School of Mechanical and Manufacturing Engineering

MMAN2130 Design and Manufacturing

Term 3 – 2019

Week 6

| Design for High Volume Manufacturing |

Overview of today

1. Why high volume manufacturing
2. Traditional costing methods
3. High volume manufacturing techniques (Sand Casting, Die Casting, Injection Molding – Videos!)
4. Applying costing to these methods
5. Design considerations for casting processes
6. Final Assignment.

Why high volume manufacturing?

Profit = Revenue – Operating Expenses

&

Revenue = Sales – COGs (Cost of Goods sold)

Streamline operations

Economies of scale

Fixed Costs (FC)

Do not vary with the amount of the products being produced. You have to pay these even if you sell nothing!

executives salaries

Rent

Insurance

Internet

Depreciation

Interest

Book keeper

accountant

Security

Variable Costs (VC)

Vary with the amount of units produced

Technicians wages

Machine hours

Assembly wages

Electricity?

Consumables
(lubricant, oil, fuel etc)

Direct Costs

These costs refer to materials, labor and expenses that are related to the production of a product (they are typically variable costs but can be fixed e.g. a machine to produce single product)

Technicians wages

Machine hours

Raw materials

Electricity?

Consumables
(lubricant, oil, fuel etc)

In-direct Costs

Indirect costs may be either fixed or variable, they include administration, personnel and security etc.

Sales people

accountant

Marketing department

Engineers

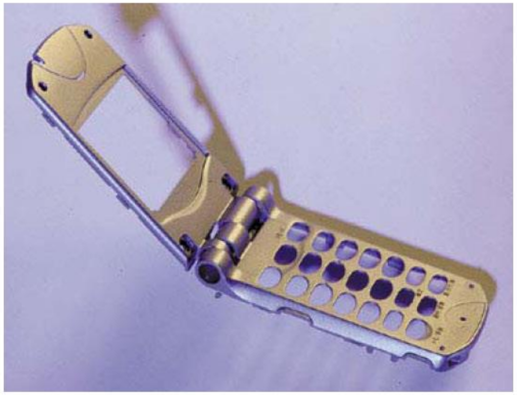
Security

How can we apply this to production ?

Lets Increase profit by reducing our Direct Labor & Direct Material Costs!

High Volume Parts

Source: www.castsolutions/archive/CastingSucceses.html



Demand unlocks economies of scale!

Sales Volume depends on Production Rate depends on Production Method

Process	Cost* Die	Cost* Equipment	Cost* Labor	Production rate (Pc/hr)
Sand Casting	L	L	L-M	<20
Shell-mold	L-M	M-H	L-M	<50
Plaster	L-M	M	M-H	<10
Investment	M-H	L-M	H	<1000
Permanent	M	M	L-M	<60
Die	H	H	L-M	<200
Centrifugal	M	H	L-M	<50

*L, low; M, medium; H, high

Difference between a mould and a die?

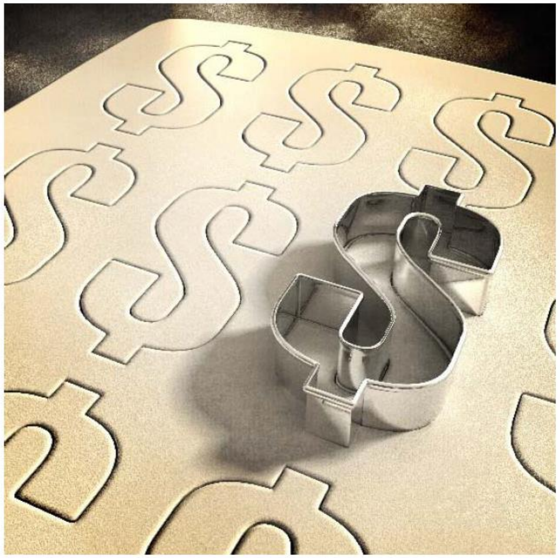
Mould = Pour molten metal into a reservoir and let it cool in the shape you want

Remember a jelly mould or ice cube tray

Difference between a mould and a die?

Die: Start with solid material, and cut out the shape you want (cold lots of pressure!)

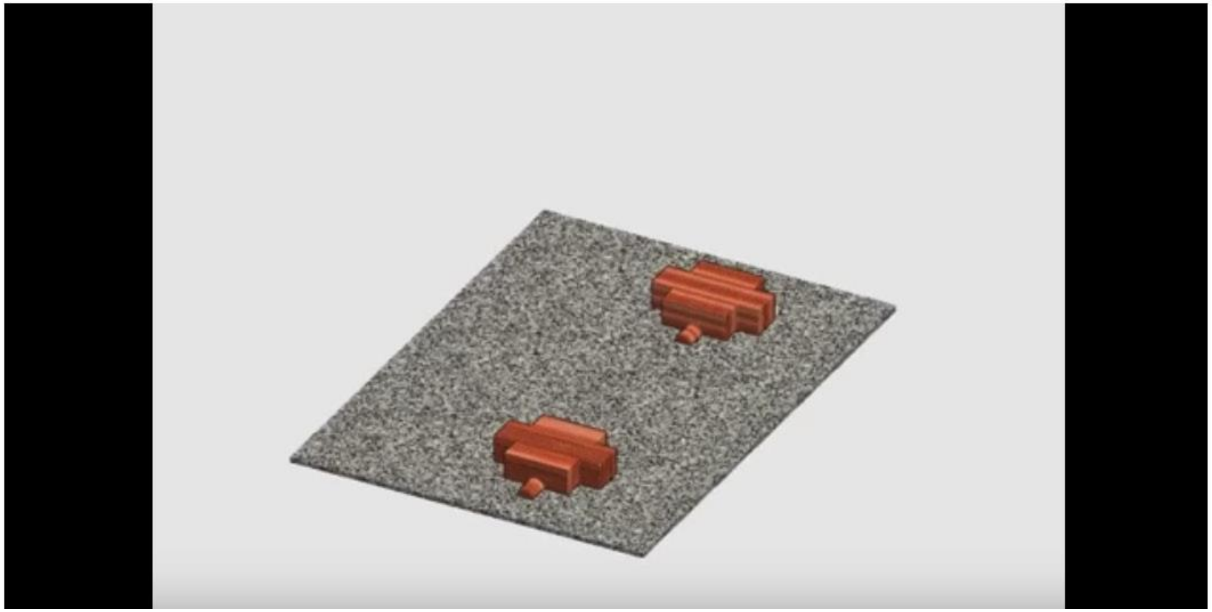
Remember: Cookie cutter
Or egg slicer.



Three high volume manufacturing processes

Sand casting (Metal)

Inexpensive , low direct materials, high direct labor. Good for small to medium size runs.



https://www.youtube.com/watch?v=2Qn0gZ86Xzg

[1m:32s]

Sand casting (Engine Block)

Inexpensive , low direct materials, high direct labor. Good for small to medium size runs.

https://www.youtube.com/watch?v=N2hYTdrzujI

[11m:37s]

Die Casting (Metal)

Great for high volume metal products with tight surface finish tolerances

High direct materials (FC), Low direct Labor (mechanized process)

https://www.youtube.com/watch?v=wKjgJT8iswM
[6m:42s]

Injection moulding (plastic)

Similar to Die Casting, but for plastics (all motorbike parts etc)

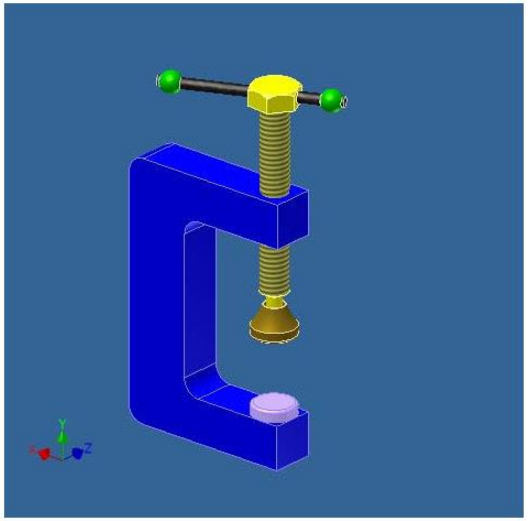
https://www.youtube.com/watch?v=RMjtmsr3CqA
[9m:36s]

Product – G Clamp

Possible high volume production methods

- Sand casting
- Die Casting

Lets compare the two!

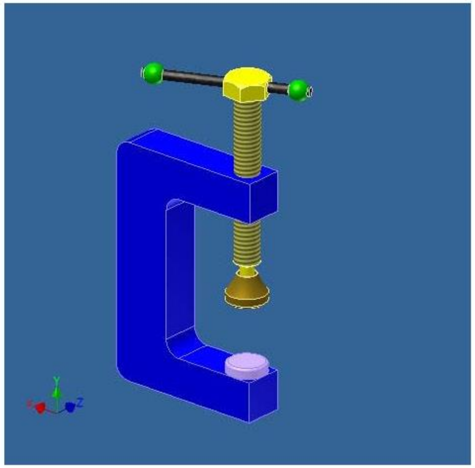


	Sand Casting	Die Casting
Quantity Required	24,000	24,000
Machine Setup Costs	$10,000	Die cost = $100,000
Operating Costs (sand, electricity etc)	$10,000	$20,000
Cost of equipment	$100,000	$500,000
Depreciation expense on equipment (10 year life)	$10,000/year	$50,000/year
Direct Labor (DL)	Labour cost / hr for all people involved ($20 / hr) 2 persons $48,000=(24000/20)*(20*2)	Labour cost / hr for all people involved ($30 / hr) 1 person $3,600=(24000/200)*(30*1)
Direct Material (DM)	Aluminium / unit mass / volume ($) $5,000	Aluminium / unit mass / volume ($) $5,000
Production Capacity	20 / hr / shift	200 / hr / shift
Total Overheads	$30,000	$170,000 (bigger factory, electricity, vacuum etc)
Overhead rate *Traditional costing **Per labor hour**	30,000 / 48,000 $0.63 per labor hour	170,000/3600 $47 per labor hour

Total Overheads = Machine Setup + Depreciation + Operating costs
Assume 40 hr work week 48 weeks/year

Product – G Clamp
Traditional Costing for 24,000

	Sand Cast	Die Cast
Direct Materials	5,000	5,000
Direct Labor	38,000	3600
Overheads	30,000	170,000
Total Cost	73,000	232,000
Cost per unit (24,000 units)	$3.04	$7.45



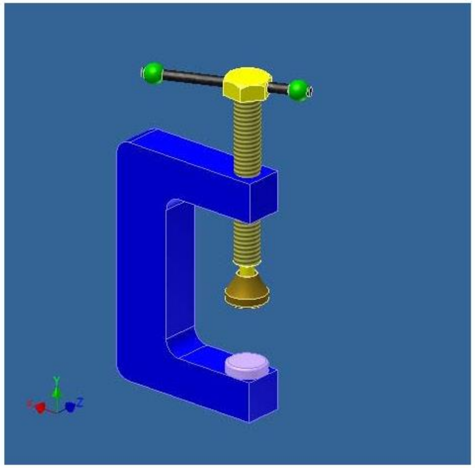
But what if we were to manufacture 240,000?

	Sand Casting	Die Casting
Quantity Required	240,000	240,000
Machine Setup Costs	$10,000	Die cost = $100,000
Operating Costs	$100,000	$200,000
Cost of equipment	$100,000	$500,000
Depreciation expense on equipment (10 year life)	$10,000/year	$50,000/year
Direct Labor (DL)	Labour cost / hr for all people involved ($20 / hr) 2 persons $480,000= (240000/20*40)	Labour cost / hr for all people involved ($30 / hr) 1 person $36,000= (240000/200*30)
Direct Material (DM)	Aluminium / unit mass / volume ($) $50,000	Aluminium / unit mass / volume ($) $50,000
Production Capacity	20 / hr / shift	200 / hr / shift
Total Overheads	$120,000	$350,000
Overhead rate Per labor hour	120,000 / 480,000 $0.25 per labor hour	350,000/36,000 $9.7 per labor hour

Total Overheads = Machine Setup + Depreciation + Operating costs
Assume 40 hr work week 48 weeks/year

Product – G Clamp
Traditional Costing for 240,000

	Sand Cast	Die Cast
Direct Materials	50,000	50,000
Direct Labor	480,000	36,000
Overheads	120,000	350,000
Total Cost	650,000	436,000
Cost per unit (240,000 units)	$2.7	$1.81



How can our designs help achieve these savings?

Design Considerations

- **Design for Expandable-Mold Casting:**
  - Corners, angles, and section thickness
    - Avoid sharp corners, angles, and fillets
      - Act as stress raisers and cause cracking and tearing of the metal during solidification.
    - Fillet radii should be 2mm to 25mm
      - To reduce stress concentrations
      - To ensure smooth liquid flow

Bad (sharp corners)

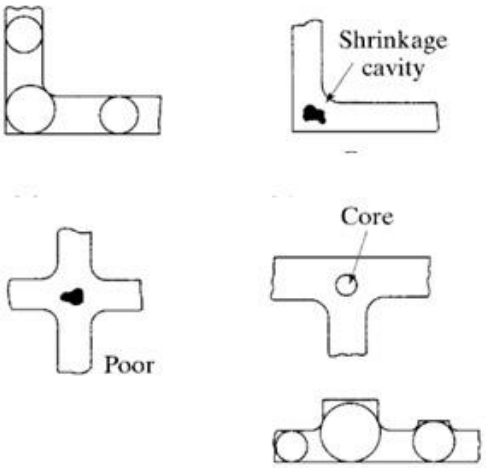
(a) (b)

Good! (smooth fillets)

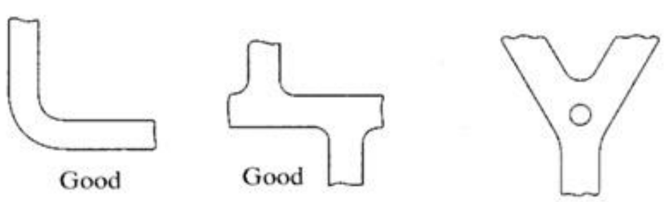
Design Considerations

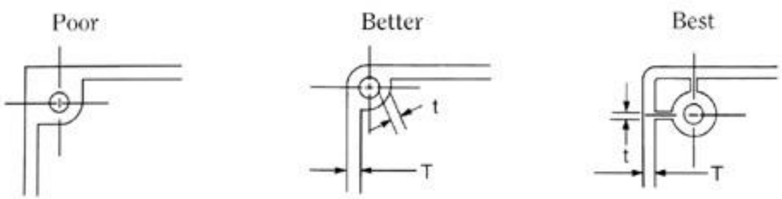
- **Design for Expandable-Mold Casting:**
  - Corners, angles, and section thickness
    - Smooth blending of section changes
      - The location of largest circle is critical since cooling rate in this regions with larger circle is slower (hot spots)

Bad (thick sections)



Good! (even section thickness)

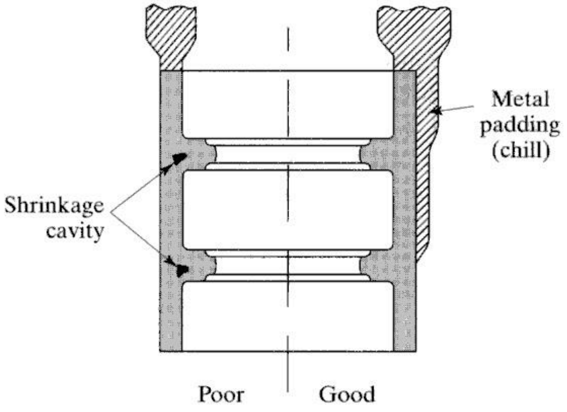




T= *wall thickness of part*
t = *wall thickness around a boss*

Design Considerations

- Design for Expandable-Mold Casting:
  - Corners, angles, and section thickness
    - Use of metal padding eliminates/minimize hot spots
      - Act as an external chills
      - **Increase cost of production**
    - **Try to maintain uniform cross-sections and wall thickness**



Design Considerations

- Design for Expandable-Mold Casting:

  Flat areas

  Avoid large flat areas / plain surfaces

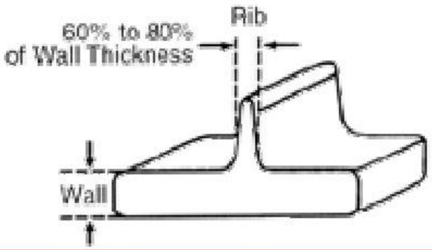
  Warp during cooling because of temperature gradients

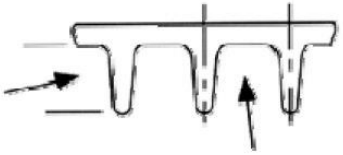
  Develop uneven surface finish due to uneven flow of metal

Flat surfaces should be broken up with ribs and serrations to add strength. There are guidelines for adding ribs to prevent sink marks or surface blemishes.

For more stiffness add more ribs (don't add height)

Max height: 3x nominal wall thickness





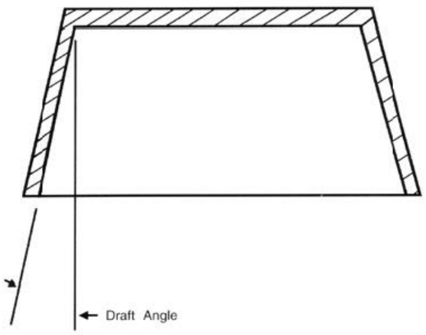
Design Considerations

- Design for Expandable-Mold Casting:
  - Shrinkage
    - Provide allowances for shrinkage during solidification
    - Different materials shrink at different rates!

Metal	Percent
Gray cast iron	0.83-1.3
White cast iron	2.1
Malleable cast iron	0.78-1.0
Aluminum alloys	1.3
Magnesium alloys	1.3
Yellow brass	1.3-1.6
Phosphor bronze	1.0-1.6
Aluminum bronze	2.1
High-manganese steel	2.6

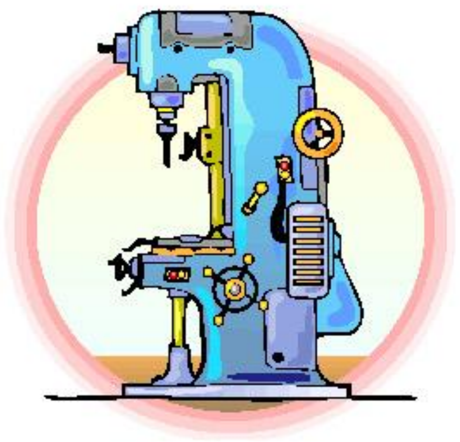
Design Considerations

- Design for Expandable-Mold Casting:
  - Draft (taper)
    - Avoid long cylindrical pieces.
    - Provided in sand-mold patterns
    - Enables removal of pattern without damaging the mold
    - Draft angle from minimum 0.5° 1.5^0 to 2^0 are considered normal.
    - The angles on inside surface are twice this range since the castings shrinks inward toward the core.



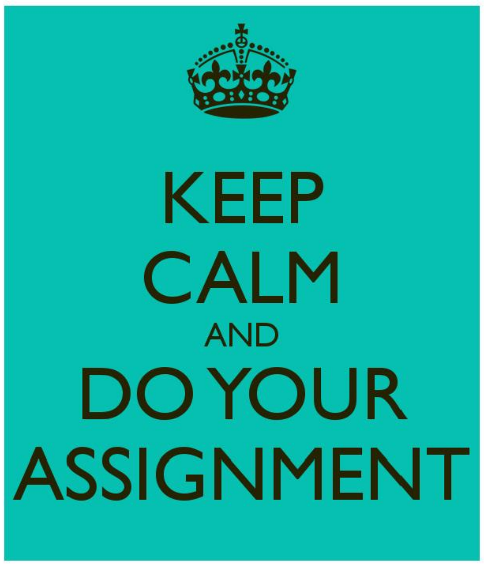
Design Considerations

- **Design for Expandable-Mold Casting**:
  - Machining allowance
    - Should be made in casting design since most expandable-mold casting require some finishing operation (usually turning or grinding).
    - Typical ranges from;
      - 2 mm to 5 mm for small castings,
      - more than 25 mm for large castings.



UNSW SYDNEY

How does this affect the final assignment?



Final Assignment (35%): You are to re-design your pump for high volume manufacture 24,000 units.

You are no longer limited by the TAFE workshop.

Things to consider:

•What material would you now make your pump out of?
•What manufacturing processes might you choose?
•What is your costing plan (per unit cost, projected profit)?
•What changes to your design do you need to make?
Prepare revised 2D Engineering drawings, Work Method Sheets, Routing chart, Exploded Assembly, BOMs (Internal and External).