



MSE-433

# Cost modelling tool for sustainable innovation

Dr. Martyn D. Wakeman  
[martyn.wakeman@epfl.ch](mailto:martyn.wakeman@epfl.ch)



# A simple cost model to try out...

- See Template Provided (excel file can be opened click on the table below)

| Simple technical cost model                                       | Process Totals | Die casting      | Punching         | Machining        |
|---|----------------|------------------|------------------|------------------|
| <b>Process Goals</b>  |                |                  |                  |                  |
| Material 1 mass per part (kg)                                     | 2.2            |                  |                  |                  |
| Material 2 mass per part (kg)                                     |                |                  |                  |                  |
| <b>Target production rate (p/yr)</b>                              | <b>120,000</b> |                  |                  |                  |
| Production duration (yrs)   | 5              |                  |                  |                  |
| <b>Dashboard</b>  |                |                  |                  |                  |
| Hours per shift (hrs/d/sh)  | 7.3            |                  |                  |                  |
| Days per year (d/yr)  | 220            |                  |                  |                  |
| Available shift operational time at 100% efficiency (hr/yr/shift) |                | 1,606            | 1,606            | 1,606            |
| <b>Time efficiency (.)</b>  |                | 80%              | 80%              | 80%              |
| Available shift operational time (hr/yr/shift)                    |                | 1,285            | 1,285            | 1,285            |
| <b>Cycle time (s/p)</b>   |                | 110              | 90               | 60               |
| Available shift production rate (p/yr/sh)                         |                | 42,048           | 51,392           | 77,088           |
| <b>Required production rate OUT (p/yr)</b>                        | <b>120,000</b> | <b>120,000</b>   | <b>120,000</b>   | <b>120,000</b>   |
| <b>Reject (.)</b>   |                | 5%               | 0%               | 2%               |
| Actual production rate IN (p/yr)                                  |                | 125,654          | 120,000          | 122,449          |
| Single shift utilisation (.)                                      |                | 2.99             | 2.33             | 1.59             |
| No of shifts required (sh)  | 3              | 3                | 3                | 2                |
| <b>Max no of shifts (sh)</b>                                      | <b>3</b>       | <b>3</b>         | <b>3</b>         | <b>3</b>         |
| No of shifts employed (sh)  |                | 3                | 3                | 2                |
| Available production rate (p/yr)                                  |                | 126,144          | 154,176          | 154,176          |
| <b>Actual utilisation rate (.) MUST BE &lt; 1</b>                 | <b>1.00</b>    | 1.00             | 0.78             | 0.79             |
| Available operational time (hrs/yr)                               |                | 4,818            | 4,818            | 3,212            |
| Actual operational time (hrs/yr)                                  |                | 4,799            | 3,750            | 2,551            |
| <b>Dedicated / Utilised</b>                                       |                | <b>dedicated</b> | <b>dedicated</b> | <b>dedicated</b> |
| Effective utilisation (.)   |                | 1.00             | 1.00             | 1.00             |

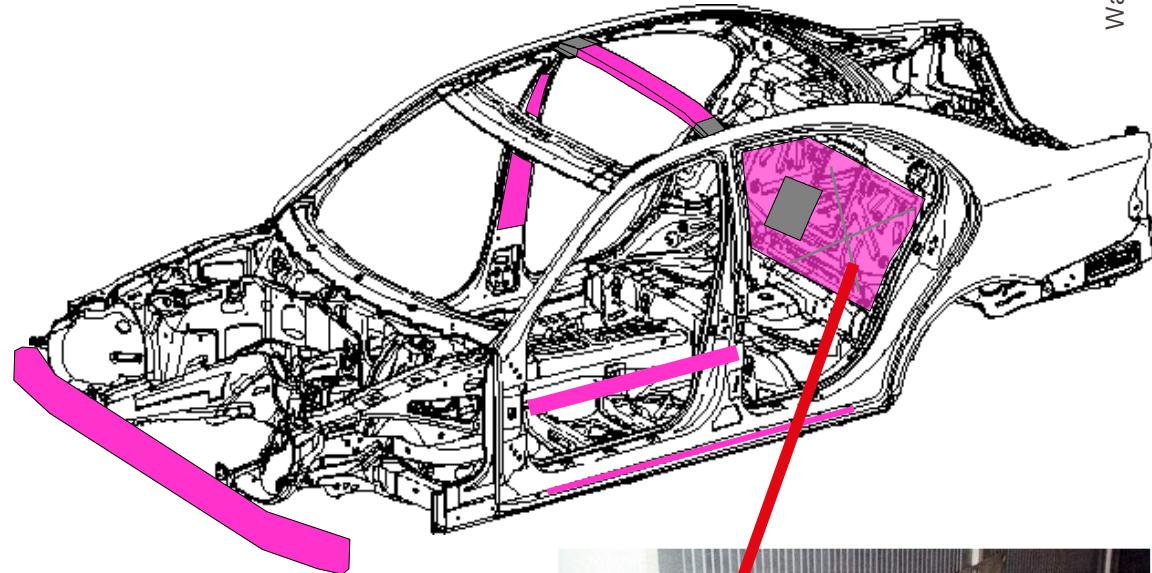
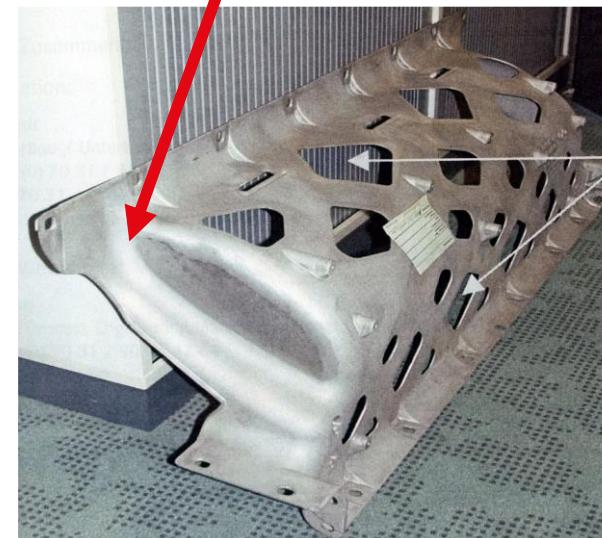


**Functional unit:****Curved structural panel**

- typical of BIW, rear bulkhead
- does not need to pass through E-coat process (but could)
- temperature capability if needed
- magnesium benchmark
- detailed sensitivity studies

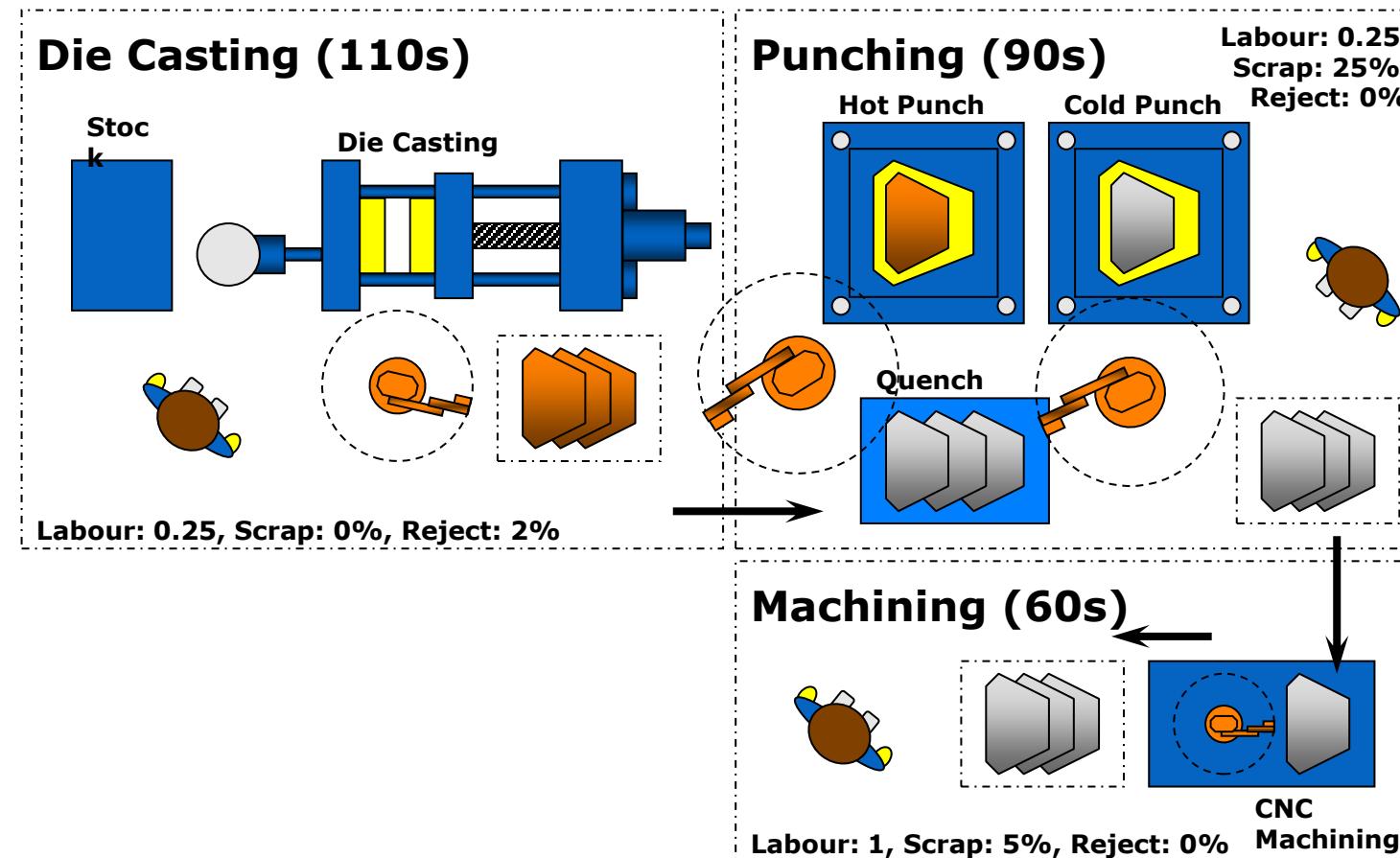
  

- Rear Structural Bulkhead
  - Steel 5.8kg
  - Magnesium 2.2kg
  - SMC 2.5kg
  - GF/PA GMT 2.4kg
  - GF NCF/HP-RTM 2.3kg
  - CF NCF/HP-RTM 1.8kg (1.2kg)

**Aluminum?**

# Example process

- Magnesium Die Casting



- Production Dashboard

Material mass per part (kg)

Target production rate (p/yr)

Production duration (yrs)

Actual operational time (hrs/yr)

Effective utilisation (.) = if a=dedicated then 1 else if a=utilised then b

└─ Dedicated / Utilised

└─ Actual utilisation (.)

No. of direct labour (pns)

Key

Data valid for entire process

Data valid for an activity / machine

Value from downstream activity

Calculated value = formula e.g. a/b

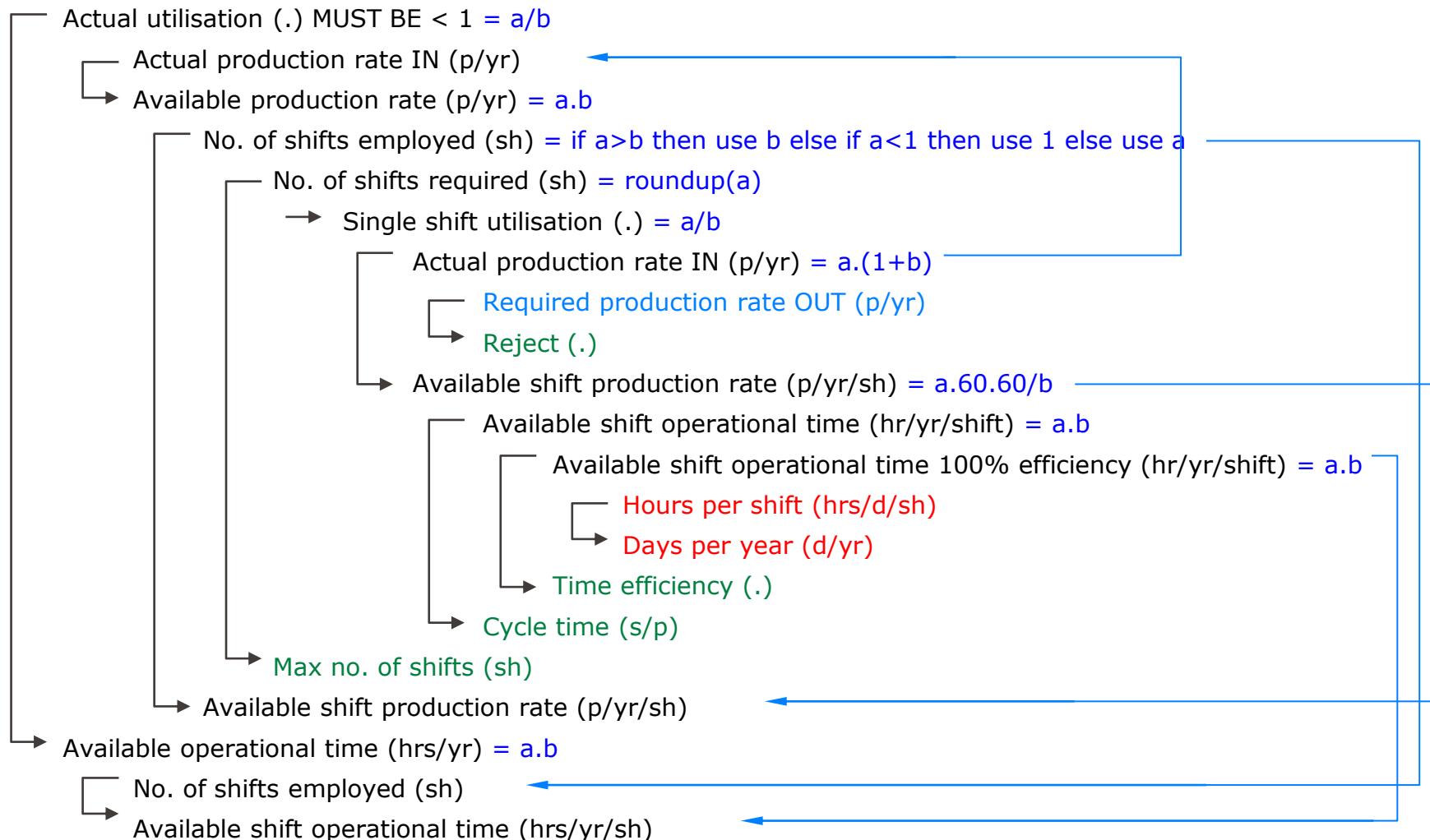
└─ value a

└─ value b

Value calculated elsewhere

# Production Dashboard

- Actual operational time (hrs/yr) =  $a.b$



## ■ Total Production Cost

Total Production Cost (€/p) = a+b+c+d+e+f+g



## ■ Material Cost

$$\text{Material value IN (€/p)} = a/b$$

$$\square \text{Annual material cost IN (€/yr)} = a.b$$

$$\square \text{Material cost (€/kg)}$$

$$\rightarrow \text{Material mass IN per year (kg/yr)} = a.b$$

$$\square \text{Actual production rate IN (p/yr)}$$

$$\rightarrow \text{Material mass per part IN (kg/p)} = a.(1+b)$$

$$\square \text{Material mass per part OUT (kg/p)}$$

$$\rightarrow \text{Scrap (.)}$$

$$\rightarrow \text{Target production rate (p/yr)}$$

# Equipment Cost Calculation

## ■ Equipment Cost

Machine depreciation (€/p) =  $a/b$

Process depreciation cost (€/yr) =  $a \cdot b$

Annual depreciation cost (€/yr) =  $a/b$

Equipment capital cost (€)

Depreciation time (yrs) = if  $a=$ utilised then  $b$  else  $c$

→ Dedicated / Utilised

→ Time until replacement (yrs)

→ Production duration (yrs)

→ Effective utilisation (.)

→ Target Production rate (p/yr)

- Tooling Cost

$$\text{Tool cost } (\text{€/p}) = a/b$$

$$\text{Annual tool cost } (\text{€/yr}) = a/b$$

$$\text{Total tool cost } (\text{€}) = a.b$$

Tool cost (€/tl)

$$\rightarrow \text{No. of tools (tls)} = \text{roundup}(a/b)$$

$$\text{Total no of shots in process (shts)} = a.b$$

Actual production rate IN (p/yr)

Production duration (yrs)

Tool life in shots (shts)

Production duration (yrs)

Target production rate (p/yr)

# Plant Operation Cost Calculation

## ■ Plant Operation Cost

Plant operating cost (€/p) =  $a/b$

└ Annual plant operating cost (€/yr) =  $a \cdot b$

└ Full plant operating cost (€/yr) =  $a \cdot b$

└ **Plant operating cost (€/m<sup>2</sup>/yr)**

└ **Plant area (m<sup>2</sup>)**

└ Effective utilisation (.)

└ Target production rate (p/yr)

# Energy Cost Calculation

- Energy Cost

$$\text{Energy cost (€/p)} = a/b$$

$$\text{Annual energy cost (€/yr)} = a.b$$

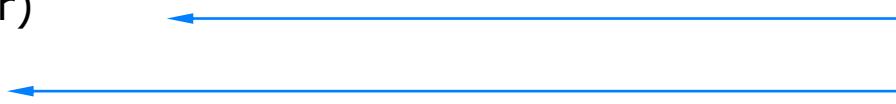
$$\text{Energy cost (€/hr)} = a.b$$

$$\text{Energy cost (€/kWh)}$$

Machine power (kW)

Actual operational time (hrs/yr)

Target production rate (p/yr)



# Labor Cost Calculation

■ Labor cost (€/p) = a+b

    Direct labor cost (€/p) = a.b

        Direct labor cost per person (€/p/pn) = a/b

            Annual direct labor cost (€/yr) = a.b

                Direct labor cost per person (€/hr)

                Actual operational time (hrs/yr)

                Target production rate (p/yr)

            No. of direct persons (pns)

    Indirect labor cost (€/p) = a.b

        Indirect labor cost per person (€/p/pn) = a/b

            Annual direct labor cost (€/yr) = a.b

                Indirect labor cost per person (€/hr)

                Actual operational time (hrs/yr)

                Target production rate (p/yr)

    No. of indirect persons (pns) = a.b

        Direct / Indirect labor ratio (.)

        No. of direct labor persons (pns)

# Consumable Cost Calculation

## ▪ Consumable Cost

$$\text{Consumables cost (€/p)} = a.b$$

└ No. of direct labour persons (pns)

→ Consumables cost per person (€/p/pn) = a/b

└ Annual consumables cost (€/yr) = a.b

**Consumables cost per direct labour person (€/hr)**

        └ Actual operational time (hrs/yr)

        └ Target production rate (p/yr)