\frac{dp}{dx} = \mu \frac{\partial^2 u}{\partial y^2}$$

velocity

melt Point

process window

*

$$\boxed{\Delta P = \frac{12 \mu Q L}{w h^3}}$$

*

$$\boxed{F_{clamp} = \frac{1}{2} \Delta P \times w L}$$

$$\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial y^2} \rightarrow$$

thermal diffusivity

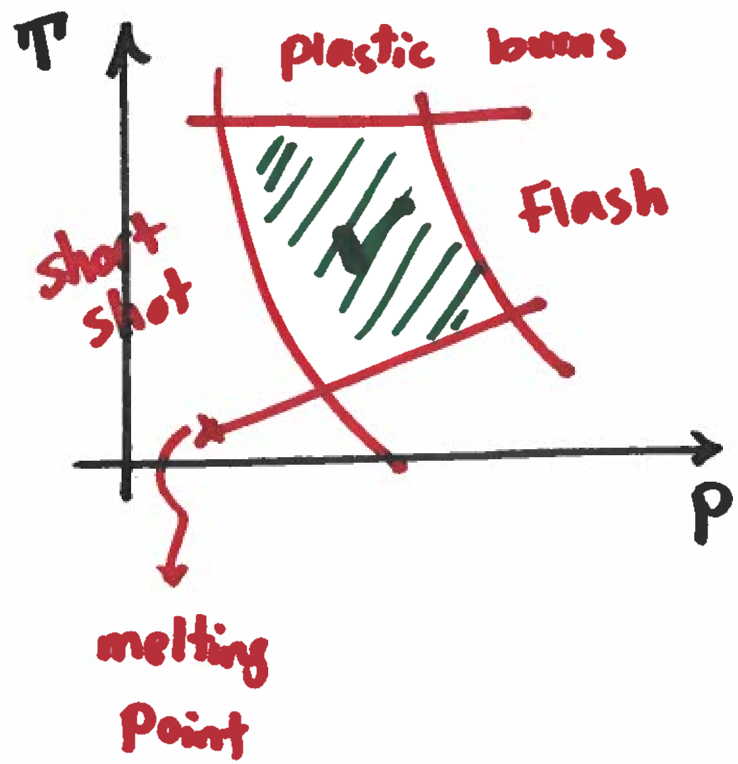
*

$$\boxed{t_{cool} = \frac{h^2}{10\alpha} \ln\left(\frac{4}{\pi} \frac{T_m - T_w}{T_e - T_w}\right)}$$

Summary :

We can control T (Temperature) and P (pressure) inside a mold :

The process window



Q: Flow Rate

1) time to fill mold $= \dfrac{Lwh}{Q}$ (1)

2) $\Delta P = \dfrac{12\mu Q L}{w h^3}$ (2)

3) (1) & (2) $\longrightarrow$ $t = \dfrac{12\mu}{\Delta P} \left(\dfrac{L}{h}\right)^2$

4) $F_{clamp} = \dfrac{1}{2} \Delta P \times WL$

5) $t_{cool} = \dfrac{h^2}{10\alpha} \ln\left(\dfrac{4}{\pi} \times \dfrac{T_m - T_w}{T_e - T_w} \right)$

6) $\alpha = \dfrac{K}{\rho c_p}$