# CHAPTER 7

# Cost estimation

## 7.1. Introduction:

Cost estimation is a specialized subject and a profession in its own right. The design engineer, however, needs to be able to make quick, rough, cost estimates to decide between alternative designs and for project evaluation. Chemical plant are built to make a profit, and an estimate of the investment required and the cost of production are needed before the profitability of a project can be assessed.

The complete plant, the complete economic process is the design engineer's goal. So the stoichiometry equation for him is:

$$\$ + A + B \rightarrow C + D + \$$$
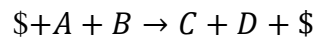
## 7.2. Estimation of MTBE plant cost:

The cost purchased equipment is the basis for estimating capital investment. So it will be start point for our calculation using the ranges outline in plant design and economic for chemical engineers.

### 7.2.1 Estimation of purchased equipment cost:

**-Distillation column cost= vessel cost + trays cost**

Vessel cost $= \$(1.67(0.041\text{P} - 8.3\text{E} - 6P^2)\,10^Z)$

$Z = 3.17 + 0.2\text{D} + 0.5\text{logL} + 0.21logL^2$

D = 1.3172m

L =34.6m

P = 20bar

Vessel cost = 89820.69$

Tray cost = No.of tray*(187+ 20D+61.5$D^2$)

$= 84*(187+ 20\times 1.3172+61.5 \times 1.3172^2)$

$= 26883.987\$$

Total column cost $= 89820.69 + 26883.987 = 116704.677\$$

Assume that three towers are identical; then:

Total column cost(T901&T902&T903) $= 3*116704.677 = 350114.031\$$

**-Reactor cost = $\$4.57E4(V, m^3)^{0.67}$**

$= \$4.57E4(65, m^3)^{0.67} = 749148.9\$$

**_Pump cost = $\$630(power, KW)^{0.6}$**

Power $\Delta P \times \dfrac{F}{\rho \times 3600}$

<div align="center">Table (7.1) pumps cost</div>

| Equipment | $\Delta P, Kpa$ | $F, Kg/h$ | $\rho, Kg/m^3$ | Cost,$ |
|-----------|-----------------|-----------|----------------|--------|
| P901 | 307.847 | 643007.7408 | 656.8378938 | 8974.593 |
| P902 | 89.132 | 296305.3294 | 957.7974478 | 2137.266 |

**−Heat exchanger cost = $\$1030(area, m^2)^{0.6}$**

Aera $= \dfrac{Q}{h \times \Delta T_M \times 3600}$

$\Delta T_M = \dfrac{(T_2 - T_{*2}) - (T_1 - T_{*1})}{ln\left(\dfrac{T_2 - T_{*2}}{T_1 - T_{*1}}\right)} X$

<div align="center">Table (7.2) Heat exchanger cost costs</div>

| Equipment | Q,KJ/h | $\Delta T_M °C$ | h,KW/$m^2$.°C | Area, $m^2$ | Cost,$ |
|-----------|--------|-----------------|---------------|-------------|--------|
| E901 | 114767838.5 | 197.5 | .532 | 303.4163429 | 312518.8332 |
| E902 | 258116146.6 | 164.2 | .857 | 509.5170219 | 524802.5326 |
| E903 | 2960120.199 | 17.16 | .375 | 127.7786497 | 131612.0092 |
| E904 | 48907569.98 | 108.7 | .857 | 145.8354877 | 150210.5523 |
| E905 | 4661602.895 | 29.3 | .375 | 117.8511666 | 121386.7016 |

**-Vessel cost = $1000\$(V, m^3)^{0.6}$**

$= 1000\$(30, m^3)^{0.6} = 7696.13\$$

The function above calculates costs in year 2001. Updating these costs to year 2014 will be performed by using MARSHALL & SWIFT EQUIPMENT COST INDEX ,which is equal to 1.45 .

The modified costs are included in table below:

Table (7.3) The modified cost

| Equipment | Cost @ 2014 US($) |
|:---:|---:|
| P901 | 13013.16 |
| P902 | 3099.036 |
| E901 | 453152.3 |
| E902 | 760963.7 |
| E903 | 190837.4 |
| E904 | 217805.3 |
| E905 | 176010.7 |
| T901 | 169221.8 |
| T902 | 169221.8 |
| T903 | 169221.8 |
| R901 | 1086266 |
| V901 | 11159.39 |
| V902 | 11159.39 |
| V903 | 11159.39 |
| V904 | 11159.39 |
| Total | 3453450 |

## 7.2.2. Estimation of total capital investment (T.C.I):

T.C.I=Fixed Capital investment + Working Capital.

T.C.I=F.C.I+W.C

Fixed capital investment=direct cost + Indirect cost.

**Direct cost:**

Table (7.4) direct costs

| Component | Rationed to purchased equipment cost | Cost |
|---|---|---|
| Purchased equipment | 100 | 3453450 |
| Equipment installation | 0.5 | 1726725 |
| Instrumentation and control | 0.36 | 1243242 |
| Piping | 0.7 | 2417415 |
| Electrical system | 0.15 | 518017.5 |
| Building (including services) | 0.35 | 1208707.5 |
| Services facilities | 0.8 | 2762760 |
| Land | 0.08 | 276276 |
| Yard improvement | 0.18 | 621621 |
| Insulation | 0.09 | 310810.5 |
| Total | 4.21 | 11085575 |

**Indirect cost:**

Table (7.5) in direct costs

| Comp | Dependency |
|---|---|
| Engineering and supervision | 0.4 of purchased equipment |
| Legal expenses | 0.15 of direct cost |
| Construction and contractor fee | 0.05 of direct cost |
| Contingency | 0.08 of fixed cost |

F.C.I = Direct cost+ Indirect cost

F.C.I = 11085575+0.4×3453450+ (0.15+0.05) × 11085575 + 0.08× F.C.I

F.C.I = 15.96094565E6$

## 7.2.3. Estimation of working capital:

W.C =15% T.C.I

T.C.I = +15.96094565E6$W.C

T.C. I =15.96094565E6$+ 0.15×T.C.I

T.C.I =18.77758312E6$

W.C = 0.15×18.77758312E6= 2.816637468E6$

## 7.2.4. Estimation of total production cost (T.P.C):

T.P.C = Manufacturing cost + General expenses

Manufacturing cost = Variable cost + Fixed charges + Plant overhead

**Estimation of variable cost:**

Table (7.6) variable costs

| Component | Dependency of T.P.C |
|---|---|
| **Operating labor** | 0.15 |
| **Direct supervision and electrical labor** | 0.0225 |
| **Utility** | 0.15 |
| **Laboratory charges** | 0.015 |
| **Patent and royalty** | 0.15 |

**Estimation of fixed charges:**

Depreciation = 10% of fixed capital investment+ 3% of building value

$$= 0.1× 15.96094565E6 + 0.03× 1208707.5 = 1.63235579E6\$$$

Local taxes = 3% of fixed capital investment

$$= 0.03× 15.96094565E6 = 478828.3695\$$$

Property insurance =1% of fixed capital investment

$$= 0.01× 15.96094565E6 = 1.596094565E5\$$$

Fixed charges = Depreciation + Local taxes + Property insurance

$$= 2.27E6\$$$

**Estimation of plant overhead cost:**

Plant overhead cost = 118% of T.P.C

**Estimation of general expenses:**

Table (7.7) Estimation of general expenses costs

| Component | Dependencies of T.P.C |
|---|---|
| Administration | 0.05 |
| Distribution and marketing | 0.1 |
| Research and development | 0.04 |
| Total | 0.19 |

**T.P.C** = 2.27E6 (0.19+1.18+0.15+0.0225+0.15+0.015+0.15) of T.P.C

**T.P.C** = 4.15016276E8$

## 7.2.5. Estimation of total income:

The selling price of MTBE (product) = 335$/Kg

Total profit = income – T.P.C

=7016276$

Net profit = $(1\text{-}T_X)$ ×Total profit

$T_X$=40%

Net profit = (1- 0.4) × 7016276$ = 4209765.6$

## 7.2.6. Estimation of payback period (PBP):

$$\text{PBP} = \frac{\text{F.C.I}}{\text{Net profit}} = \frac{15.96094565E6}{4209765.6} = 3.7\text{year.}$$

## 7.2.7. Net present value (NPV):

i = 0.12

n (useful life) =10 years

$$\text{NPV} = \frac{Net\ profit((1+i)^n-1)}{i(1+i)^n} - TCI = \frac{4209765.6((1.12)^{10}-1)}{0.12(1.12)^{10}} - 18.77758312E6$$

= 5.0085314E6

## 7.2.8. Breakeven point:

TPC per tone=$\frac{415016276}{1E5}$= 4150.16276$/ton

Price of mtbe per tone =335$/tone

Fixed charges = 2.27E6$

No. of kilograms needed for abreak even point is given point by:

2.27E6 +4150.16276X= 335X

X=594.99 tone/year

## 7.2.9. Internal rate of return (IRR):

$$\textbf{IRR} = \frac{\text{Net profit}}{\textbf{\textit{F.C.I}}} = \frac{4209765.6}{15.96094565E6} = 0.27.$$