IMPERIAL

MANUFACTURING TECHNOLOGY AND MANAGEMENT

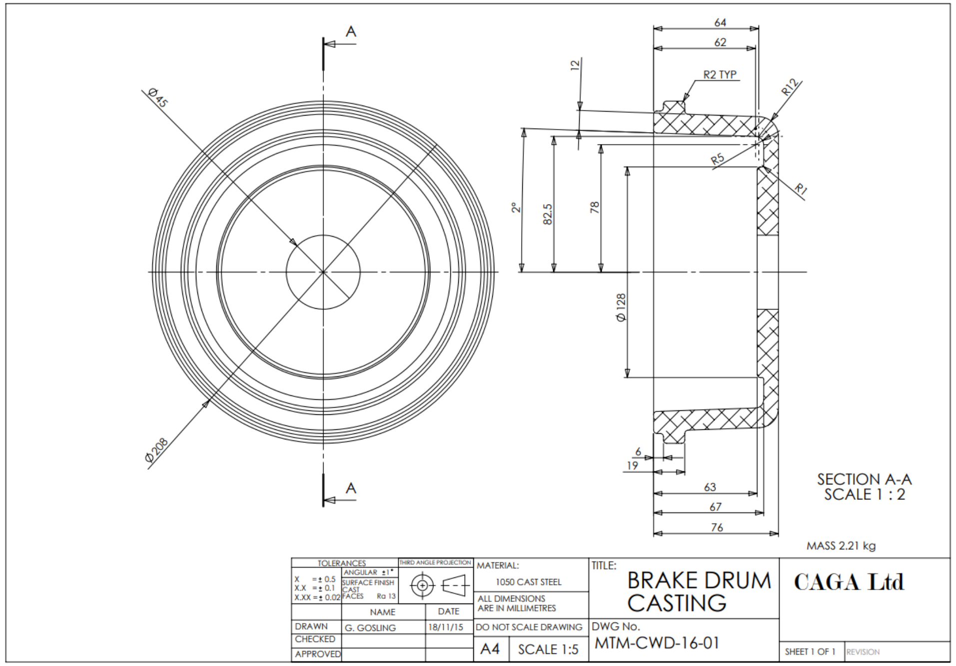
CONTINUOUS AUTOMATED PRODUCTION OF A STEEL BRAKE DRUM

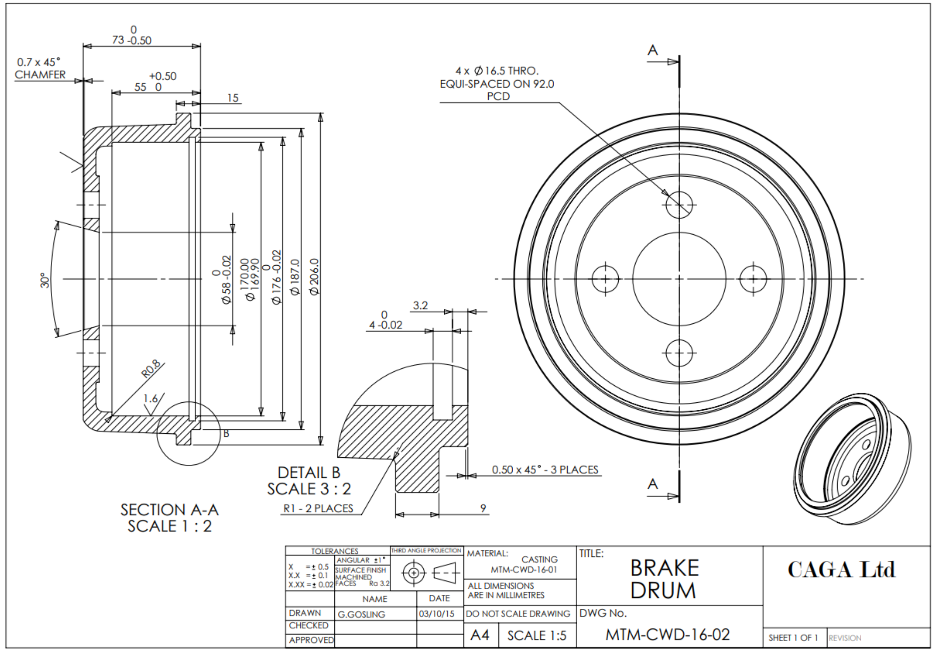
Group 7 - Leonna Aranda, Max Bruneau, Chris Hayes, Oliver Telfer

04/03/2025

Objective

- Continuous production
- 240 finished brake drums per day
- Include automation
- Design factory layout
- Machined surfaces are protected from accidental damage





Overview

Manufacturing Method
- Machinery
- Machining Steps
- Tooling Selection

Part Handling
- Automation
- Work Holding
- Part Loading
- Part Storage
- Metrology
- Work Centre Layout

Costing
- Finite Capacity Plan
- Processing Costs
- Materials and Tooling
- Final Cost

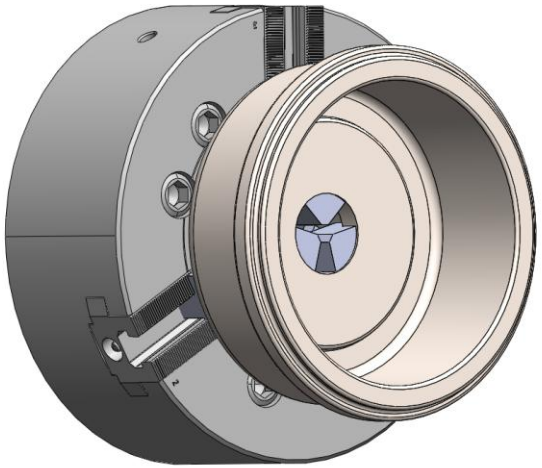
Overview – Who did What?

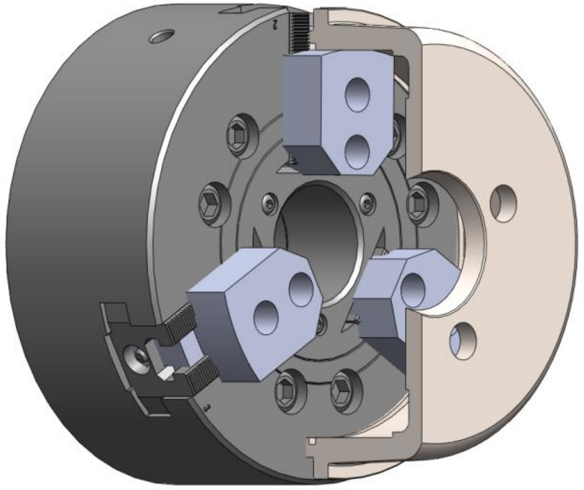
Task	Name
Manufacturing method	Leonna + Oliver
Work holding & part handling (part packaging)	Chris + Leonna
Cutter tooling	Max + Leonna
CAM programs and CNC setting sheets	Max
Metrology equipment and process	Chris
Factory model & Part Costing (only non-ME3)	Chris + Oliver

Manufacturing Method
Machinery

The Haas DS-30Y:

- Dual Spindle:
  - Primary Spindle – 254mm chuck
  - Secondary Spindle – 210mm chuck
    - Synchronised
- Compatibility with automation
  - Automatic Door
  - Robots
  - Hydraulic Chucks
- 12-station BMT65 turret
- C-axis Indexing
- Coolant



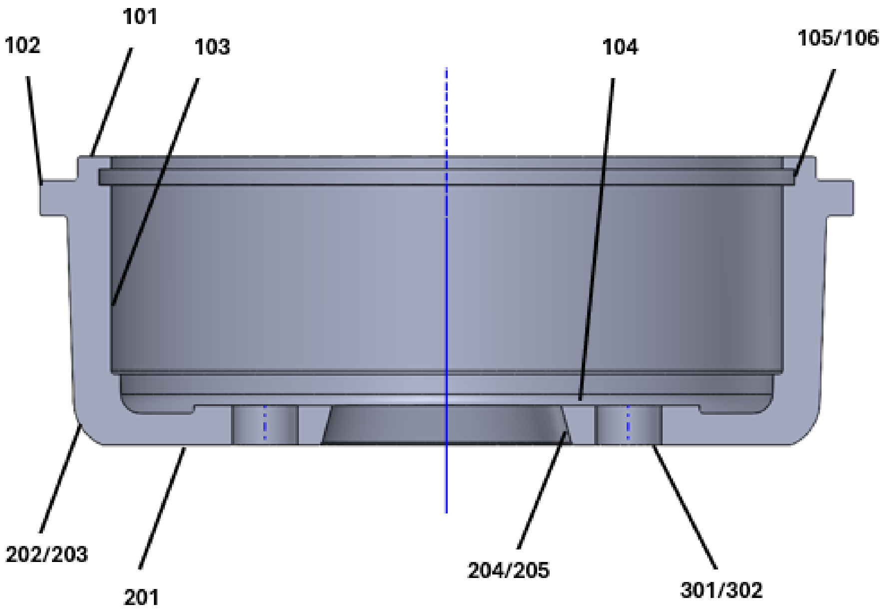


Manufacturing Method
Machining Steps

Primary Spindle – Hold from the inside Ø 45mm

Secondary Spindle – Hold from the inner diameter

Total Run Time: 5.98 minutes



Bill of Materials

Part No.	Part Description	Unit of measure	Quantity
BRDR 001	1050 Cast Steel Casting	each	1

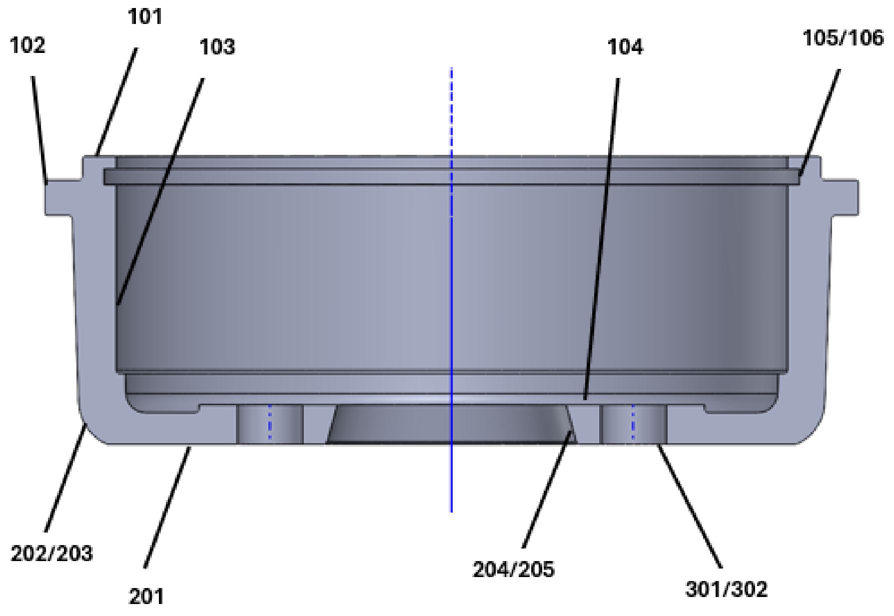
Manufacturing Method

Machining Steps

Primary Spindle – Hold from the inside Ø 45mm

Secondary Spindle – Hold from the inner diameter

Total Run Time: 5.98 minutes



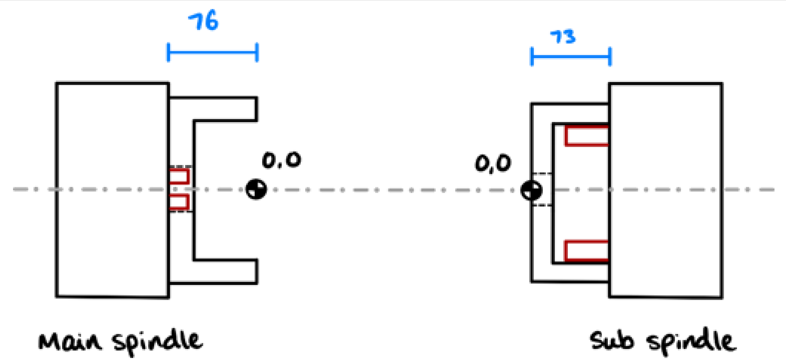
CNC Turning Centre - Set Up Sheet

Part Number	BRDR 001		Machine Tool	HAAS DS-30Y
Description	DRUM BRAKE - GROUP 7		Tool holder	12 Station BMT65
Operation No.	10		Program No.	1
Material & grade	1050 CAST STEEL		Prepared by	MAX B
Section & Size	ROUND Ø208		Date	16/02/2025
Work Holding	Main	3 Jaw Chuck	Matl. Loading	Automatic - Robotic Arm
Work Holding	Sub	3 Jaw Chuck		

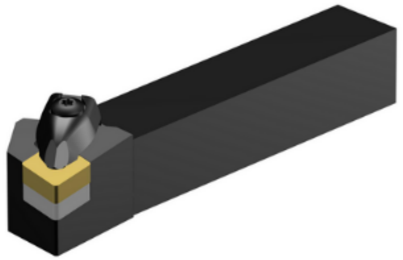
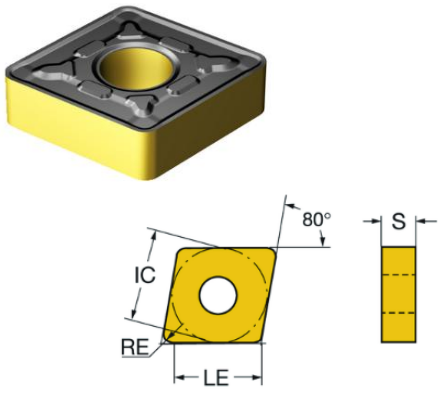
	Turning Tools					
Tool #	Generic Description	Matl	RH/LH	Tool code	Insert No.	Tool Location
1	Probe (WIPS-L)					1
2	EXTERNAL TURN & FACE	Carbide	RH	DCLNR 2525M 16	CNMG 16 06 08-PR 4425	2
3	INTERNAL BORE	Carbide	RH	C5-TR-V13UBR-35060C1	TR-VB1308-F 4415	3
4	INTERNAL FACE FINISH	Carbide	RH	PSKNR 2525M 15	SNMG 15 06 24-PR 4425	4
5	INTERNAL GROOVE CUT	Carbide	RH	570-32RSMAL3	MAGL 3 250 1025	5,6
6	EXTERNAL FACE	Carbide	LH	DSSNL 2020K 12	SNMG 12 04 16-PM 4425	7
7	EXTERNAL TURN	Carbide	LH	DCLNL 2525M 16	CNMG 16 06 08-PR 4425	8
8	INTERNAL BORE	Carbide	LH	A25T-SSKCL 12	SCMT 12 04 12-PR 4425	9

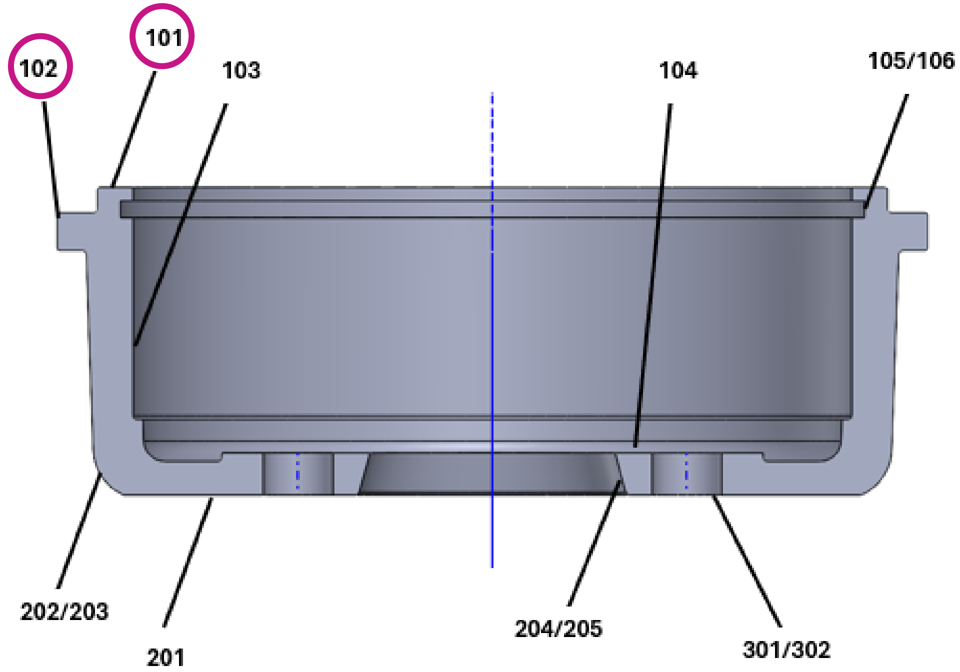
	Milling/Drilling Tools					
	Generic Description	Matl	Dia.	Exposed Length	Fixed/Live Axial/Radial	Tool Location
9	CENTER DRILL	HSS	5		AXIAL/ LIVE	10
10	DRILL	HSS	16.5	53.56	AXIAL/ LIVE	11,12

Set up drawing - show in *working holding including datum*



Manufacturing Method
Tooling Selection
[101] Facing Off
[102] Finishing Off External Shoulder

Turret Location: 2		
Tool Holder	Tool Insert	
DCLNR 2525M 16	CNMG 16 06 08-PR 4425	
		Angle: 80˚ Corner Radius: 0.7938mm Cutting edge count: 4 Grade: 4425



Justification:
Same tool was used for both processes to reduce lead times from tool changes and corner radius is sufficient for what is needed (R1 fillet)

Manufacturing Method

Tooling Selection

Justification

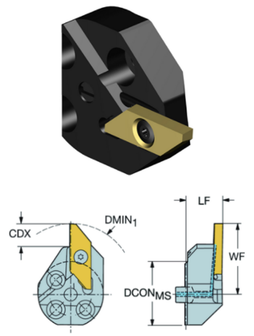
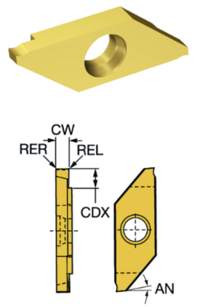
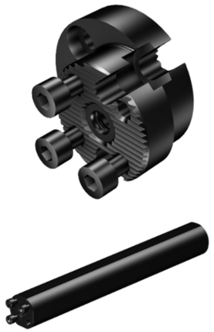
- Tooling selected with Sandvik CoroPlus tool guide

- Groove tool - TiAlN and TiN coating
  - Corrosion resistance and Thermal Stability
  - Prevent built-up edge and attrition wear
    - Maintain surface quality and tool longevity

- Drill bit - hardened steel and TiAlN coating
  - Harder than Casting material to prevent wear

- All other inserts - carbide and use same coatings (TiCN+Al2O3+TiN)
  - Reduces diffusion or abrasion

- Skipping roughing
  - Suitable to finish off the surface due to short cut depths
  - Reduces run time and increases tool longevity

Turret Location: 5,6					
[105]: Roughing of internal groove					
570-32RSMAL3		**MAGL 3 250 1025**		**ADAPTORS**	
	**WF:** 30.5 mm **LF:** 14 mm **CDX:** 8.2 mm **DMIN1:** 50 mm **DCONMS:** 32 mm		**RER:** 0.05 mm **REL:** 0.05 mm **Corner radius Tolerance:** +- 0.02 **CW:** 2.5 mm **CDX:** 3.7 mm **S:** 3.175 mm **AN:** 6 ° **Cutting edge count:** 2 **Grade:** 1025 **Coating:** PVD TiAlN+TiN		**570-40 22-32** **570-2C 40 283**
Cutting speed (m/min)	146	**Depth of cut (mm)**	2.5		
Feed rate (mm/rev)	0.09				

[106]: Finishing of internal groove			
Cutting speed (m/min)	146	**Depth of cut (mm)**	1.5
Feed rate (mm/rev)	0.135	**Tool life count**	14.96

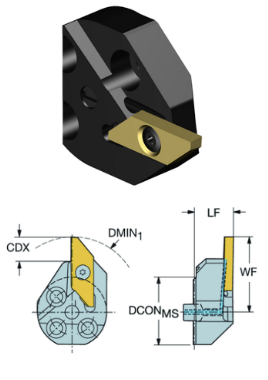
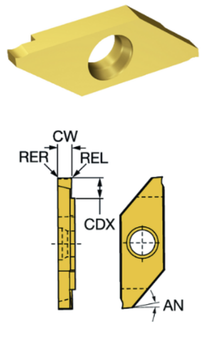
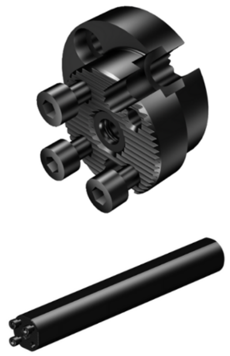
Titanium Nitride	TiN	+ BUE/Attrition wear familiar gold colouring on drills.
Titanium CarboNitride	TiCN	+ Abrasive wear + Adhesion between coatings
Alumina	Al_2O_3	Good Thermal insulator + Diffusion/Crater wear

Manufacturing Method
Tooling Selection – Tool life

- Individual cutting times found from SolidWorks CAM.
- Each tool was assumed to have a tool life of 15 minutes.

$$Tool\ life\ usage = \frac{24}{29.92} = 0.802 = 80.2\%$$

- For the Groove insert and Drilling steps, tool life counts were under the batch amount of 24 drums.
- 1 spare of each was placed in the tool turret's spare slots.

Turret Location: 5,6					
[105]: Roughing of internal groove					
570-32RSMAL3		**MAGL 3 250 1025**		**ADAPTORS**	
	**WF:** 30.5 mm **LF:** 14 mm **CDX:** 8.2 mm **DMIN1:** 50 mm **DCONMS:** 32 mm		**RER:** 0.05 mm **REL:** 0.05 mm **Corner radius Tolerance:** +- 0.02 **CW:** 2.5 mm **CDX:** 3.7 mm **S:** 3.175 mm **AN:** 6 ° **Cutting edge count:** 2 **Grade:** 1025 **Coating:** PVD TiAlN+TiN		**570-40 22-32** **570-2C 40 283**
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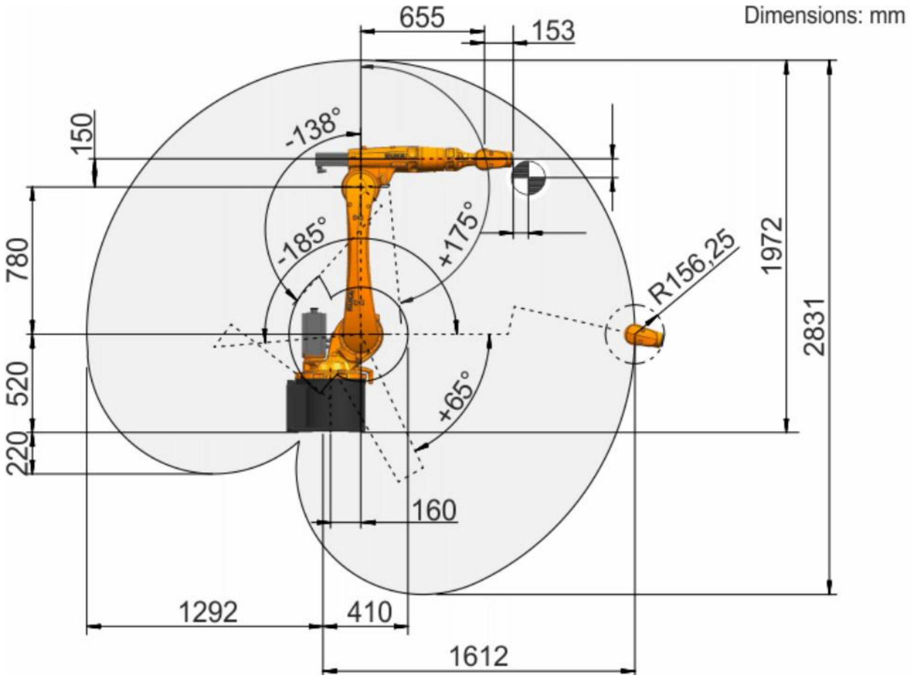
[106]: Finishing of internal groove			
Cutting speed (m/min)	146	**Depth of cut (mm)**	1.5
Feed rate (mm/rev)	0.135	**Tool life count**	14.96

Part Handling
Automation

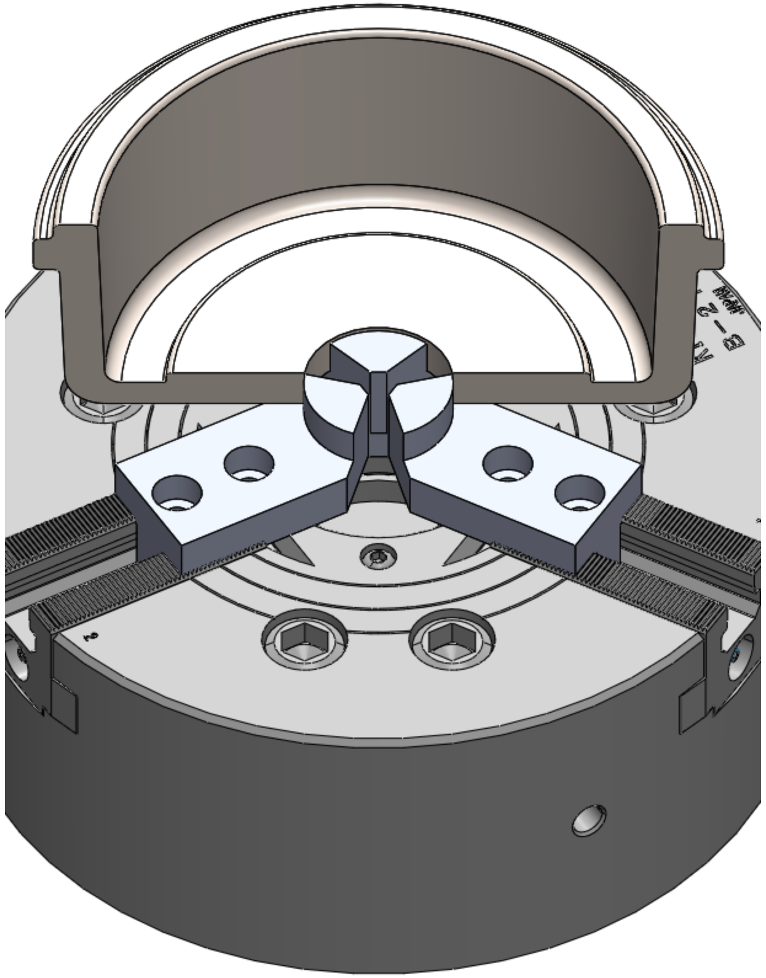
KUKA KR16 R1610 :

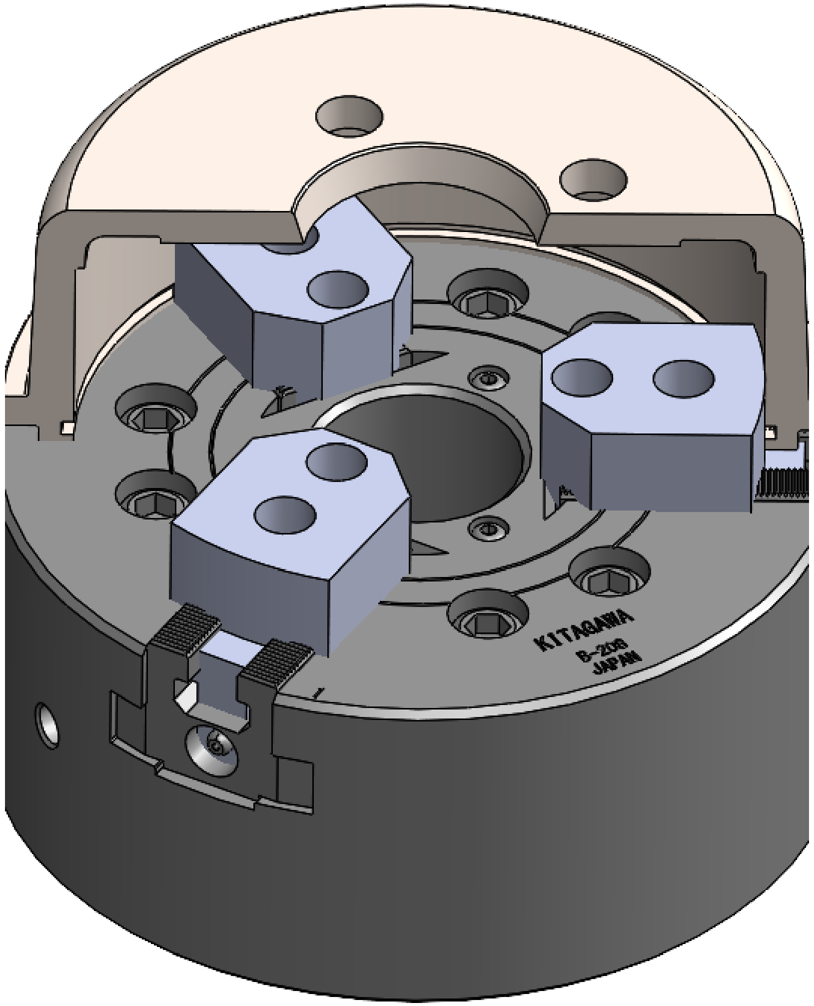
- Articulated robot arm with 6 DOFs
- Rated payload of 16kg
- Large working envelope and maximum reach of 1.61m
- Synchronisation with machines
- Pick and place mechanism
  - Table grid pick up system
  - Finished part drop off – dual table method
- Joint-type motion **and** cartesian motion



Part Handling
Work Holding

- 3 jaw chucks for both the primary and secondary spindle.
- Hardened jaws for first step
- Improved contact area between jaws and the part
- Soft jaws for the second
- Can be machined down to repair surface

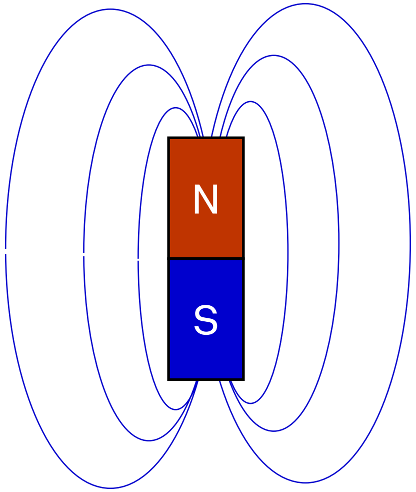


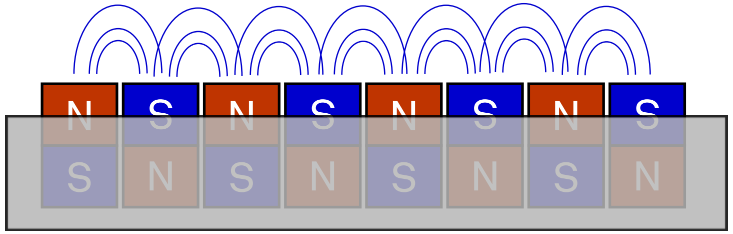


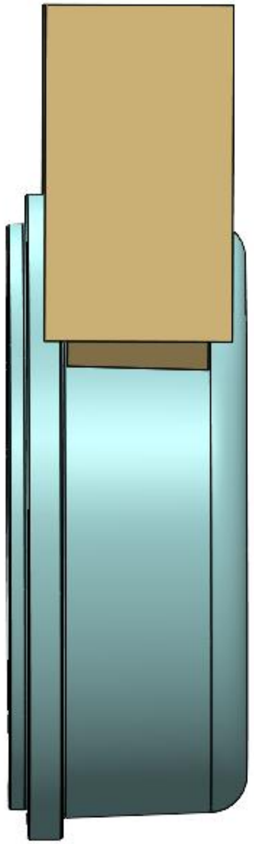
Part Handling
Part Loading

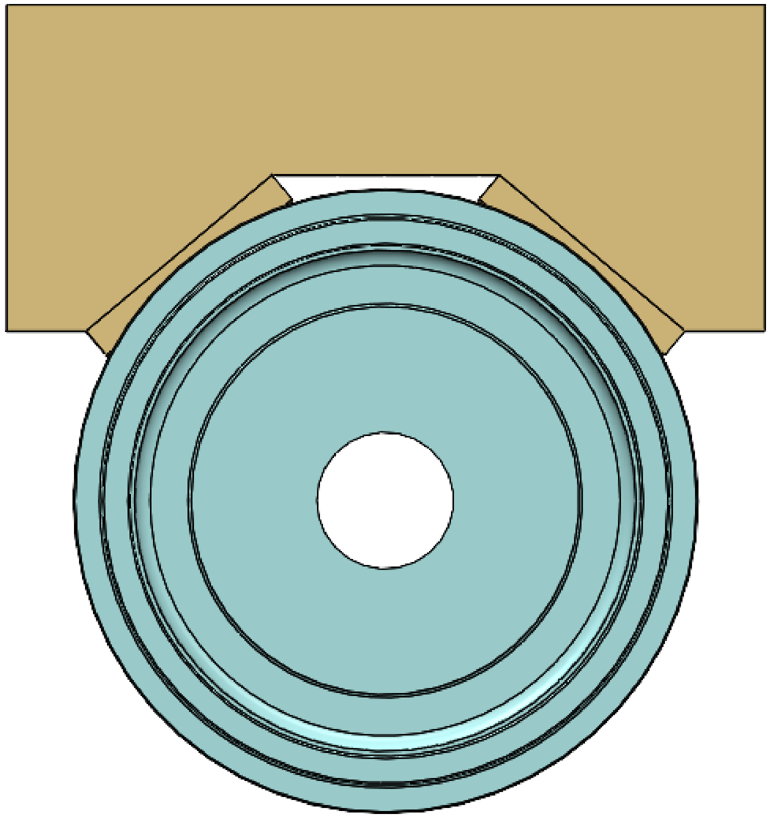
Custom Magnetic Clamp:

- Holds the tapered outer diameter
- Enough 'leeway' to hold before and after machining
- Can pick up from any orientation
- Low pole size keeps the magnetic field highly localised









Part Handling
Part Storage

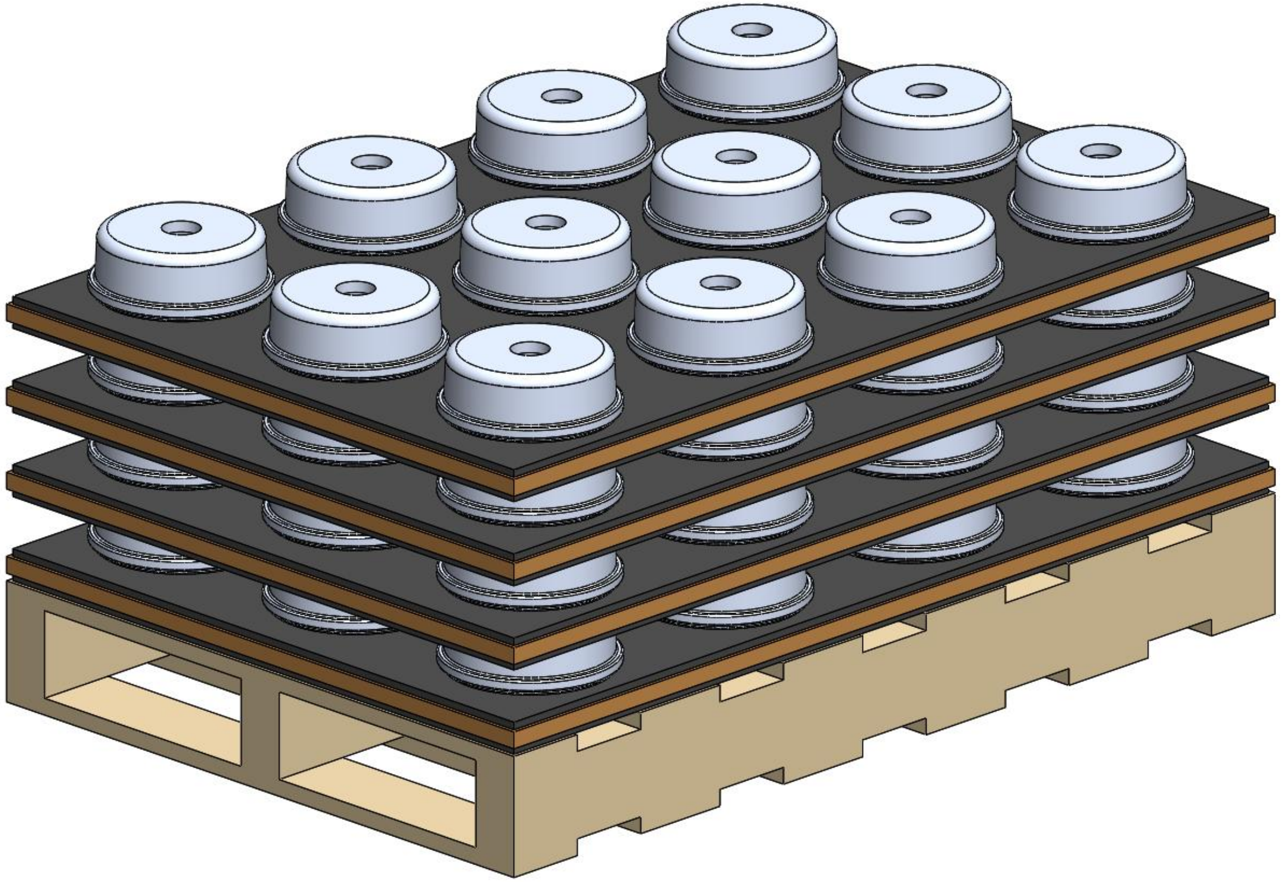
- Stored on pallets
- Separated by thick panels of chipboard and rubber matting

- Comfortably holds 48 drums per pallet
- 10 pallets and 40 panels required

<u>Estimated Weight:</u>
2kg per drum
3kg per divider
→ 27kg per layer

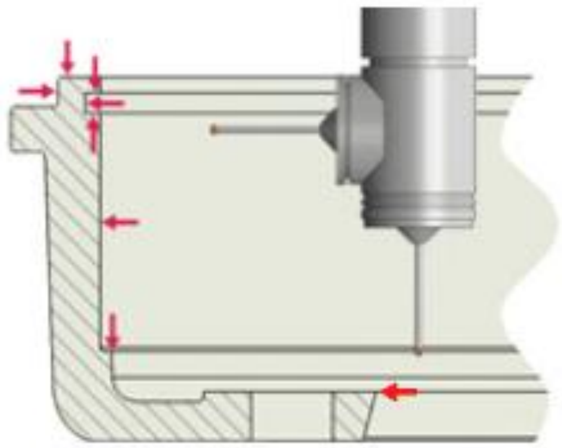
20kg per pallet
→ 128kg Total

<u>Estimated Cost:</u>
£15 per pallet
£110 per panel
→ £4,550 total cost



Metrology
Method and Measurement

- Renishaw Equator 300 Gauging System with an Automatic Transfer System (ATS)
- Critical dimensions were determined based on tolerances and location
- Integrates with continuous production line



- Height
- Outer race diameter
- Groove location and dimensions
- Inner surface diameter + flatness
- Location of bottom shoulder
- Tapered hole minimum diameter

Metrology
Procedure

- CNC production – “one off” defects unlikely
- Testing for catastrophic failure (unexpected tool damage)
- Full automation → check the whole part
- Utilise the machine → check every part

Metrology
Calibration

Equator:

- Calibrate the Equator off a “perfect part”
- Verify the perfect part with the factory’s CMM
- Create new perfect part every 1,000 drums or so

Turning Centre:

- Use a ball bar to calibrate the Turning Centre against localised wear every maintenance shutdown.

Work Centre
Layout and Production Path

- Two CNC machines
- Two KUKA Robots
- Four total pallets – Two for castings and two for finished
- Blue line indicates the process flow:

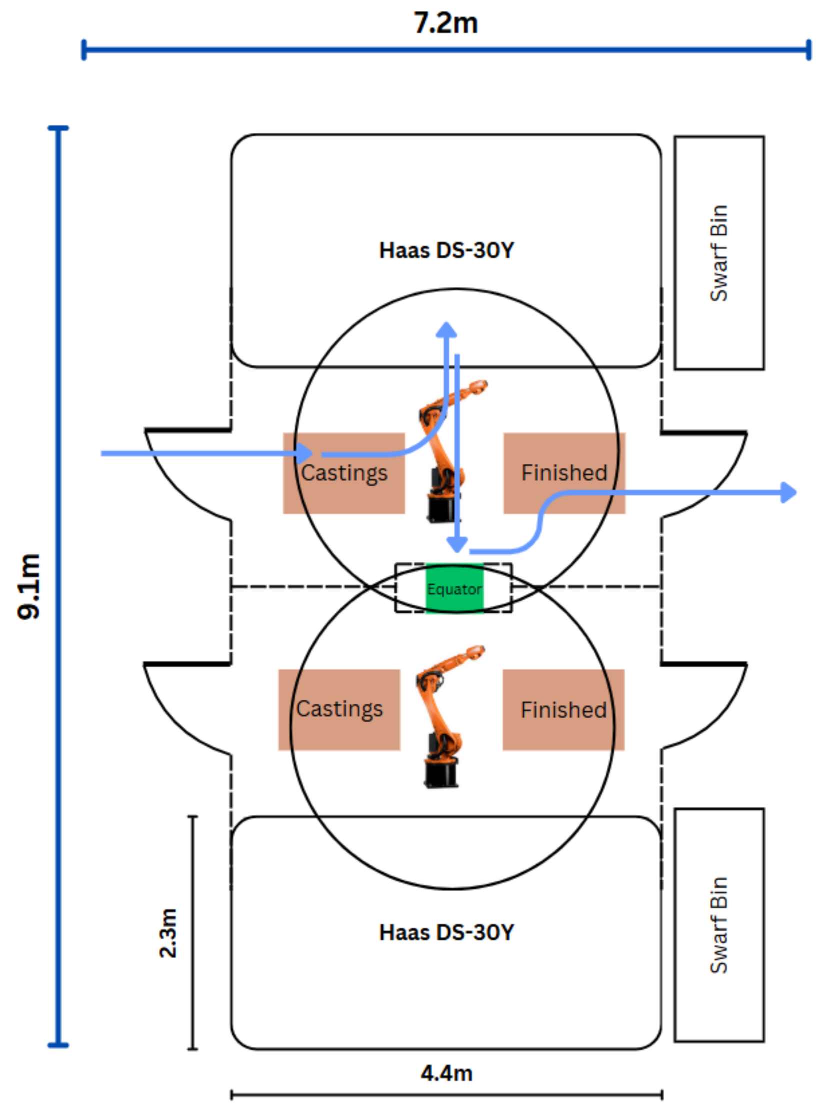
I. Pallet is wheeled into the manufacturing centre

II. Castings are loaded into the LH spindle by the robotic arm
→ Turn step 1

III. Turning centre transfers the casting into RH spindle
→ Turn step 2

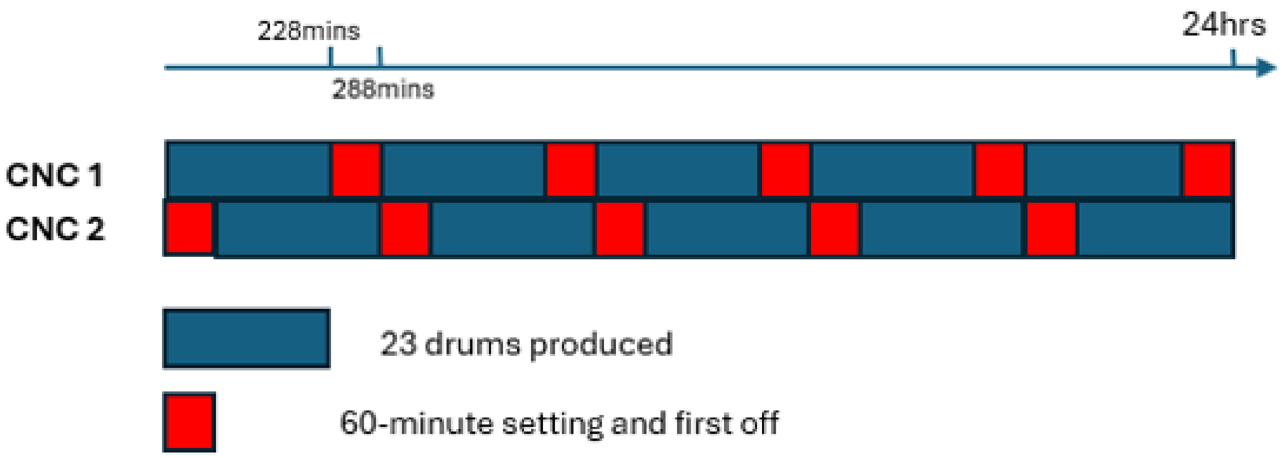
IV. Robotic arm removes the casting from the RH spindle and loads into the Equator gauging system
→ Tolerances and critical dimensions are checked

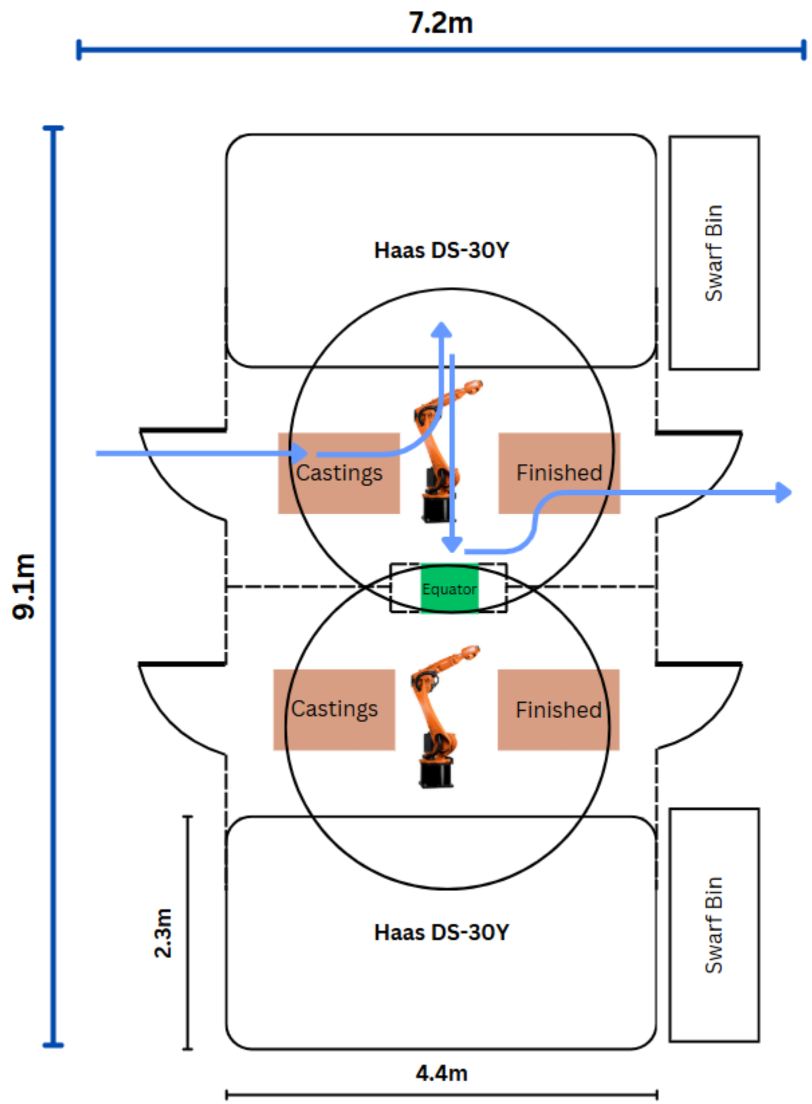
V. Robotic arm moves the part onto the second pallet



Work Centre
Shift Plan

- Tooling changed every 24 drums
- Pallets changed every 48 drums (2 tool changes)
- 60 minutes allocated for tool changing, first-off, and pallet changes





Costing
Finite Capacity Plan

Production & Scheduling

- The production line runs 24/7, except for 4 annual maintenance closures.
- Each turning centre performs 5 tool changes/day, each lasting 60 minutes.
- Two turning centres produce 240 drums/day, by maintaining a 12-minute MLT:

$$MLT = \frac{Setup\ time}{Batch\ size} + Run\ time + Transport\ time$$

$$MLT = \frac{60}{24} + 5.98 + 3.52 = 12$$

Key Features:

- 3.52-minute transport time allows flexibility for setup issues.
- Costing accounts for 361 operational days/year (excluding maintenance).

Costing
Manufacturing Costing Equation

The cost per part was calculated by breaking down the manufacturing cost into 3 categories:

- Materials
- Processing
- Tooling

$$M_c = C_m \cdot V + \sum (C_p \cdot T) + \frac{C_t}{N}$$

Costing

Manufacturing Costing Equation

Processing

$$M_c = C_m \cdot V + \boxed{\sum (C_p \cdot T)} + \frac{C_t}{N}$$

Processing costs are all calculated per hour and then multiplied by the manufacturing lead time to obtain the processing cost per part.

These costs include labour, depreciation, overheads, consumables and power

$$\sum C_p = C_l + C_d + C_o + C_c + C_{pow}$$

Costing

Manufacturing Costing Equation

Processing - Labour

$$M_c = C_m \cdot V + \boxed{\sum \left(C_p \cdot T\right)} + \frac{C_t}{N}$$

Assuming 1 unskilled worker attends to both machines for the whole period and a setter works 10 hours over a 24-hour period, labour cost per hour can be calculated:

$$C_{l1} = 15 + (25 \times 0.42) = £25.41$$

Labour costs over shutdown days:

$$C_{l2} = \frac{6 \times 4 \times 25}{361 \times 24} = £0.068$$

Final labour cost of:

$$C_l = 15_{operator} + 10.41_{setter} + 0.068_{Servicing} = \mathbf{£25.478/hr}$$

Costing
Manufacturing Costing Equation
Processing - Depreciation

$$M_c = C_m \cdot V + \boxed{\sum \left(C_p \cdot T\right)} + \frac{C_t}{N}$$

To calculate hourly costs due to depreciation, used the formula:

$$C_d = \frac{Cost\ of\ Replacement}{Service\ Life\ in\ Hours}$$

- Main depreciation costs came from the Haas DS-30Y, robotic arm and magnetic clamp.
- They together they cost £148,900 and must be replaced every 5-years.

$$C_d = 6.874_{Machinery} + 0.0514_{Storage} + 0.317_{Metrology} + 0.064_{Toolholders} + 0.05_{ChuckJaws} = \mathbf{£7.356}$$

Costing
Manufacturing Costing Equation
Processing - Overheads

$$M_c = C_m \cdot V + \boxed{\sum (C_p \cdot T)} + \frac{C_t}{N}$$

1. Total production line footprint is 64m^2 and totaling £76,800 per year at a floor cost of £1200/m^2. Storage space for 480 drums adds a further £9,600 annually

2. Handling of unprocessed castings and finished brake drums to and from storage is estimated to cost £60 per day

3. A factory administrator and 2-person cleaning staff expected to have 1/5th of their day assigned to brake drum production is calculated to cost £88 per day

4. Additional annual charge of £3000 for the use of factory equipment

$$C_o = 9.14_{spaces} + 2.5_{handling} + 3.708_{administration\,\&\,cleaning} + 0.346_{hire} = \mathbf{£15.695/hr}$$

Costing

Manufacturing Costing Equation

Processing - Consumables and Power

$$M_c = C_m \cdot V + \boxed{\sum (C_p \cdot T)} + \frac{C_t}{N}$$

Consumables

- Haas DS-30Y has 108L cooling tank, expecting to use 6 tanks worth of coolant
- Coolant cost £0.15/L to buy and £0.2/L to dispose
- Other general Consumables (paper, soap, cleaning materials, etc.): £0.02/hour

$$\boldsymbol{c_c} = 0.056_{coolant} + 0.02_{other} = \mathbf{£0.076}$$

Power

- Machines operate on a duty cycle of 0.25.
- Turning centre uses 15.4kW as well as the robotic arm 5.2kW.
- Assuming fixed electrical cost of £0.2/kWh

$$\boldsymbol{C_{pow} = £2.07}$$

Costing
Manufacturing Costing Equation
Materials and Tooling

$$M_c = \boxed{C_m \cdot V} + \sum (C_p \cdot T) + \boxed{\frac{C_t}{N}}$$

Material cost, $C_m \cdot V$ is simply the cost of the casting, **£6.15.**

Tooling cost per part of each tool was calculated:

$$\frac{C_t}{N} = \frac{Cost\ of\ insert}{N.\,cutting\ edges} \times \frac{1}{N.\,parts\ produced}$$

- An early tooling replacement strategy was employed to help minimise downtimes.
- The total tooling cost comes out to be **£6.26** per part

Conclusion

- Final cost: £22.545 each (incl. £6.15 of casting)
- 240 drums was tricky
- 1 CNC → too tight on time
- Aware that it is not most cost-effective solution, but it is complete
- Process could be further optimised for tool life

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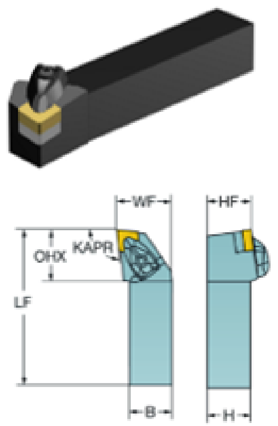
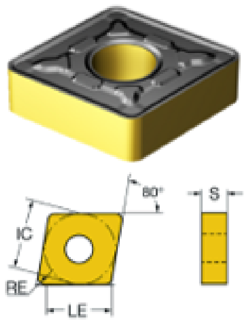
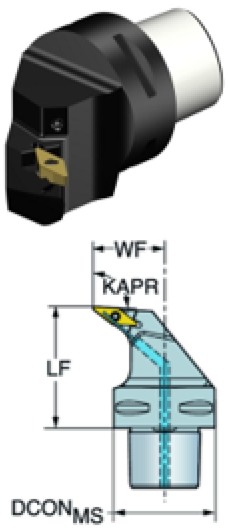
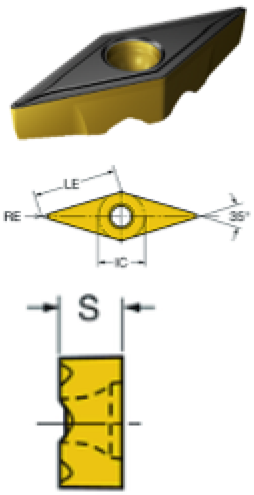
Any Questions?

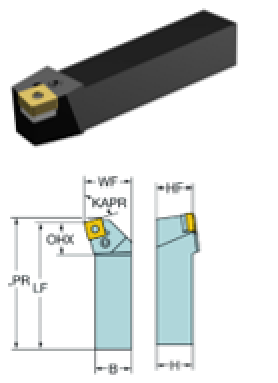
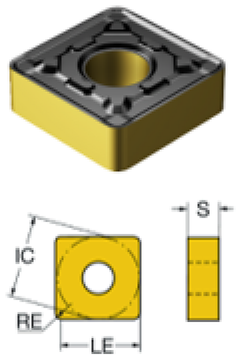
Manufacturing Method
Tooling Selection - Continued

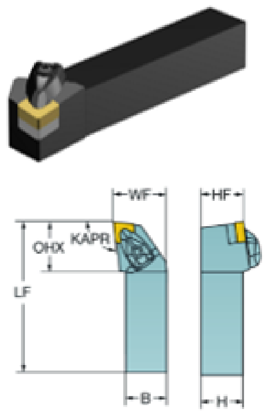
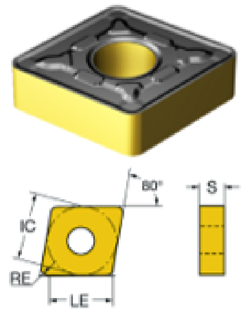
TOOL		INSERT	
Turret Location: 2			
[101]: Facing off drum			
DCLNR 2525M 16		**CNMG 16 06 08-PR 4425**	
	**KAPR:** 95 ˚ **PSIR:** -5 ˚ **OHX:** 39 mm **WF:** 32 mm **LF:** 150 mm **B, H, HF:** 25 mm		**Angle:** 80 ˚ **IC:** 15.875 mm **RE:** 0.7938 mm **LE:** 15.3199 mm **S:** 6.35mm **Cutting edge count:** 4 **Grade:** 4425 **Coating:** CVD TiCN+Al2O3+TiN
Cutting speed (m/min	338	**Depth of cut (mm)**	2
Feed rate (mm/rev)	0.288		

[102]: Finishing off external shoulder			
Cutting speed (m/min)	338	**Depth of cut (mm)**	2
Feed rate (mm/rev)	0.288	**Tool life count**	45.45

Turret Location: 3			
[103]: Finishing of internal bore			
C5-TR-V13UBR-35060C1		**TR-VB1308-F 4415**	
	**KAPR:** 93 ˚ **WF:** 35 mm **LF:** 60 mm **DCONMS:** 50 mm		**Angle:** 35 ˚ **IC:** 8 mm **RE:** 0.7938 mm **LE:** 12.2 mm **S:** 4.525 mm **Cutting edge count:** 2 **Grade:** 4415 **Coating:** CVD TiCN+Al2O3+TiN
Cutting speed (m/min)	392	**Depth of cut (mm)**	0.4
Feed rate (mm/rev)	0.206	**Tool life count**	66.67

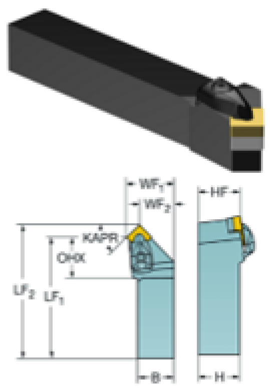
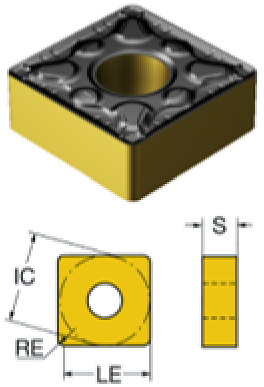
Manufacturing Method
Tooling Selection - Continued

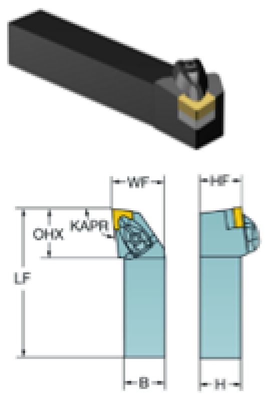
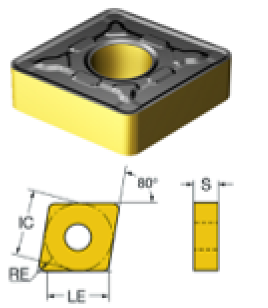
Turret Location: 4			
[104]: Finishing of internal face			
PSKNR 2525M 15		SNMG 15 06 24-PR 4425	
	**KAPR:** 75 ° **PSIR:** 15 ° **OHX:** 28.9 mm **WF:** 32 mm **LF:** 150 mm **LPR:** 153.8 mm **B, H, HF:** 25 mm		**Angle:** 90 ° **IC:** 15.875 mm **RE:** 2.3813 mm **LE:** 13.475 mm **S:** 6.35 mm **Cutting edge count:** 8 **Grade:** 4425 **Coating:** CVD TiCN+Al2O3+TiN
Cutting speed (m/min)	283	**Depth of cut (mm)**	3
Feed rate (mm/rev)	0.5	**Tool life count**	154.64

TOOL		INSERT	
Turret Location: 2			
[101]: Facing off drum			
DCLNR 2525M 16		CNMG 16 06 08-PR 4425	
	**KAPR:** 95 ° **PSIR:** -5 ° **OHX:** 39 mm **WF:** 32 mm **LF:** 150 mm **B, H, HF:** 25 mm		**Angle:** 80 ° **IC:** 15.875 mm **RE:** 0.7938 mm **LE:** 15.3199 mm **S:** 6.35mm **Cutting edge count:** 4 **Grade:** 4425 **Coating:** CVD TiCN+Al2O3+TiN
Cutting speed (m/min	338	**Depth of cut (mm)**	2
Feed rate (mm/rev)	0.288		
[102]: Finishing off external shoulder			
Cutting speed (m/min)	338	**Depth of cut (mm)**	2
Feed rate (mm/rev)	0.288	**Tool life count**	45.45

Manufacturing Method

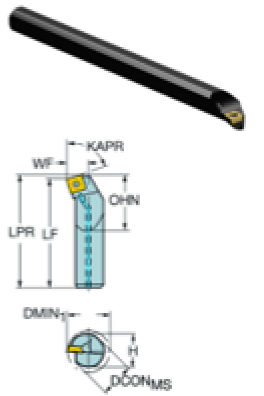
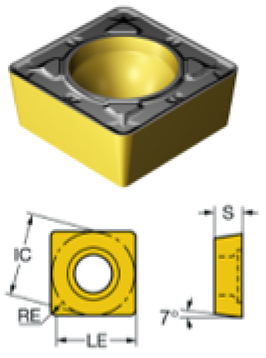
Tooling Selection - Continued

Turned Location: 7			
Turret Location: 7			
[201]: Facing off drum			
DSSNL 2020K 12		**SNMG 12 04 16-PM 4425**	
	**KAPR:** 45 ° **PSIR:** 45 ° **OHX:** 27.5 mm **WF:** 25 mm **LF:** 125 mm **B, H, HF:** 20 mm		**IC:** 12.7 mm **RE:** 1.5875 mm **LE:** 11.1 mm **S:** 4.7625 mm **Cutting edge count:** 8 **Grade:** 4425 **Coating:** CVD TiCN+Al2O3+TiN
Cutting speed (m/min)	338	**Depth of cut (mm)**	1
Feed rate (mm/rev)	0.408	**Tool life count**	223.88

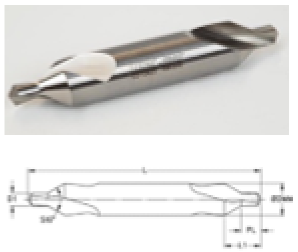
Turret Location: 8			
[202]: Roughing of external shoulder and diameter			
DCLNL 2525M 16		**CNMG 16 06 08-PR 4425**	
	**KAPR:** 95 ° **PSIR:** -5 ° **OHX:** 39 mm **WF:** 32 mm **LF:** 150 mm **B, H, HF:** 25 mm		**Angle:** 80 ° **IC:** 15.875 mm **RE:** 0.7938 mm **LE:** 15.3199 mm **S:** 6.35 mm **Cutting edge count:** 4 **Grade:** 4425 **Coating:** CVD TiCN+Al2O3+TiN
Cutting speed (m/min)	317	**Depth of cut (mm)**	4.51
Feed rate (mm/rev)	0.35		
[203]: Finishing of external shoulder and diameter			
Cutting speed (m/min	338	**Depth of cut (mm)**	2.16
Feed rate (mm/rev)	0.288	**Tool life count**	32.59

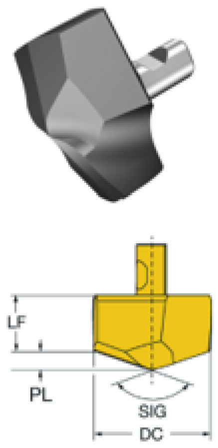
Manufacturing Method

Tooling Selection - Continued

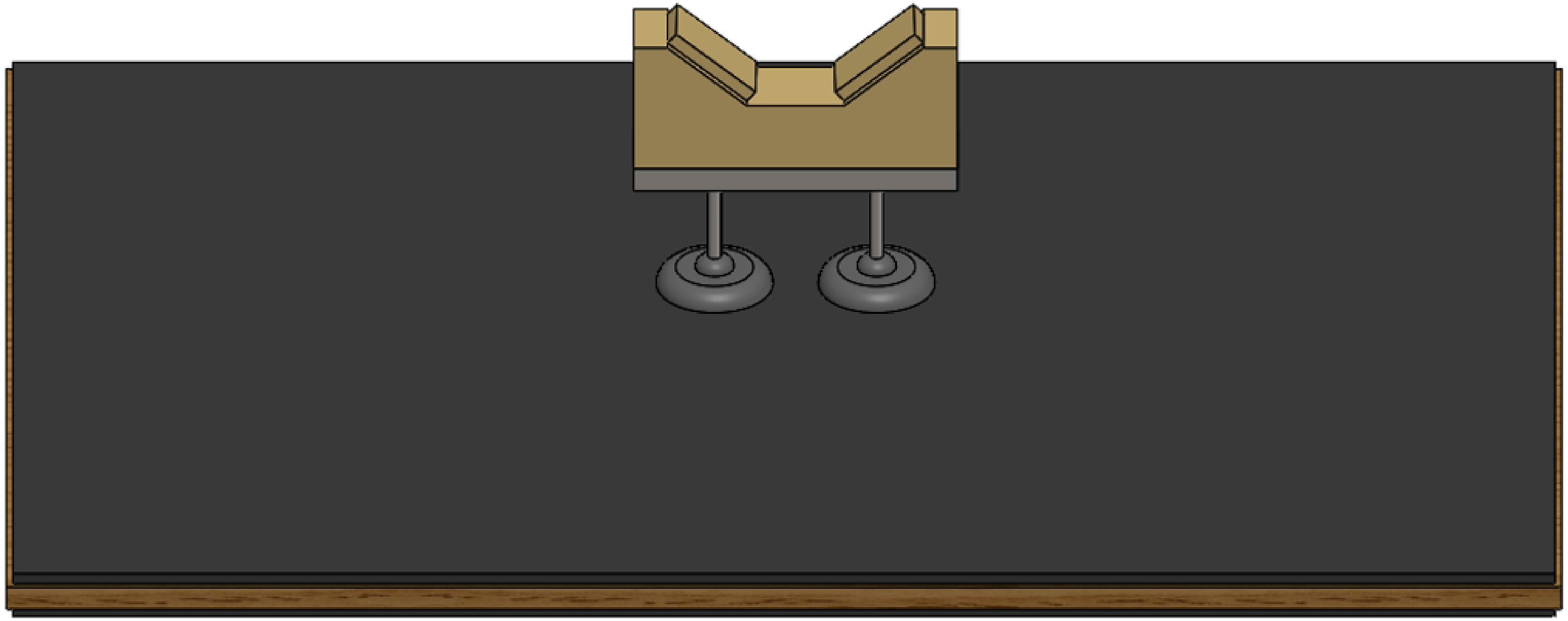
Turret Location: 9			
[204]: Roughing of internal bore			
A25T-SSKCL 12		SCMT 12 04 12-PR 4425	
	**KAPR:** 75 ° **PSIR:** 15 ° **OHX:** 100 mm **WF:** 17 mm **LF:** 300 mm **LPR:** 303.05 mm **B, H, HF:** 23 mm		**IC:** 12.7 mm **RE:** 1.1906 mm **LE:** 11.5 mm **S:** 4.7625 mm **AN:** 7 ° **Cutting edge count:** 4 **Grade:** 4425 **Coating:** CVD TiCN+Al2O3+TiN
Cutting speed (m/min)	314	Depth of cut (mm)	2.27
Feed rate (mm/rev)	0.373		

[205]: Finishing of internal bore			
Cutting speed (m/min	320	Depth of cut (mm)	1.96
Feed rate (mm/rev)	0.353	Tool life count	92.02

Turret Location: 10			
[301]: Centre drilling 4 holes			
Haas HSS 60° Centre Drill			
	**ØDMM:** 12.5 mm **D1:** 5 mm **SIG:** 60 ° **L1:** 12.8 mm **PL:** 6.3 mm **L:** 63 mm		
Cutting speed (m/min)	177	Depth of cut (mm)	4
Feed rate (mm/rev)	0.27	Tool life count	36.76

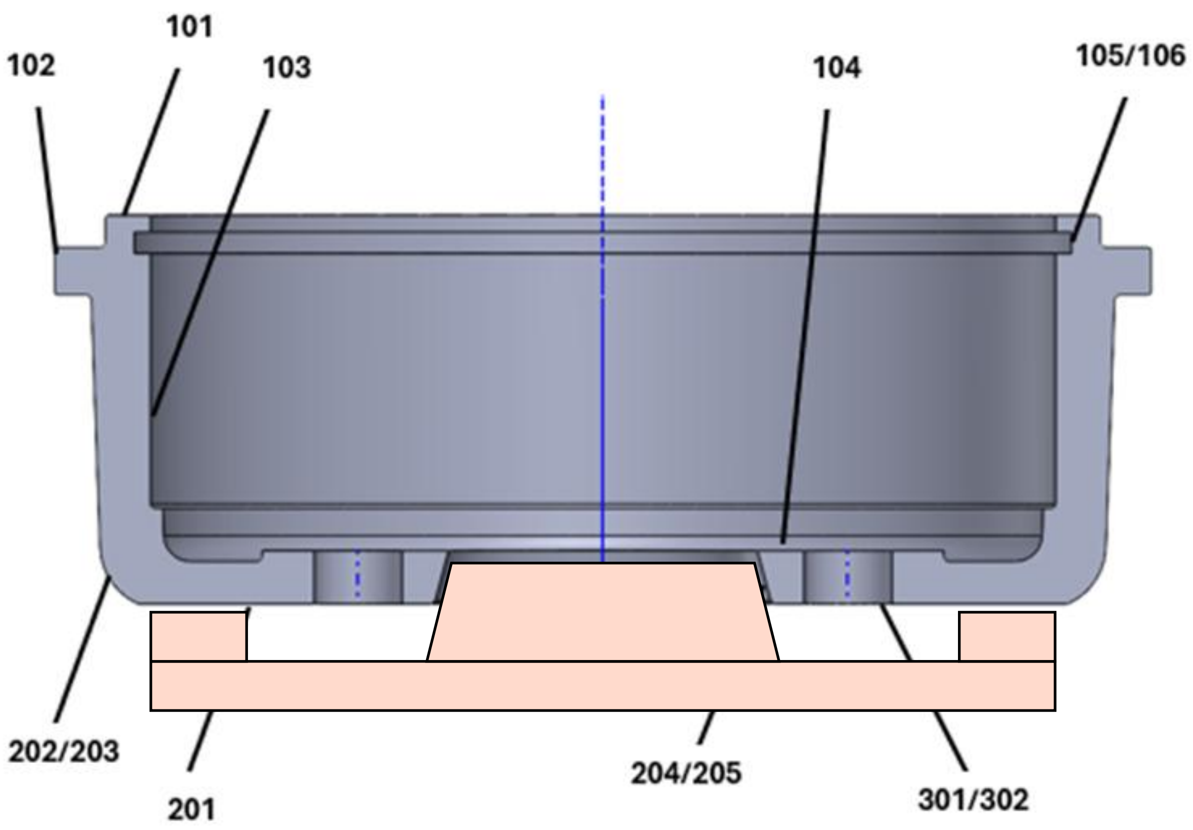
Turret Location: 11, 12			
[302]: Drilling of 4 holes			
870-1600-16LX075-3		870-1640-16-PM 4334	
	**PL:** 2.58 mm **LU:** 53.56 mm **LB:** 56 mm **LF:** 69.42 mm **OAL:** 122 mm **DCONMS:** 19.05 mm		**ØDC:** 16.4 mm **SIG:** 142 ° **LF:** 7.51 mm **PL:** 2.4 mm **Grade:** 4334 **Coating:** PVD TiAlN
Cutting speed (m/min)	110	Depth of cut (mm)	10
Feed rate (mm/rev)	0.326	Tool life count	16.88

Part Handling
Divider Transport



Two vacuum pads are used to transport the drum dividers from one pallet to the next. This is done while the 13th pallet is being machined and does not slow production. The two pads are fitted onto the robotic arm, on the opposite side to the magnetic clamp, and are actuated pneumatically. Assuming a pad diameter of 10mm, a divider weight of 3kg, and a suction force of 0.5atm (50.66kPa), the pads are capable of lifting the divider with a safety factor of $(3 \times 9.81)/(2 \times \pi(0.005)^2 \times 50.66 \times 10^3) = 3.70$.

Metrology
Part holding



Costing
Insert Utilisation

Insert costs								
Insert	cost/unit	N. edges	tool life (minutes)	cutting time per part (s)	N. parts can be produced	time based cost (£)	N. parts actually produced	parts based cost (£)
CNMG 16 06 08-PR 4425	£2.17	8	15.00	19.80	45.00	0.006	24	0.0113
TR-VB1308-F 4415	£1.92	4	15.00	13.50	67.00	0.0071	48	0.01
SNMG 15 06 24-PR 4425	£2.17	2	15.00	5.82	155.00	0.007	144	0.0075
MAGL 3 250 1025	£7.65	8	15.00	60.16	15.00	0.0638	12	0.0797
SNMG 12 04 16-PM 4425	£1.37	8	15.00	4.02	224.00	0.0008	216	0.0008
CNMG 16 06 08-PR 4425	£2.17	4	15.00	27.62	33.00	0.0164	24	0.0226
SCMT 12 04 12-PR4425	£1.55	4	15.00	9.78	92.00	0.0042	72	0.0054
Centre drill	£7.00	1	15.00	10.00	90.00	0.0778	72	0.0972
870-1600-16LX075-3	£273.00	1	30.00	24.00	75.00	3.64	72	3.7917
870-1640-16-PM 4334	£107.00	1	30.00	30.00	60.00	1.7833	48	2.2292
				Total:		£5.61		£6.26