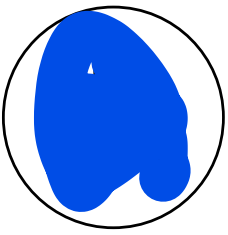


# Process Selection

SEM313 – Manufacturing

Matt Jennings





## 1. Achievability

- Is the process possible for the selected material?

## 2. Affordability

- What is the cost per part?

## 3. Properties

- What does the process do to the final properties?

## 4. Shape

- How close will the dimensions be to specification?

## 5. Quality

- What are the likelihood of introducing defects? What defects might arise and how can they be fixed?

## 6. Surface Quality

- What does the process do to the surface? Will it look acceptable? Will it accept a coating?

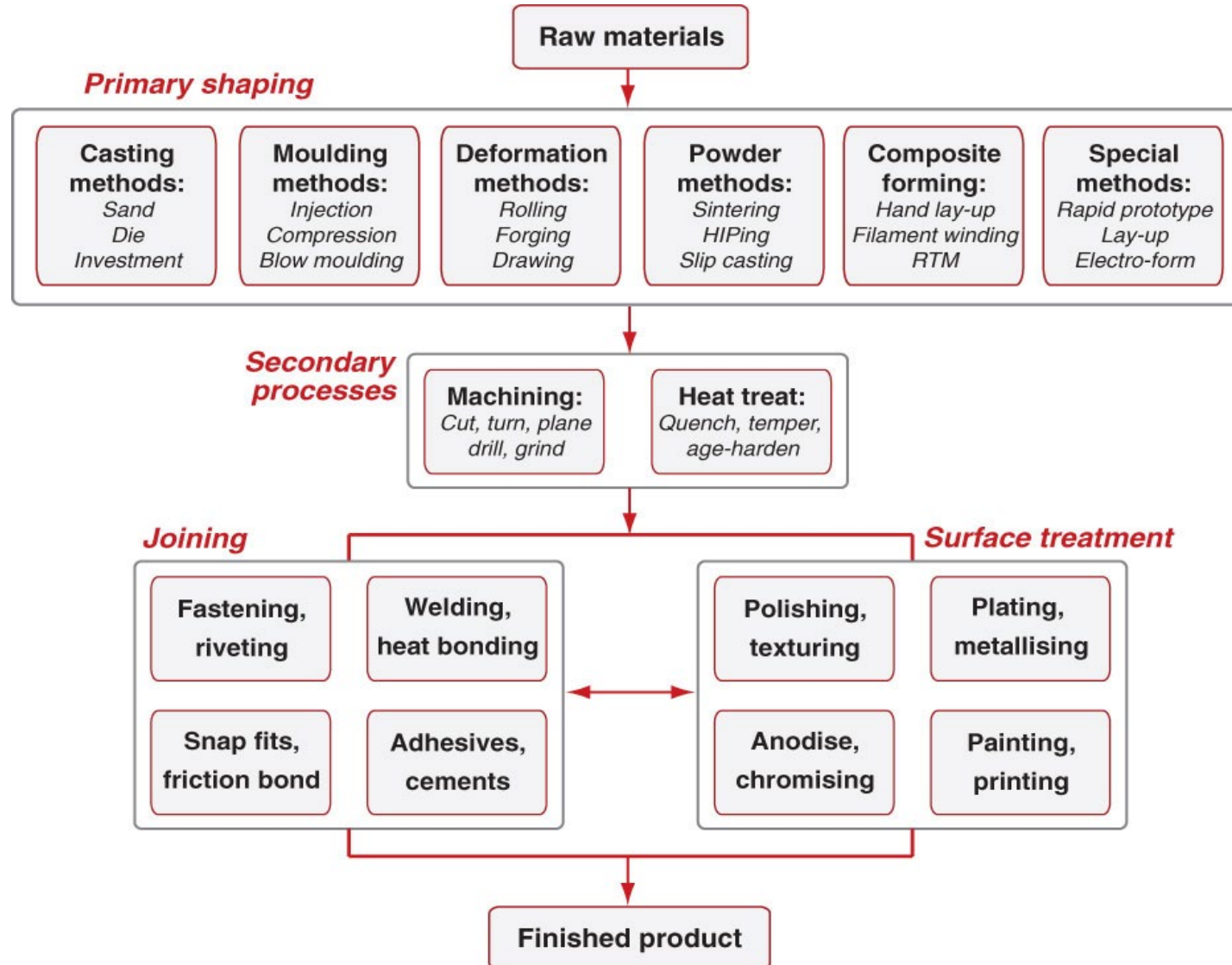
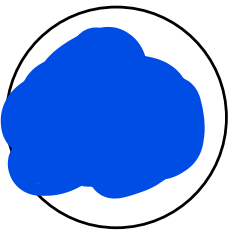
## 7. Controllable

- How consistent is the process? How easy is the process to control?

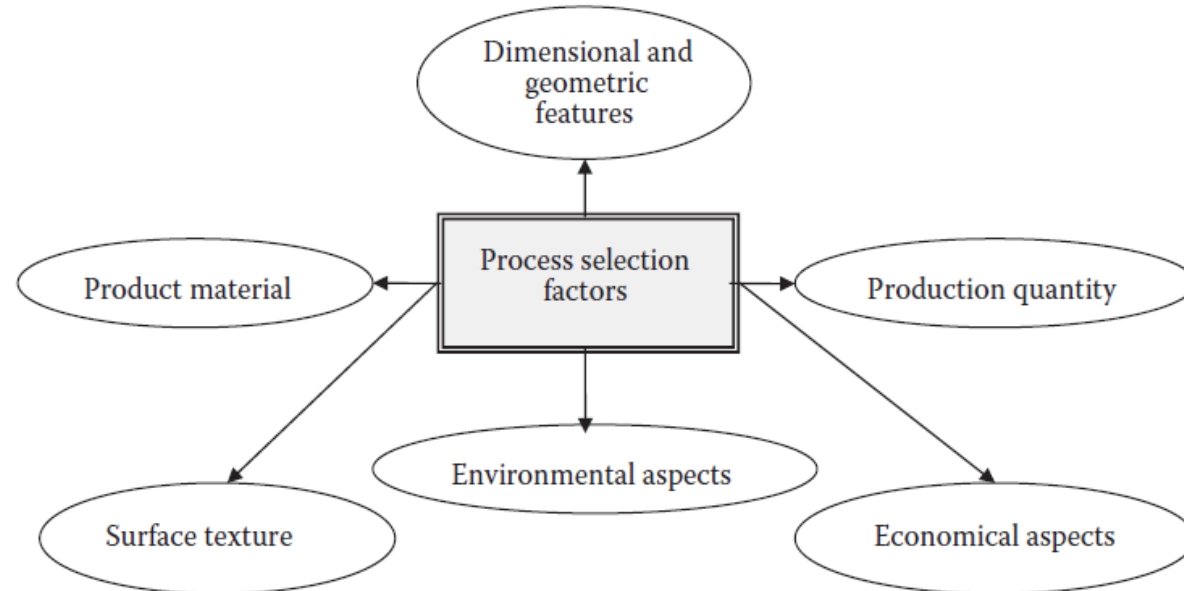
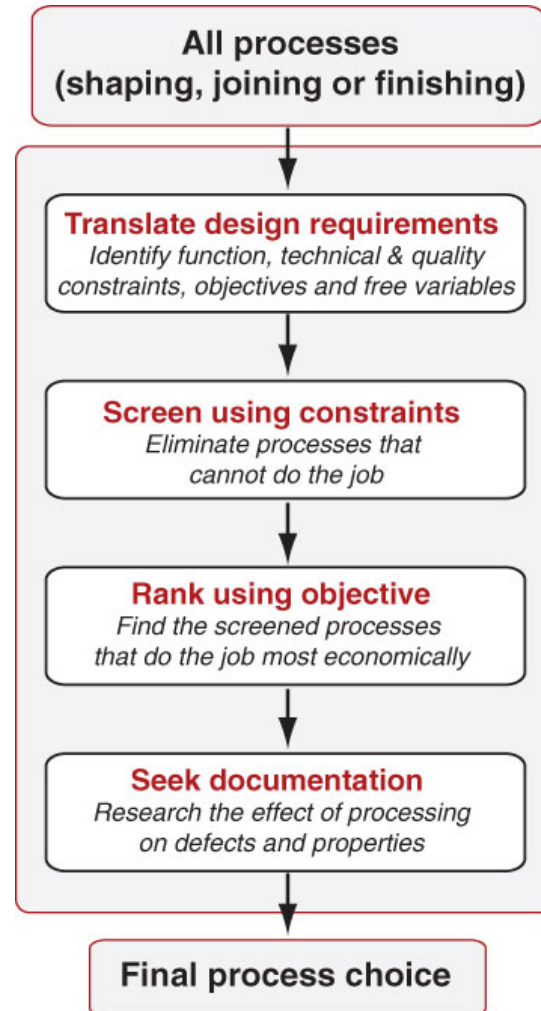
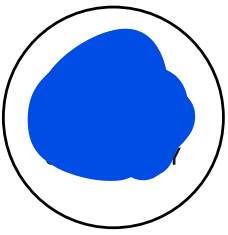
## 8. Integration

- How does it fit with prior and subsequent processes?

# Manufacturing Processes for Engineering Materials



# Process selection



*This will be the focus of the week 2 studio*

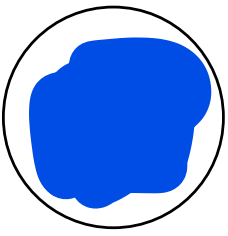
# Process limits

[redacted] determine

Matt Jennings

[redacted]

# What are process limits?

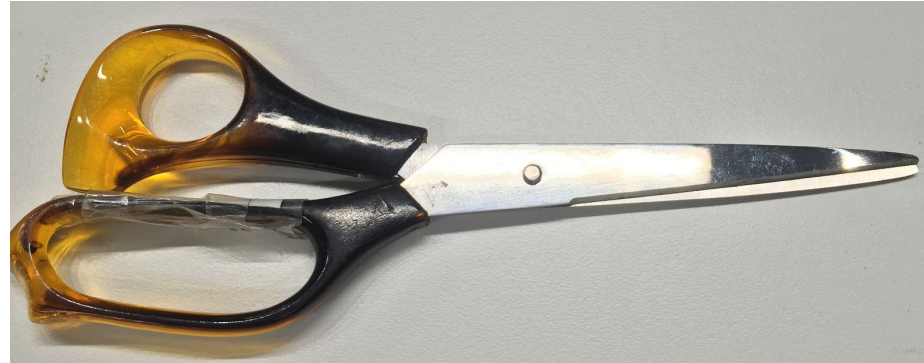
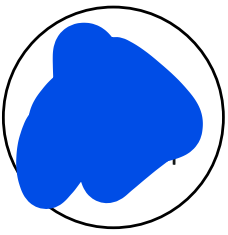


We always want to be able to produce components that meet **ALL** specifications in terms of properties, surface finish, defects and dimensional accuracy (tolerances). With this in mind:

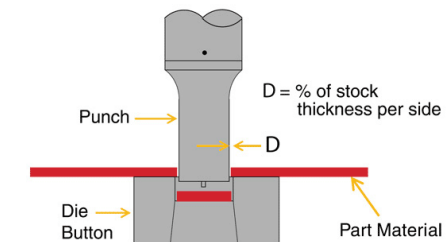
- What are the limits of the machine/tooling in the process?
- What are the limits of the material in the process?

Most processes will have different issues that affect these, so you generally need to investigate and understand the limits of 'your' process

# Example

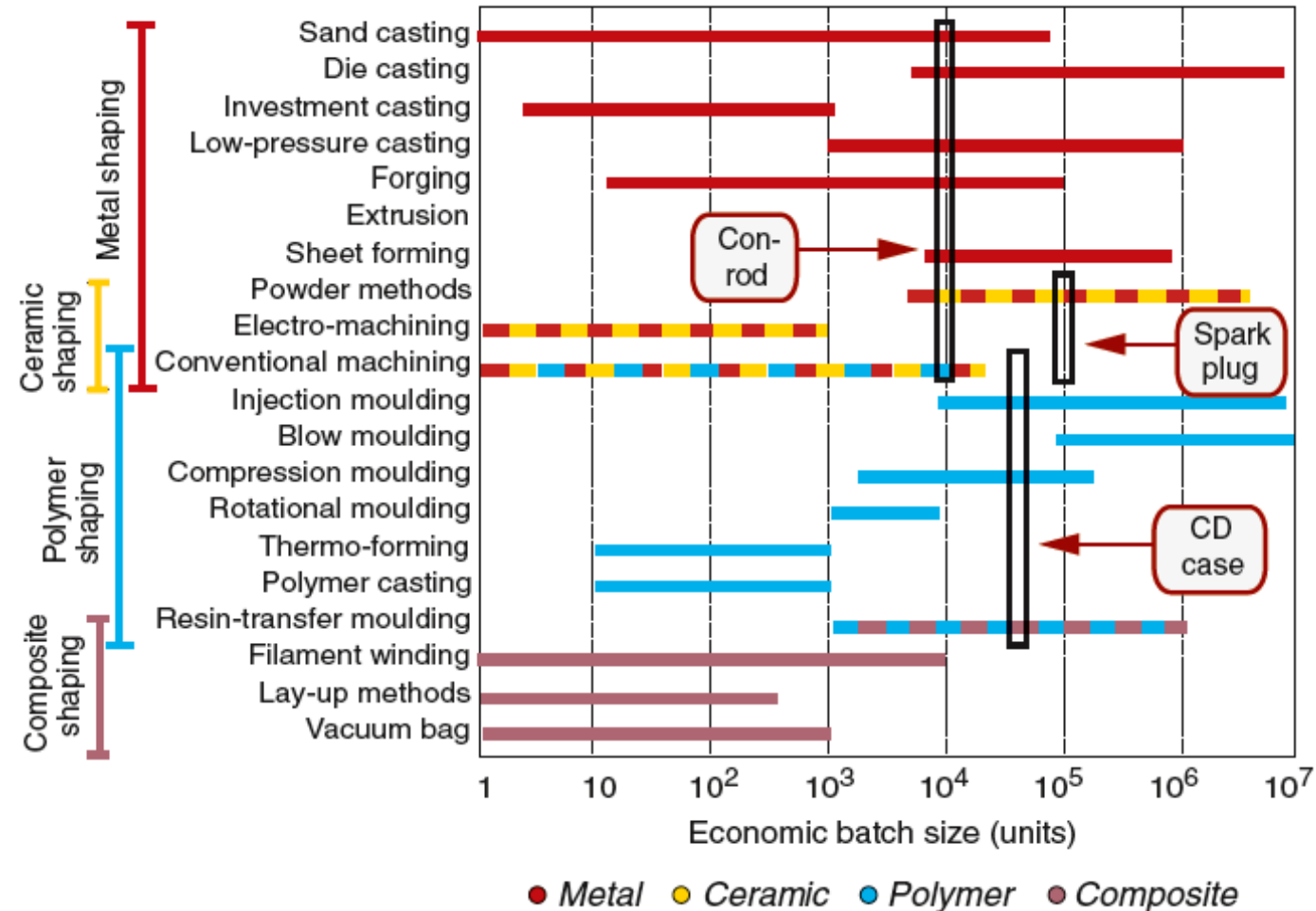
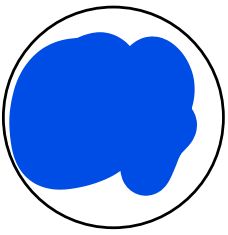


Scissors are a very simple shearing process – slightly simpler than these:

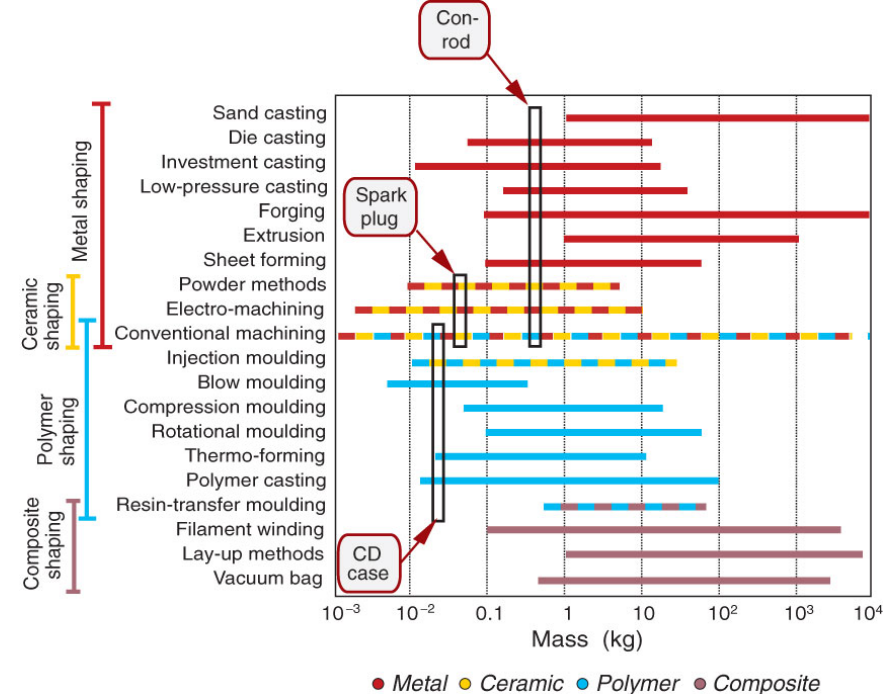
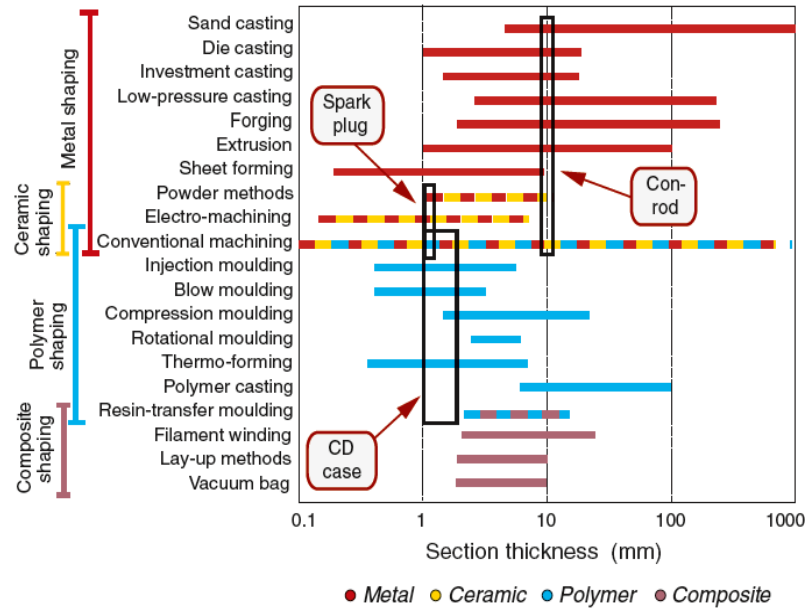
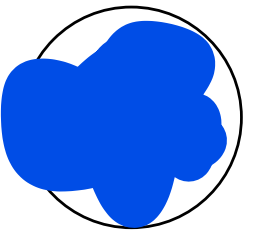


**What are the process limits for this manufacturing process?**

# Process – Economic Batch Size



# Example: Casting – size limits



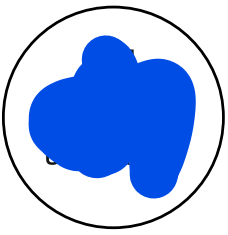
- Thinner sections limited by cooling – fluidity problems
- Thicker sections limited by shrinkage

# Process limits

SEM313 – Manufacturing

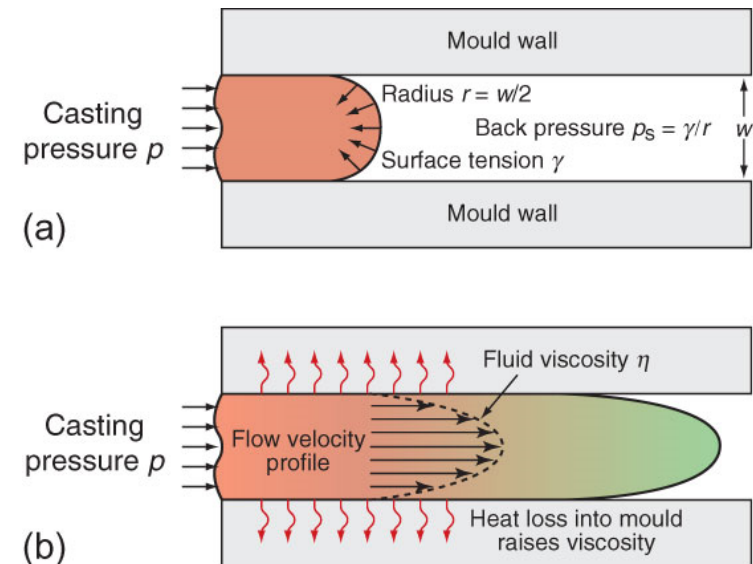
Matt Jennings



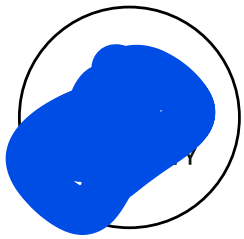


Describes the capability of the molten material to fill mold cavities. It depends on:

- Material composition
- Temperature
- Surface tension (e.g. presence of oxide films)
- Surface roughness
- Inclusions
- Solidification range (freezing range)
- Mold design
- Mold material and mold surface roughness
- Pouring rate (higher cooling rate when poured slow)



# Shrinkage



**TABLE 10.1**

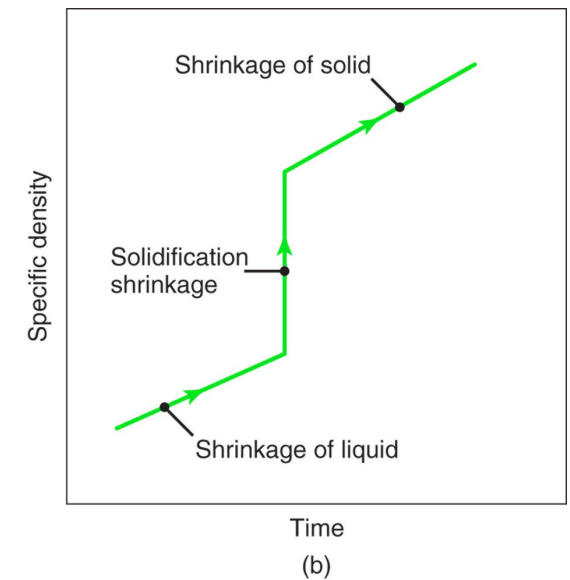
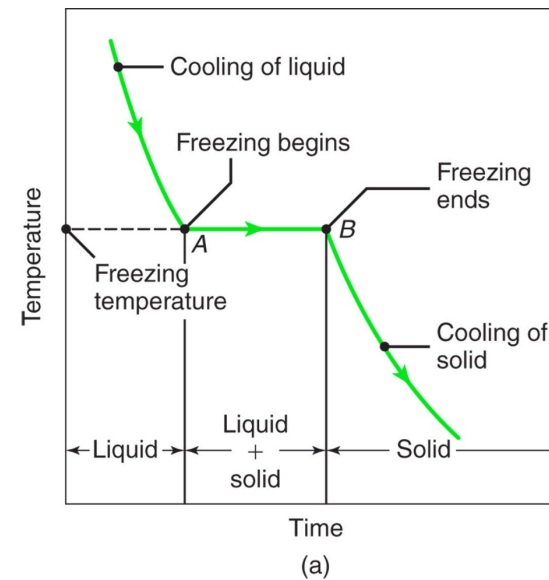
Volumetric Solidification Contraction or Expansion for Various Cast Metals			
Contraction (%)		Expansion (%)	
Aluminum	7.1	Bismuth	3.3
Zinc	6.5	Silicon	2.9
Al-4.5% Cu	6.3	Gray iron	2.5
Gold	5.5		
White iron	4–5.5		
Copper	4.9		
Brass (70–30)	4.5		
Magnesium	4.2		
90% Cu–10% Al	4		
Carbon steels	2.5–4		
Al–12% Si	3.8		
Lead	3.2		

Kalpakjian and Schmid – Manufacturing processes for Engineering materials

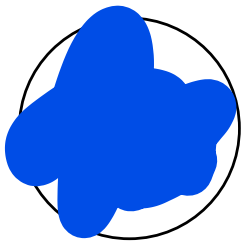
## Why does this matter?



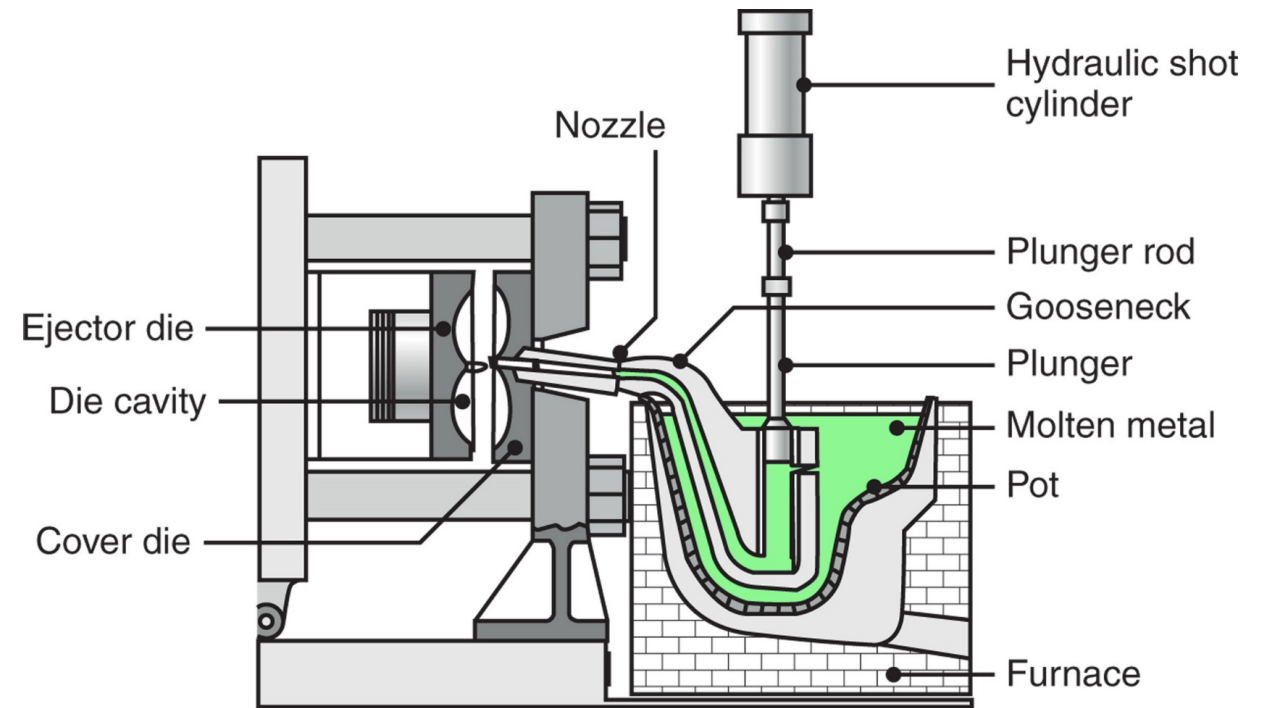
<http://sewculture.blogspot.com.au/2012/06/shrinkage.html>



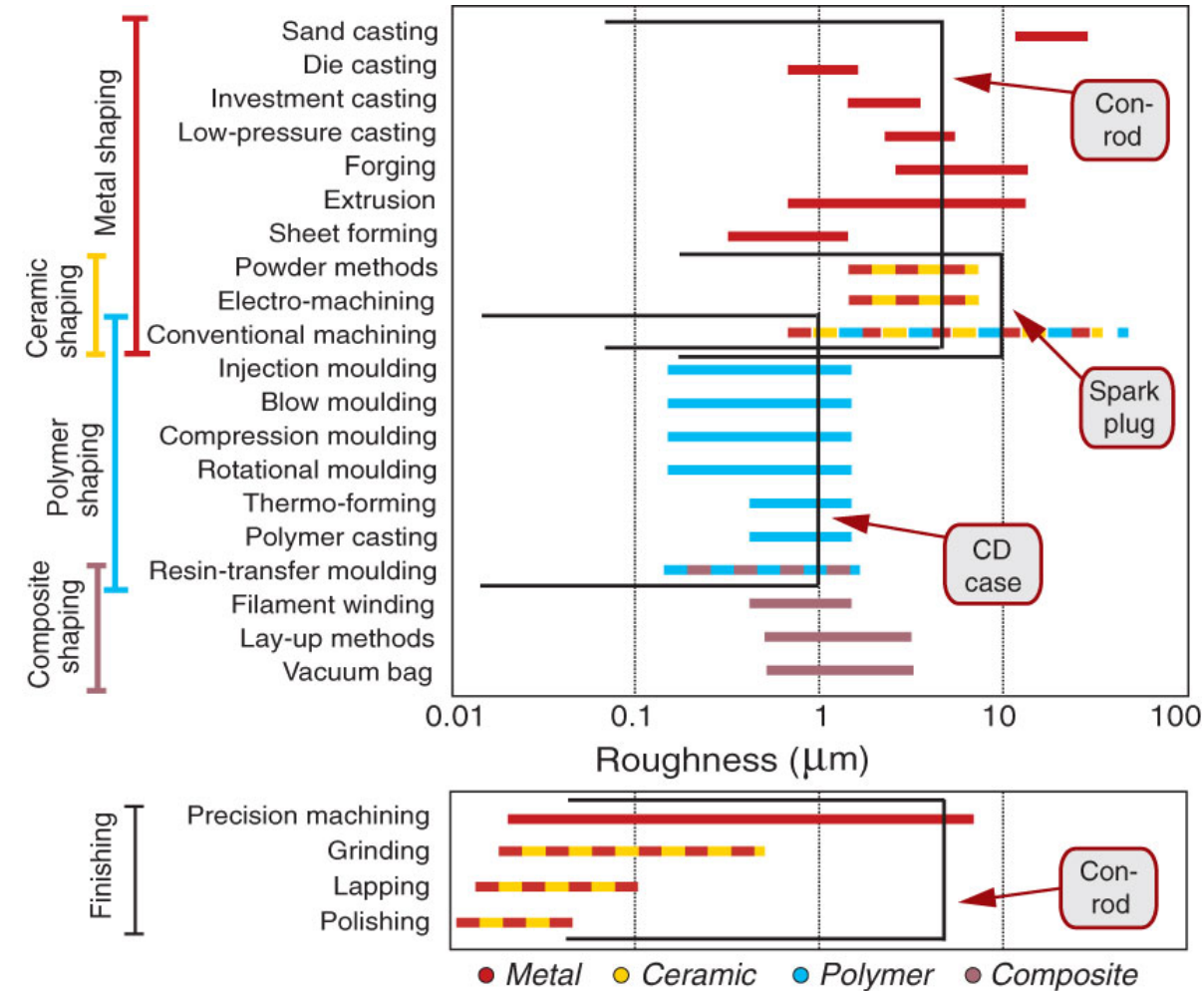
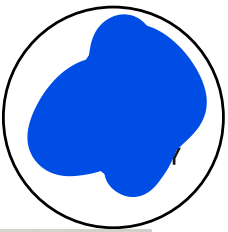
# Dealing with shrinkage – risers or pressure



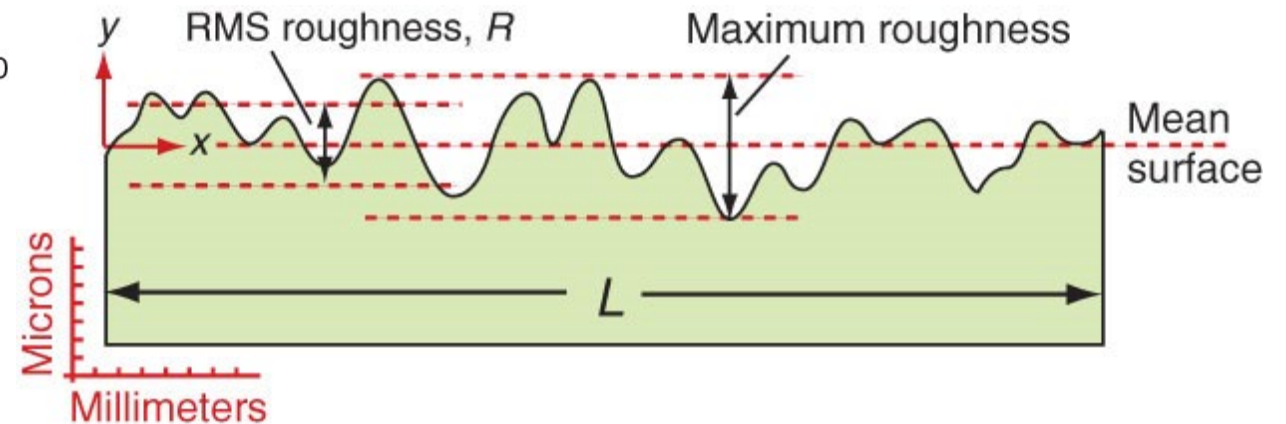
Aluminum piston for an internal combustion engine: (a) as cast and (b) after machining. The part on the left is as cast, including risers, sprue, and well, as well as a machining allowance; the part on the right is the piston after machining. *Source:* After S. Paolucci.



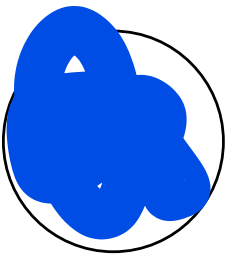
# Surface quality – casting example



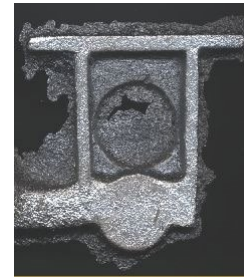
Example – aluminium sand casting



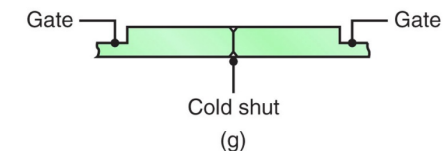
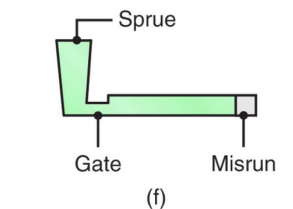
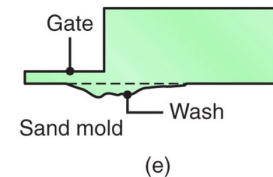
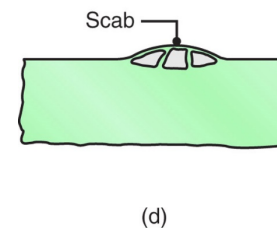
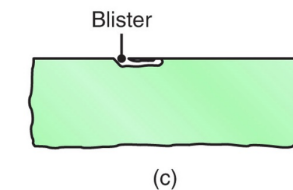
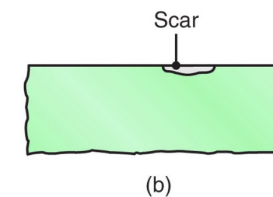
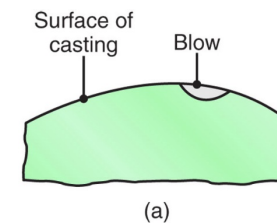
# Defects – casting example



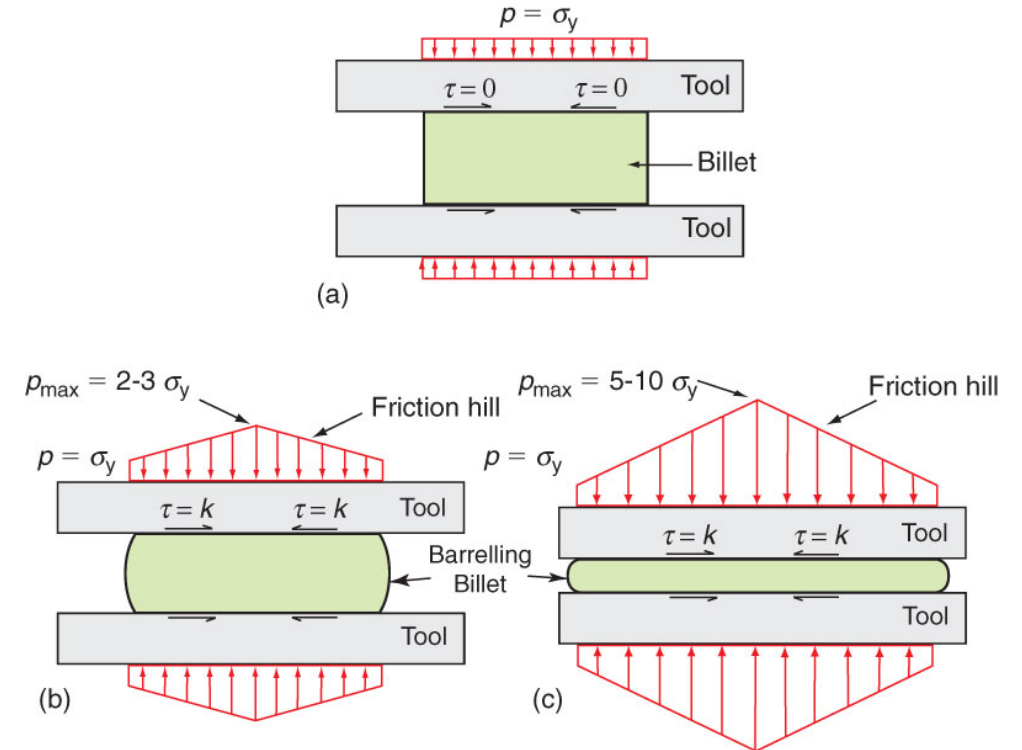
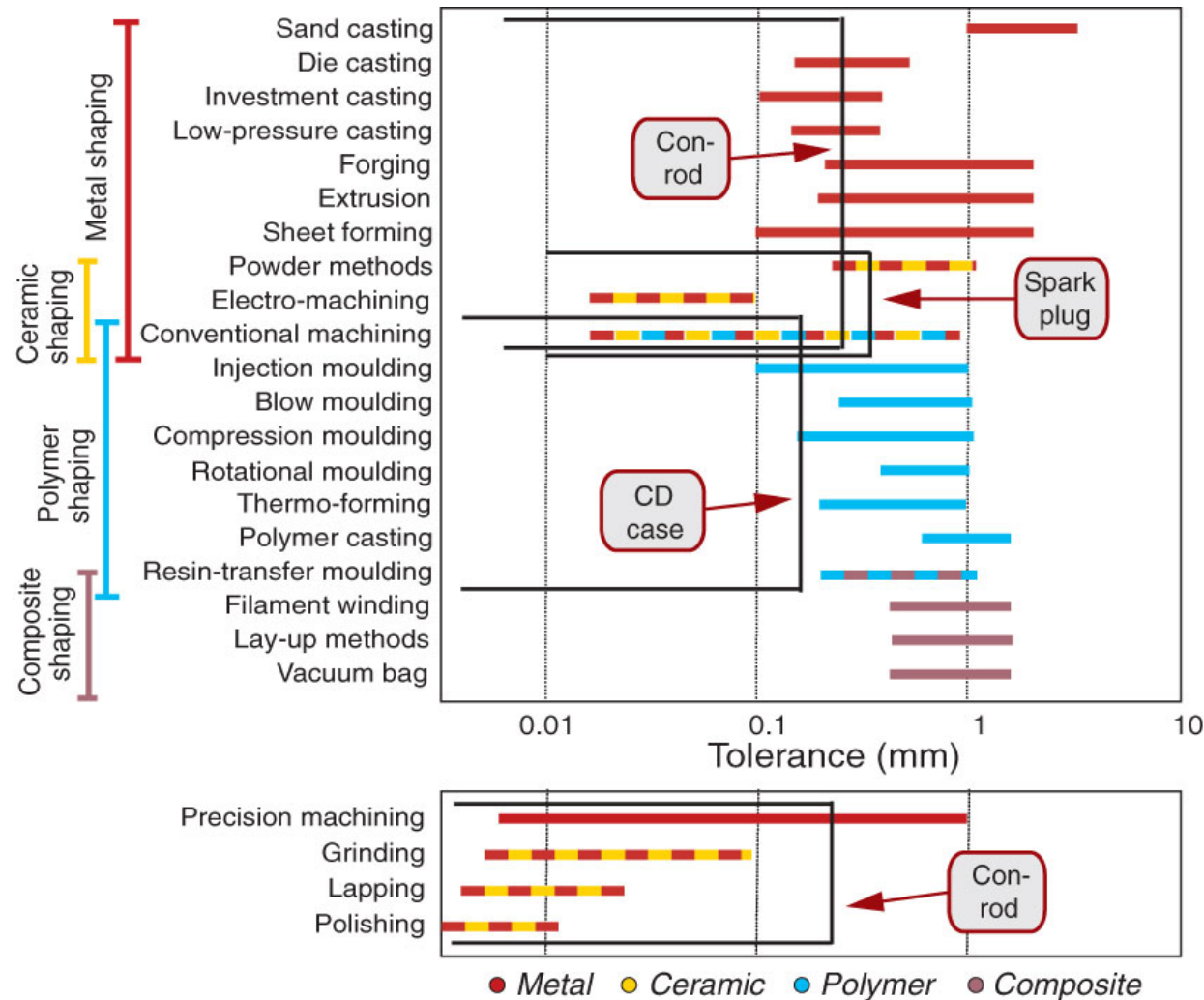
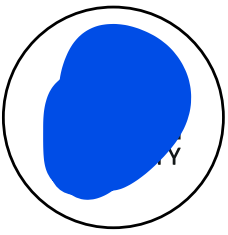
- Metallic projections
- Cavities
- Discontinuities
- Defective surface
- Incomplete casting
- Incorrect dimensions or shape
- Inclusions (non-metallic)
- Composition gradients



[http://www.abymc.com/tmoranwms/Casting\\_Defects.html](http://www.abymc.com/tmoranwms/Casting_Defects.html)

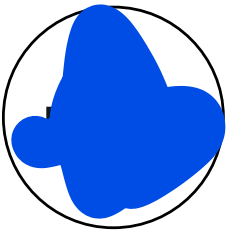


# Dimensional accuracy/ tolerance – rolling example

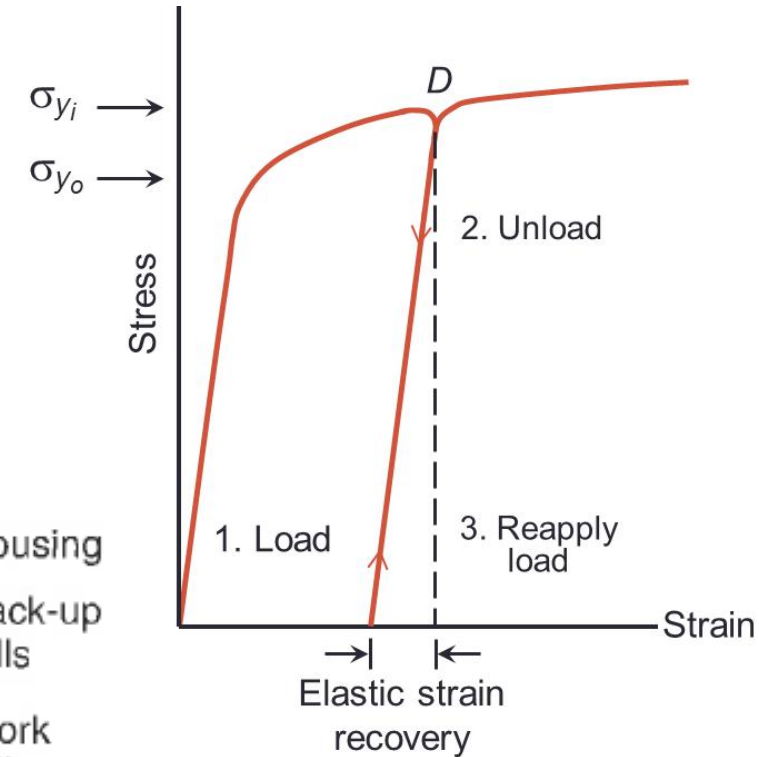
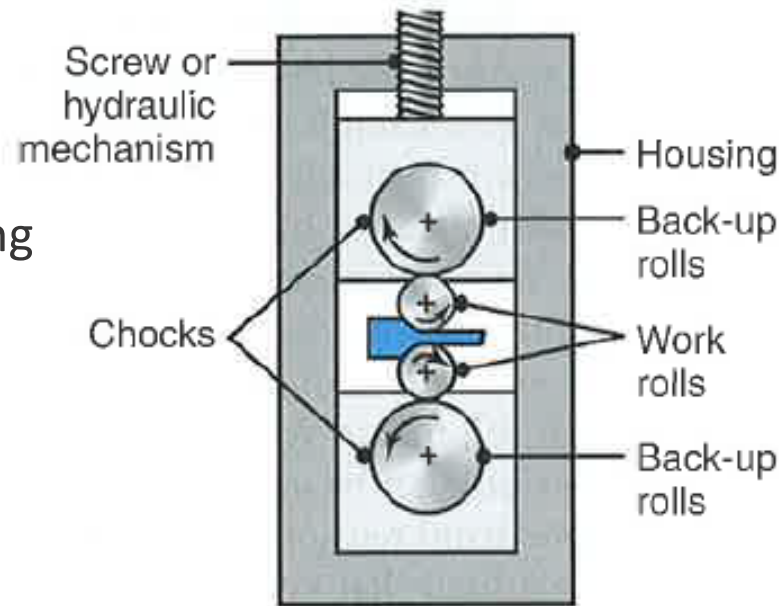


The deformation 'challenge' – increase in pressure when the material becomes thin (example in figure is for forging)

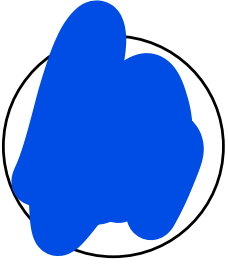
# Hot versus cold - cold rolling example



- Typically want smaller rolls in contact with the material as this reduces the contact area (hence load) during rolling
- The material will not be reduced in thickness as much as intended due to:
  - the rolls tend to deflect due to the high loads
  - the elastic recovery of the material being rolled
- The material could crack if rolled too much (either in total or at a time)



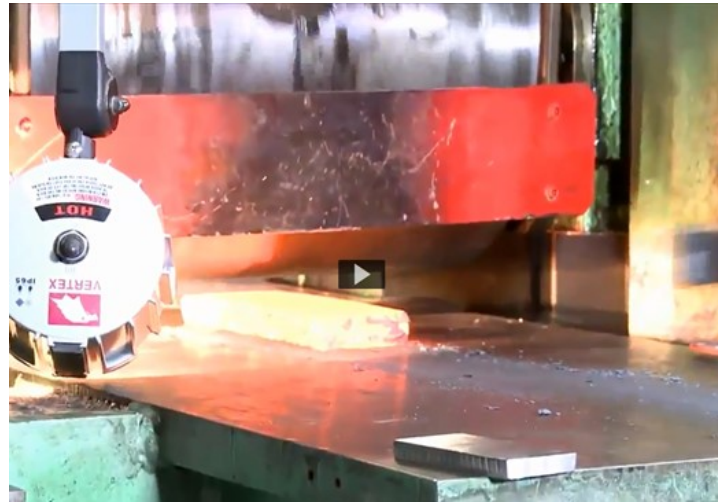
# Hot versus cold - hot rolling example



- Lower loads and higher ductility

## But:

- Thermal contraction of material
- Lubrication more difficult
- Work metal tends to oxidise
- Tool life tends to be shorter because of the previous two points
- Poor surface finish and loss of geometric control because of all the previous points

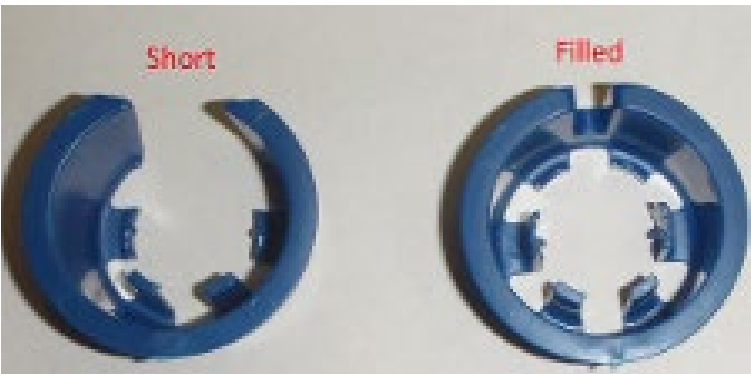
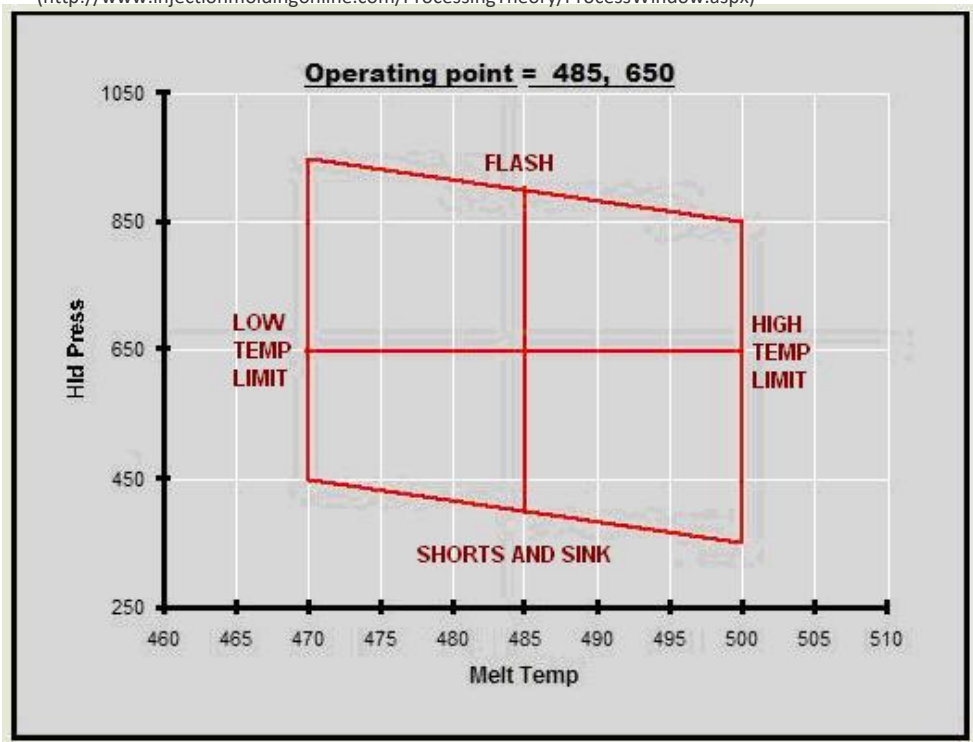


# Process windows

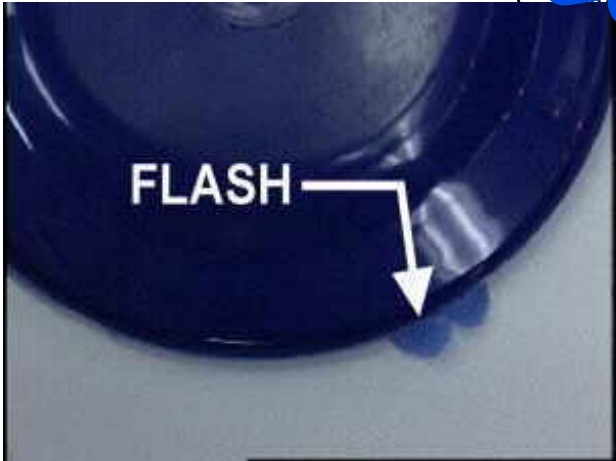
Process window is the range of process parameters that allows a product to meet specifications

Example of a holding phase process window for injection moulding

(<http://www.injectionmoldingonline.com/ProcessingTheory/ProcessWindow.aspx>)



<https://www.creativemechanisms.com/blog/what-cause-injection-molding-defects-and-how-to-fix-them>



<http://www.plastictroubleshooter.com/ThePlasticTroubleshooter/images/FlashOpt.jpg>

