

Collaborative Engineering

Machining Cost Estimation

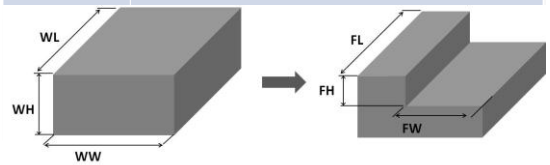
- Machining Cost
- Product Complexity
- Injection Molding Cost



OrthoCAD Lab, I.I.T. Bombay

Machining Cost Components

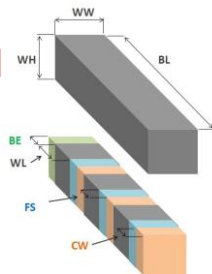
| | |
|-------------------|---|
| Material | - Form of material: Bar, Rod, Extruded - Conversion to work piece |
| Production | - Complexity, Tolerance and Surface finish - Material Removal Rate (MRR) - Tool path and cutting time |
| Tooling | - Tool material, Tool Life |



Machining Cost: Material Cost

STOCK INFORMATION

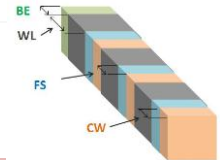
| | |
|---------------------------------------|-----------|
| Part Quantity | 100 |
| Defect Rate (%) | 2 |
| Run Quantity | Q 103 |
| Material | Al |
| Cost of Material (Rs/Kg) | C 120 |
| Material Density (Kg/m ³) | D 2.38 |
| Work piece Shape | Rectangle |
| Work piece Length (cm) | WL 10.00 |
| Work piece Width (cm) | WW 6.00 |
| Work piece Height (cm) | WH 5.00 |



Material Cost

STOCK PARAMETERS

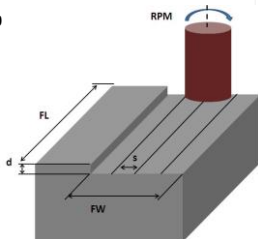
| | |
|---------------------------------|---|
| Bar Length (cm) | BL 150.00 |
| Bar end (cm) | BE 5.00 |
| Facing Stock (cm) | FS 0.05 |
| Cutoff Width (cm) | CW 0.25 |
| Parts per bar | PPB 14 = (BL-BE) / (WL+FS+CW) |
| Bar Quantity | BR 7 = PPB/Q |
| Price per bar (Rs) | P 1285 = (BL x WW x W) x D x C |
| Cut Charge (Rs/part) | CC 1.50 |
| Mark up (ratio) | MU 0.10 Transport/labour/profit |
| Total Material Cost (Rs) | TMC 10207 = Mu x ((BRxP) + (CCxQ)) |
| MATERIAL COST/PART (Rs) | MC 102 = TMC/Q |



Production Cost

OPERATION INFORMATION

| | |
|-------------------------|----------|
| Face Size - Length (cm) | FL 10.00 |
| Face Size - Width (cm) | FW 4.00 |
| Face Size - Height (cm) | FH 2.00 |
| Depth of cut (cm) | d 0.05 |
| Step over (cm) | s 1.00 |
| Surface Roughness (µm) | IMP |
| No. of faces | 1 |
| Tool Diameter (cm) | TD 2.00 |
| Number of tooth | n 6 |



Production Cost

CUTTING TIME

| | | |
|----------------------------|------------|-------------------------------|
| Feed per Tooth (cm) | f 0.05 | Depth that each tooth goes in |
| Cutting Speed (cm/min) | v 3000 | Tool travel speed: machining |
| Cutting Feed (cm/rev) | F 0.30 | = f x n |
| Spindle Speed (rev/min) | RPM 477.46 | = v / (pi x TD) |
| Feed Rate (cm/min) | FR 143.24 | = RPM/F |
| No. of machined layers | l 40 | = FH/D |
| Number of single runs | r 4 | = FW / (TD-s) |
| Cutting Length/layer (cm) | Li 40.00 | = FL x r |
| Tool Running length (cm) | Lr 1600 | = Li x l |
| Tool Insertion length (cm) | Li 16.00 | = d x r x l |
| Cutting Length (cm) | L 1616 | = Lr + Li |
| Cutting Time (min) | CT 11.28 | = L/FR |

Production Cost

IDLE TIME

| | | | |
|--------------------------|-----|------|-------------------------------|
| Workpiece clearance (cm) | WC | 0.1 | Initial tool distance |
| Rapid travel rate cm/min | RTR | 1000 | Tool travel speed: Idle |
| Rapid travel length (cm) | RTL | 420 | = Hypotenuse(FL,FW) x (l - 1) |
| Idle Time | IT | 0.42 | = (RTL/RTR) + (WC/FR) |

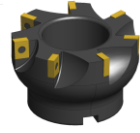
SETUP TIME

| | | | |
|----------------------------|-----|-------|------------------------------|
| Machine setup time (min) | MST | 30 | |
| Programming time (min) | PT | 30 | |
| Fixture setup time (min) | FST | 30 | |
| Tool change time (min) | TCT | 1 | |
| Total Setup Time (min) | TST | 30.42 | = MST + PT + FST + TCT |
| PRODUCTION COST/PART | PC | 421 | = (ro x (CT+T)) + (rs x TST) |
| Total Production Cost (Rs) | TPC | 42984 | = PC*Q |

Tooling Cost and Total Cost

TOOLING COST (Milling)

| | | | |
|----------------------------|-----|-------|------------------------------|
| Material | HSS | | |
| Tool Size - Diameter (cm) | TD | 2 | |
| Number of tooth | n | 6 | |
| Tool Price | TP | 1000 | |
| Tool Life (min) | TL | 60 | Tool life - cutting velocity |
| Number of tools | Nt | 19 | = (CT x Q)/TL |
| Total Tooling Cost (Rs) | TTC | 18803 | = Nt x TP |
| TOOLING COST PER PART (Rs) | | 184 | = TTC/Q |
| TOTAL COST PER PART (Rs) | | 707 | = MC + PC + TC |



CNC Machining and Product Complexity

Product Complexity

- Features
- Surface profile
- DOF
- Number of operations

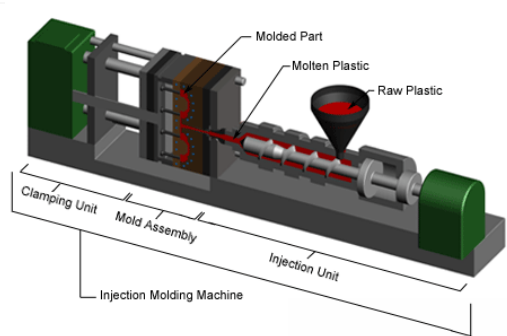


| Axes of CNC machine | Cost (Rs/hr) |
|---------------------|--------------|
| Three (X,Y,Z) | 800 |
| Four (X,Y,Z,Rx) | 2000 |
| Five (X,Y,Z,Rx, Ry) | 6000 |

Condyle

- M/c: Makino Max 65S,
- Material: CoCr
- Time: 32 hrs 30 min
- 9 Operations on 3-axis machine

Injection Molding

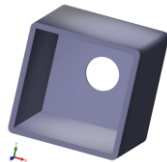


[Source: <http://www.custompartnet.com>]

Injection Molding Cost: Part Information

PART INFORMATION

| | | | |
|---------------------------------------|----|--------|----------------|
| Part Quantity required | Q1 | 100000 | |
| Material | | ABS | |
| Cost of Material (Rs/Kg) | C | 80 | |
| Material Density (g/cm ³) | d | 0.11 | |
| Envelop - X (cm) | L | 5.00 | |
| Envelop - Y (cm) | W | 5.00 | Bounding box |
| Envelop - Z (cm) | H | 5.00 | |
| Max wall thickness (cm) | T | 2.00 | less than 6 mm |
| Feature size (cm) | x | 1.00 | Hole diameter |
| Number of features | n | 1 | Holes |



Material Cost

MATERIAL INFORMATION

| | | | |
|--------------------------|-----|--------|---|
| Defect Rate (%) | D | 5 | Recycled |
| Run Quantity | Q | 105263 | = Q1*(100+D)/100 |
| Cost of Material (Rs/Kg) | C | 80 | |
| Part Weight (g) | m | 25.59 | = Volume x d |
| Regrind ratio (%) | rr | 5 | Recycling of scrap |
| Regrind cost (Rs/kg) | rc | 0.25 | Less than cost of raw mat. |
| Additive ratio (%) | ar | 2 | Colorant |
| Additive cost (Rs/kg) | ac | 0.25 | |
| Material markup | MM | 25 | |
| Total Material Cost (Rs) | TMC | 269430 | = ((Qxm/1000)x (C + rr*rc/100 + ar*ac/100)) |
| MATERIAL COST/PART (Rs) | MC | 2.56 | = TMC/Q |

Production Cost

OPERATION INFORMATION

| | | | |
|----------------------------|-----|------|---------------------------|
| Hourly rate (Rs/hr) | r | 1500 | Hourly manufacturing cost |
| Production rate (parts/hr) | p | 182 | |
| Machine setup time (hr) | MST | 8.00 | Calibration, tooling etc. |
| Post processing time (hr) | PPT | 0.50 | trimming, cleaning etc. |
| Production markup | PM | 10 | Labor, profit etc. |

Total Production Cost (Rs) TPC 968334 = $r \times ((Q/p) + MST + PPT) \times (PM + 100) / 100$

PRODUCTION COST/PART (Rs) PC 9.20 = TPC/Q

Tooling Cost and Total Cost

OPERATION INFORMATION

| | | |
|--------------------------|------|--|
| Tolerance (mm) | 0.25 | 0.5 - 0.05 |
| Surface roughness (µm) | 0.40 | 0.8 - 0.05 |
| Number of cavities | 2.00 | Complexity |
| SPI mold class | SPI | 104.00 Society of Plastics industry |
| Mold Making rate (Rs/hr) | rm | 3000 Machining, inspection, labor etc. |
| Mold making time (hr) | Tm | 300 |

Total Tooling Cost (Rs) TTC 900000 = $Tm \times rm$

TOOLING COST/PART (Rs) TC 8.55 = TTC/Q

TOTAL COST PER PART (Rs) 20.31 = $MC + PC + TC$

SUMMARY

- Material and its form
- Product Complexity
- Features
- Process Parameters
- Tool material and life

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