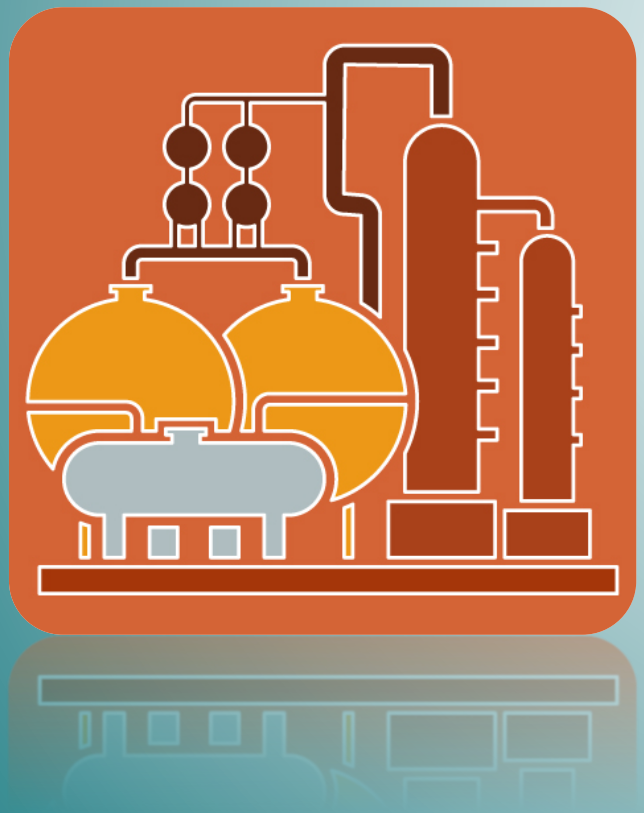
Chemical Process Design / Diseño de Procesos Químicos

Topic 6.2. Capital and COM



Javier R. Viguri Fuente
Eva Cifrian Bemposta

Department of Chemistry and Process & Resource Engineering
GER Green Engineering and Resources Research Group

INDEX

1.- Economic aspects of the preliminary design

2.- Cost Estimates

3.- Capital Investment

4.- Manufacturing cost

5.- Simple measures to estimate earnings and return on investment

6.- Profitability Measures

7.- Further Reading and References

PRACTICAL CHAPTER

RELEVANT TO LEARNING

3.- Capital investment

(CAPITAL INVESTMENT or CAPITAL COST – C_{TCI} –) *(Inversion de capital)*. [€]

a) Guthrie's modular method, based on individual factors, used for preliminary design:

$$C_{TCI} = C_{TPI} + C_{WC} =$$

Total Capital Investment | **Total Permanent Investment** | **Working Capital**

$$= 1.18\,(C_{TBM} + C_{site} + C_{buildings} + C_{offsite\ facilities}) + C_{WC}$$

Total bare-module cost: Σ(BMC) of the process equipment

Cost of site preparation = 10% - 20% C_{TBM}

Process and non-process buildings = 10% C_{TBM}

Utility plants and pollution control = 5% C_{TBM}

Updated Bare Module Cost = BMC = UF · BC · (MPF + MF – 1) + Contingencies and Contractor's fee = 18% BMC.

$$C_{TCI} = 1.18\,(1.35\,C_{TBM}) + C_{WC}$$

3.- Capital investment

(CAPITAL INVESTMENT or CAPITAL COST – C_{TCI} –) *(Inversion de capital)*. [€]

a) Method of Lang, based on overall factor, to study estimate:

$$C_{TCI} = 1.05\ f_{LTCI}\ \Sigma\ (I_i / I_{bi})\ C_{pi}$$

1.05: to account for delivery of the equipment to the plant site.

f_{LTCI}: Lang Factors according to the processing plant (solids, solids-fluids, fluids).

* $\Sigma\ (I_i / I_{bi})\ C_{Pi}$: Total purchase cost as sum of the updated equipment cost data.

3.- Capital investment

(CAPITAL INVESTMENT or CAPITAL COST – C_{TCI} –) *(Inversion de capital)*. [€]

c) Method based in estimation of the capital cost components:

Base cost for equipment

BC

On-Site Cost

- *Installation.*
- *Supervision.*
- *Taxes.*

BC (MF – 1); 4 BC

Indirect Costs

- *Construction overhead.*
- *Own Engineering.*

0.25 · (on-site + off-site)

Off-site Cost

- *Equipment to supply process utilities.*
- *Site development, Auxiliary buildings.*

0.45 · (on-site)

Σ = Fixed Capital = 1.8 · (on-site) = 7.2 BC

Manufacturing Capital

Non- Manufacturing Capital

Fixed Capital

1.8 · (on-site) = 7.2 BC

Plant startup costs

- *Equipment performance and personnel.*

0.1 · Fixed Capital

Working Capital

- *Early plant operation. Cost of raw materials and value of products.*

0.15 · Capital Costs

Σ = Capital Costs = 1.3 · Fixed Capital = 9.4 · BC

Capital Costs

TCI = 9.4 · BC

Equipment life (t)

10 years

Annual Interest (i)

15%

Annualized Total Capital Costs (ATCI)

$$ATCI = TCI * i * \left[\frac{(1+i)^t}{(1+i)^t - 1}\right] \equiv$$

$$\equiv TCI * \left[\frac{i}{(1+i)^t - 1} + i\right] \equiv$$

$$\equiv TCI * \left[\frac{i}{1 - \left(1/(1+i)\right)^t}\right]$$

ATCI = 2 · BC [€ / year]

4.- Manufacturing Cost

(MANUFACTURING COSTS *(Costes de fabricación)*. [€ / t] (COM)

- **Direct Manufacturing Costs (DMC):** vary with production rate.
- **Fixed Manufacturing Costs (FMC):** independent of changes in production rate.
- **General Manufacturing Expenses (GE):** business functions and seldom vary with production level.

$$COM = DMC + FMC + GE$$

COM can be determined when the following costs can be estimated:

1. Base Module Cost, BMC
2. Operating Labor, C_{OL}
3. Utilities, C_{UT}
4. Waste treatment, C_{WT}
5. Raw Materials, C_{RM}

$$COM = 0.304\ BMC + 2.73\ C_{OL} + 1.23\ (C_{UT} + C_{WT} + C_{RM})$$

→ The Service Factor needs to be known = N° days in operation during the year / 365.

4.- Manufacturing Cost

Factor	Factor Description	Value
1. Direct Costs (DC)	**Factors that vary with rate of production = $C_{RM} + C_{WT} + C_{UT} + 1.33\ C_{OL} + 0.03\ COM + 0.069\ BMC$**	**$C_{RM} + C_{WT} + C_{UT} + 1.33\ C_{OL} + 0.03\ COM + 0.069\ BMC$**
Raw materials	Costs of chemical feedstocks. Flow rates from the PDF.	C_{RM}
Waste treatment	Costs of waste treatment.	C_{WT}
Utilities	Gas, oil, coal, electric power, steam, water, air, inert gas, refrigeration, etc.	C_{UT}
Operating Labor	Cost of personnel for plant operations.	C_{OL}
Direct supervisory	Costs of administrative/engineering and support personnel, clerical labor.	(0.1 - 0.25) C_{OL}
Maintenance & Repairs	Costs of labor & materials associated with maintenance.	(0.02 - 0.1) BMC
Operating Supplies	Costs of miscellaneous supplies that support daily operation not considered raw materials (chart paper, lubricants, protective clothing, etc.).	(0.1 - 0.2) BMC
Laboratory charges	Costs of laboratory quality control tests.	(0.1 - 0.2) C_{OL}
Patents and Royalties	Costs of using patented or licensed technology.	(0 - 0.06) COM
2. Fixed Costs (FC)	**Factors not affected by the level of production = $0.708\ C_{OL} + 0.168\ BMC$**	**$0.708\ C_{OL} + 0.168\ BMC$**
Depreciation	Costs associated with the physical plant (buildings, equipment). Legal operating expenses for tax purposes.	0.1 BMC
Local taxes and Insurance	Based on plant location and severity of the process.	(0.014 - 0.05) BMC
Plant Overhead Costs	Catch-all costs associated with operation of auxiliary facilities supporting manufacturing process (fire protection, safety and medical services, etc.).	(0.5 - 0.7) C_{OL} + BMC
3. General Expenses (GE)	**Costs associated with management level + administrative activities = $0.177\ C_{OL} + 0.009\ BMC + 0.16\ COM$**	**$0.177\ C_{OL} + 0.009\ BMC + 0.16\ COM$**
Administration Costs	Salaries and other administration.	0.325 (C_{OL} + (0.02 - 0.1) BMC
Distribution and Selling	Sales and marketing required to sell products.	(0.02 - 0.2) COM
Research & Development	Costs of R&D activities related to the process.	0.05 COM

4.- Manufacturing Cost

- **Cost of Raw Materials – C_{RM}**
  - Price quotations from prospective suppliers of feedstocks.
  - ICIS Chemical Business Americas (Chemical Market Reporter).

- **Cost of waste treatment – C_{WT}**
  - Legal framework, minimization, IPPC, BAT Technologies, BREF Documents (Integrated Environmental Authorization –IEA–).

- **Utility Cost – C_{UT}**

C_{UT} = a · (CE Plant Cost Index) + b · Cs, f

a, b: coefficient cost for different kinds of utilities.

CE Plant Cost Index as the effective date of the estimate (Basis, 1958 = 100).

Cs, f: price of the fuel used to generate the utility.

4.- Manufacturing Cost

- **Cost of Operating Labor – C_{OL}**
  - Annual Operator Salary ($) = 41.600 x $(1,03)^{\text{year-2003}}$
  - Operator Requirements for process equipment per shift.
    - 49 weeks/operator/year · 5 shifts/week = 245 shifts/operator/year.
    - 365 days/year · 3 shifts/day = 1095 shifts/year.
    - [1095 shifts/year] / [245 shifts/operator/year] = 4.5 operators for a single shift.

→ **C_{OL} = (4.5) operators · (Σ n° operators/shift) · € / year**.

P: Solids / Particulate processing steps

$$\text{N° operators per shift} = (6.29 + 31.7\,P^2 + 0.23\,Nnp)^{0.5}$$

Nnp: non-particulate processing steps (compression, heat interchange, mixing, separation, reaction)

BMC

Updated Bare Module Cost = BMC = UF · BC · (MPF + MF – 1)