Oliver song 2.008 Exam 1 crib sheet

Engineering stress: $\sigma = P/A_o$
Engineering strain: $e = (L - L_o)/L_o = d/L_o$
Effectiveness = Cost + Quality + Flexibility + Rate

Machining (Material Removal)

Price -, Quality ++, Flexibility ++, Rate -
Milling
Turning

Squeezing (Forming)

Price +, Quality ~, Flexibility limited by die shape (dies need to be manufactured), Rate ++
Forging- heat and press into a shape
Stamping- heat and cut into a shape
Rolling- heat and press between rollers to make a sheet
Extruding- heat and press through small hole

Melting

Price -, Quality - (post finishing needed), Flexibility + (good and cheap for large parts. wooden patterns), Rate --

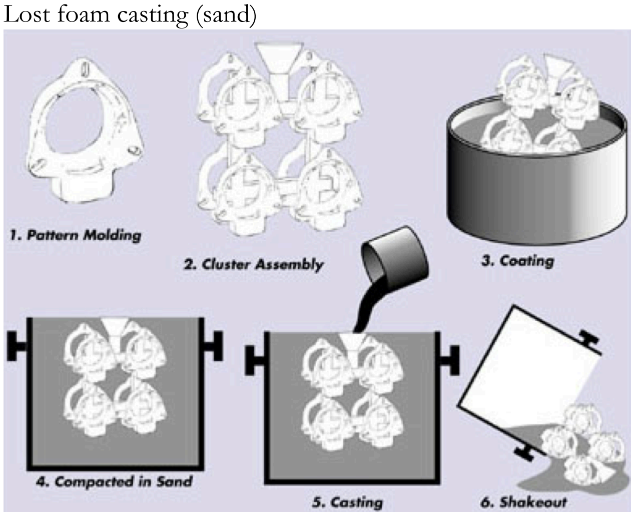
Casting

Disposable mold

Sand casting

1. Make polystyrene blank, Surround with sand ,Pour metal into blank, Blank evaporates, sand holds shape
2. Solidification time: $t_s=C(V/A)^2$
3. Cost: Tooling and equipment cost _, labor cost ^, material utilization _, finishing cost ^
4. Quality: ~1mm tolerance, defects in shrinkage, material is inherently poor, rough surface generally.
5. Rate: 2-10 weeks. production rate depends on cool time
6. Flexibility: High shape complexity limited by pattern

Lost foam casting (sand)



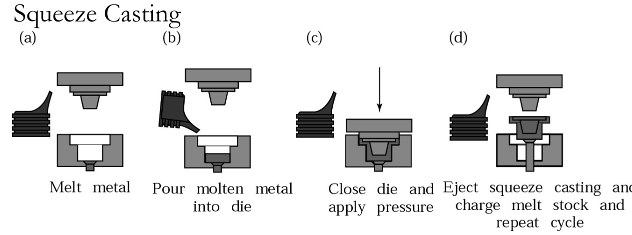
Investment casting
-Like lost foam but with slurry+stucco to make shell on outside of assembly
-Advantages: Intricate geometry, close dimensional tolerance, superior surface finish, high melting point alloys
-Cost: Tooling costs ~, equipment costs _, labor costs ^, material costs _
-Quality: ~.1mm tolerance, good to excellent surface detail if fine slurry
-Rate: 5-16 weeks, production depends on cooling
-Flexibility: Complex possible but at increased costs

Cool: centrifugal casting for metal pipes

Permanent Mold

Die Casting
-Make mold, inject into mold and release, repeat
-Advantages: high production rate, closer dimensional tol, superior surface finish, improved mechanical properties, 0.5 million shots die life
-Solidification time: $t_s=C(V/A)$
-Cost: Tooling and equipment costs ^, labor costs ~, material utilization ^
-Quality: 0.02~0.6mm tolerance, good mechanical and microstructure properties due to high pressure, excellent surface detail
-Rate: 12-20 weeks, production depends on cooling
-Flexibility: Low- high die modification cost

Squeeze Casting

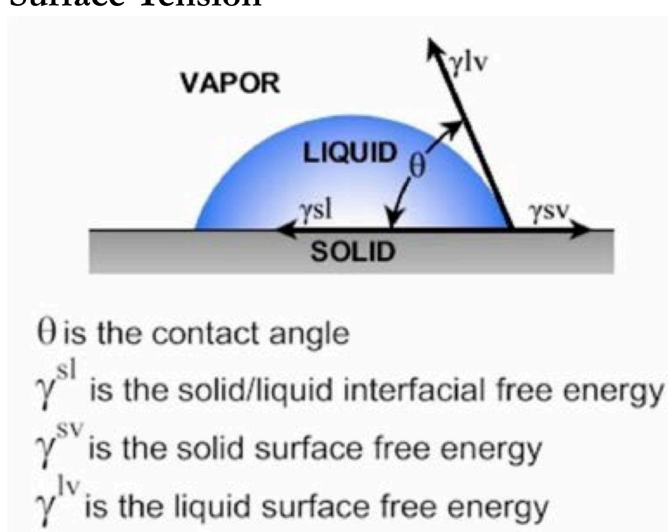


Plastics processing

Cost ~, Quality ++, Flexibility -- (Dies need made), Rate ++
Injection Molding
- Thermosets
- Hold pressure = 150% injection pressure
- Clamping force = projected area * injection pressure
- Gate location: Central for balancing travel, thickest part for balancing cooling rate, hidden for finish, consider weld-line, molecular orientation, size/location to control jetting

Thermoforming
-Thermoplastics

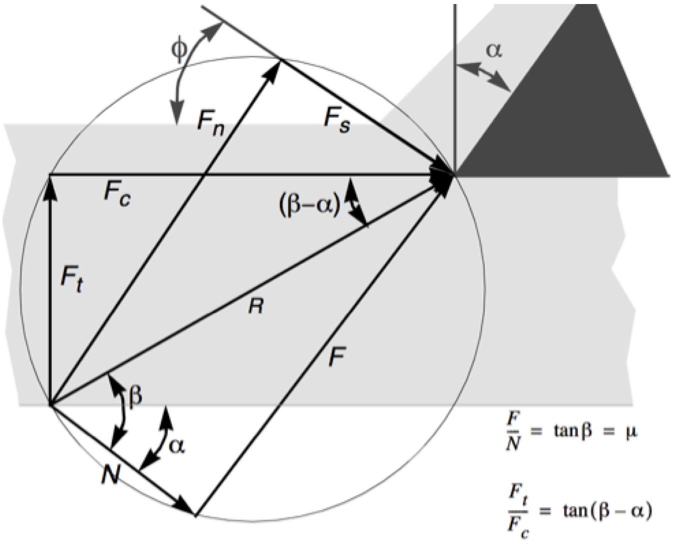
Surface Tension



Young's equation

$$\gamma_{SL} + \gamma_{LG}\cos\theta_c = \gamma_{SG}$$

Cutting Forces



MRR * Specific Energy = Power required

Thrust force is $F_t = F_c \tan(\beta-\alpha)$

If $\beta = \alpha$, Thrust goes to zero!

If $\beta \leq \alpha$, thrust is reversed, keeps tool engaged in cut

$F = F_c\sin(\alpha) + F_t\cos t(\alpha)$

$N = F_c\cos(\alpha) - F_t\sin(\alpha)$

$F_c = R\cos(\beta-\alpha)$

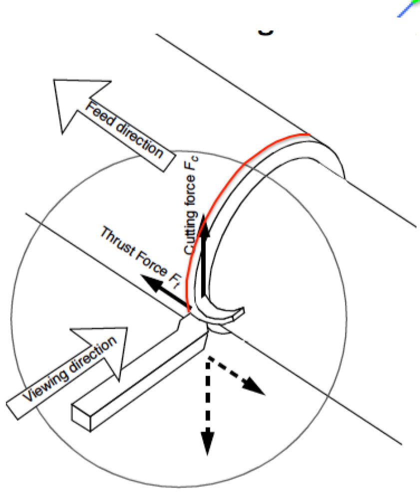
$F_t = R\sin(\beta-\alpha)$

$F_s = F_c\cos(\Phi) - F_t\sin(\Phi)$

$F_n = F_c\sin(\Phi) + F_t\cos(\Phi)$

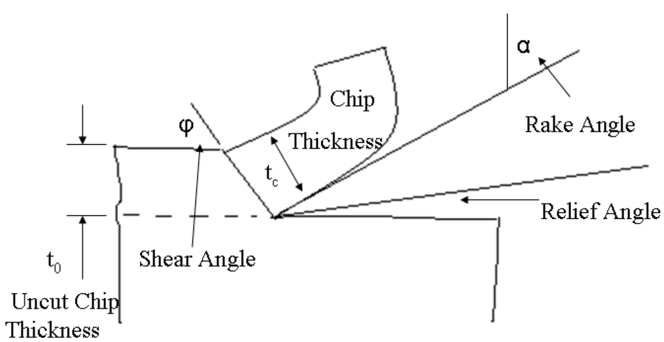
$$\tau = \frac{F_c \cos(\varphi + \beta - \alpha)\sin(\varphi)}{t_0 w \cos(\beta - \alpha)}$$

$$\varphi = 45 + \frac{\alpha}{2} - \frac{\beta}{2}$$



$$\tau = \frac{F_c \cos(\phi + \beta - \alpha)\sin(\phi)}{t_0 w\cos(\beta - \alpha)}$$

tau=shear stress
w=width of work



Power

How does one design a motor for a cutting operation? We need power. The power in cutting is:

$F_c \cdot V$

where F_c the horizontal cutting force and V is is the cutting velocity.

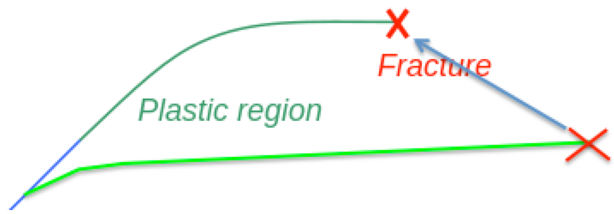
The material removal rate, or MRR is $V \cdot w \cdot t_0$. The specific energy of a material is

$$\frac{F_c \cdot V}{V \cdot w \cdot t_0} = \frac{F_c}{w \cdot t_0}$$

Tools

Tool life **$V_c T^n = C$ (V_c = cutting speed, T = tool life)**

Hardness vs Toughness:



Equations

$$F = A_o K \ln(\frac{A_o}{A_f})$$

Extrusion force

where K is extr const

$$F = Y_{avg} A_f \ln(\frac{A_o}{A_f})$$

Wire drawing force

where Y_{avg} is speed of drawing or temperature or lubrication

$$|F_z| = (\pi \cdot R^2) \cdot Y \cdot \left[1 + \left(\frac{2}{3} \cdot \frac{\mu \cdot R}{h}\right)\right]$$

Forging force

Shearing force F_c=0.7 UTS * h * b

Bending (Springback)