

COST ESTIMATION AND ECONOMICS

Given in the literature is the cost versus size Nomograph, from which the cost of Sulfuric Acid Plant within the capacity between 50 – 500 TPD can be calculated.

The cost for 500 TPD plant with Chemical Engineering Cost Index (CE) =130 (Basis = 1957 -59; CE = 100) is as follows:

$$\text{Cost for 500 TPD} = \text{Rs. } 5.25 \times 10^7 \text{ /-}$$

As we know that, from the relation,

$$C = [a \times S]^n$$

Where, ' C ' is the cost in Rupees
' S ' is the size of the plant in TPD
' a ' is a constant.
' n ' is the Exponential Factor

We can then write,

$$[C_1 / C_2] = [S_1 / S_2]^n$$

Now with

S_1	= 500 TPD
C_1	= Rs. 5.25×10^7 /-
n	= 0.65
S_2	= 1000 TPD
C_2	= To be found out for year 1971

Substituting in the above equation we have,

$$C_2 = \text{Rs. } 8, 23, 81, 330 \text{ /-}$$

Obtained from one of the Internet sites, that Chemical Engineering Plant Cost Index are given as:

Cost index in 1971 = 132

Cost index in 2002 = 402

Thus,

Present Cost of Plant = (Original Cost) x (Present Cost Index) / (Past Cost Index)
= (8,23,81,330 /-) x (402/132) = Rs. 254.8×10^6 /-

Capital Investment = Rs. 254.8×10^6 /-

ESTIMATION OF CAPITAL INVESTMENT COST:

DIRECT COSTS:

Material and labour involved in actual installation of complete facility (70-85% of fixed-capital investment)

a) Equipment + installation + instrumentation + piping + electrical + insulation + painting (50-60% of Fixed-capital investment)

a. Purchased equipment cost (PEC):

	RANGE	= 15-40% of Fixed-Capital Investment
Let Purchased Equipment Cost		= 20% of Fixed-Capital Investment
	PEC	= 20% of Rs. 254.8 x 10 ⁶ /-
		= Rs. 50.96 x 10 ⁶ /-

b. Installation, including insulation and painting (IC):

	RANGE	= 25-55% of Purchased Equipment Cost.
Let Installation Cost		= 40% of Purchased Equipment Cost
	IC	= 40% of Rs. 50.96 x 10 ⁶ /-
		= Rs. 20.384 x 10 ⁶

c. Instrumentation and controls, installed (ICC):

	RANGE	= 6-30% of Purchased Equipment Cost.
Let Instrumentation Cost		= 20% of Purchased Equipment Cost
	ICC	= 20% of x Rs. 50.96 x 10 ⁶ /-
		= Rs. 10.192 x 10 ⁶ /-

d. Piping Installed (PC):

	RANGE	= 10-80% of Purchased Equipment Cost
Let Piping Cost		= 45% of Purchased Equipment Cost
	PC	= 45% x Rs. 50.96 x 10 ⁶ /-
		= Rs. 22.932 x 10 ⁶ /-

e. Electrical, installed (EC):

	RANGE	= 10-40% of Purchased Equipment Cost
Let Electrical cost		= 25% of Purchased Equipment Cost
	EC	= 25% x Rs. 50.96 x 10 ⁶ /-
		= Rs. 12.74 x 10 ⁶ /-

Buildings, process and Auxiliary (BPC):

	RANGE	= 10-70% of Purchased Equipment Cost
Let Buildings, process and auxiliary cost		= 50% of Purchased Equipment Cost
	BPC	= 50% x Rs. 50.96 x 10 ⁶ /-
		= Rs. 25.48 x 10 ⁶ /-

Service facilities and yard improvements (SF & YIC):

	RANGE	= 40-90% of Purchased Equipment Cost
Let Facilities and yard improvement cost		= 70% of Purchased Equipment Cost
	SF & YIC	= 70% x Rs. 50.96 x 10 ⁶ /-
		= Rs. 35.67 x 10 ⁶ /-

Land (LC):

	RANGE	= 4-8% of Purchased Equipment Cost
Let the cost of land		= 6 % of Purchased Equipment Cost
	LC	= 6 % x Rs. 50.96 x 10 ⁶ /-
		= Rs. 3.0576 x 10 ⁶ /-

Thus, Total Direct cost = Rs. 181.4156 x 10⁶ /-

Indirect Costs (IC):

Expenses which are not directly involved with material and labour of actual installation of complete facility (15-30% of Fixed-capital investment)

1. Engineering and Supervision (E & SC):

	RANGE	= 5-30% of Direct costs
Let the cost of engineering and supervision		= 20% of Direct costs
	E & SC	= 20% x Rs. 181.4156 x 10 ⁶ /-
		= Rs. 36.283 x 10 ⁶ /-

2. Construction Expense and Contractor's fee (CE & CC):

	RANGE	= 6-30% of Direct costs
Let construction expense & contractor's fee		= 20% of Direct costs
	CE & CC	= 20% x Rs. 181.4156 x 10 ⁶ /-
		= Rs. 36.283 x 10 ⁶ /-

3. Contingency (CC):

	RANGE	= 5-15% of Fixed-Capital Investment
Let the contingency cost		= 7% of Fixed-Capital Investment
	CC	= 7% x Rs. 254.8 x 10 ⁶ /-
		= Rs. 18.14 x 10 ⁶ /-

Thus, Indirect Costs = Rs. 90.706 x 10⁶ /-

Fixed Capital Investment (FCI):

Fixed Capital Investment		= Direct Costs + Indirect Costs
		= Rs 272.1216 x 10 ⁶ /-

Working Capital (WC):

Let the Working Capital RANGE = (10-20% of Total Capital Investment)
 = 20 % of Total Capital Investment

Total Capital Investment (TCI):

Total capital investment = Fixed-Capital Investment + Working Capital

$$\begin{aligned} T C I &= F C I + 0.2 \times T C I \\ T C I &= Rs [272.1216 \times 10^6 / -] / 0.8 \\ &= Rs 340.152 \times 10^6 / - \end{aligned}$$

ESTIMATION OF TOTAL PRODUCT COST:**Manufacturing Cost**

Manufacturing cost is the sum of Direct Production Cost, Fixed Charges and Plant Overhead Cost.

Fixed Charges (FC):

RANGE = 10-20% Total Product Cost

Depreciation (DC):

RANGE = Depends on life period, Salvage Value and method of calculation-about 10% of FCI for Machinery & Equipment, 2-3% for Building Value for Buildings.

Let us consider Depreciation Cost = 10% of Fixed Capital Investment for Machinery & Equipment and 2.5 % for Building Value for Buildings.

DC = $27.21 \times 10^6 + 0.637 \times 10^6$
 = Rs. $27.847 \times 10^6 / -$

Local Taxes (LT):

Let the local taxes RANGE = 1-4% of Fixed Capital Investment
 = 2% of Fixed Capital Investment
 LT = $2\% \times Rs. 272.1216 \times 10^6 / -$
 = Rs. $5.4424 \times 10^6 / -$

Insurance (InC):

Let the Insurance Cost RANGE = 0.4-1% of Fixed Capital Investment
 = 0.6% of Fixed Capital Investment
 InC = $0.6\% \times Rs. 272.1216 \times 10^6 / -$
 = Rs. $1.6327 \times 10^6 / -$

Then, Total Fixed Charges = Rs. $34.9224 \times 10^6 / -$

Fixed Charges (FC):

	RANGE	= 10-20% of Total Product Cost
Let the fixed charges		= 15% of Total Product Cost
Then Total Product Cost		= Rs. 232.81 x 10 ⁶ /-

**Direct Production Cost:
Raw Materials (RMC):**

	RANGE	= 10-50% of Total Product Cost
Let the cost of raw materials		= 40% of Total Product Cost
	RMC	= 40% x Rs. 232.81 x 10 ⁶ /-
		= Rs. 93.1252 x 10 ⁶ /-

Operating Labour (OLC):

	RANGE	= 10-20% of Total Product Cost
Let the cost of operating labour		= 12% of Total Product Cost
	OLC	= 12% x Rs. 232.81 x 10 ⁶ /-
		= Rs. 27.937 x 10 ⁶ /-

Direct Supervisory and Clerical Labour (DS & CLC):

	RANGE	= 10-25% of Operating Labour
Let the above mentioned cost		= 15% of Operating Labour
	DS & CLC	= 15% x Rs. 27.937 x 10 ⁶ /-
		= Rs. 4.1905 x 10 ⁶ /-

Utilities (UC):

	RANGE	= 10-20% of Total Product Cost
Let the Cost of Utilities		= 14% of Total Product Cost
	UC	= 14% x Rs. 232.81 x 10 ⁶ /-
		= Rs. 32.6 x 10 ⁶ /-

Maintenance and Repairs (M & RC):

	RANGE	= 2-10% of Fixed Capital Investment
Let the Maintenance and Repair Cost		= 5% of Fixed Capital Investment
	M & RC	= 5% x Rs. 272.1216 x 10 ⁶ /-
		= Rs. 13.6061 x 10 ⁶ /-

Operating Supplies (OSC):

	RANGE	= 10-20% of Maintenance & Repairs
Let the Cost of Operating Supplies		= 13% of Maintenance & Repairs
	OSC	= 13% x Rs. 13.6061 x 10 ⁶ /-
		= Rs. 1.7687 x 10 ⁶ /-

Laboratory Charges (LCC):

	RANGE	= 10-20% of Operating Labour Charges
Let the Laboratory charges		= 15% of Operating Labour Charges
	LCC	= 15% x Rs. 27.937 x 10 ⁶ /-
		= Rs. 4.19055 x 10 ⁶ /-

Patent and Royalties (P & RC):

	RANGE	= 0-6% of Total Product Cost
Let the cost of Patent and royalties	P & RC	= 3% of Total Product Cost = 3% x Rs. 232.81 x 10 ⁶ /- = Rs. 6.9843 x 10 ⁶ /-

Thus, Total Direct Production Cost = Rs. 184.396 x 10⁶ /-

Plant OverHead Cost (POHC):

	RANGE	= 50-70% of the Operating labour, supervision, maintenance or 5-15% of total product cost; includes for the following: general plant upkeep and overhead, payroll overhead, packaging, medical services, safety and protection, restaurants, recreation, salvage, laboratories, and storage facilities.
Let the plant overhead cost	POHC	= 10% Total Product Cost = 10% of Rs. 232.81 x 10 ⁶ /- = Rs. 23.281 x 10 ⁶ /-

Thus,

Manufacturing Cost = Direct Production cost + Fixed charges + Plant Overhead cost
= Rs. [184.396 x 10⁶ /- + 34.9224 x 10⁶ /- + 23.281 x 10⁶ /-]
= Rs 242.5994 x 10⁶ /-

General Expenses

General Expenses is the sum of Administrative Costs, Distribution and Selling Cost and Research and Development Costs.

Administrative costs (AC):

	RANGE	= 2-6% of Total Product Cost
Let the Administrative costs	AC	= 4% of Total Product Cost = 4% x Rs. 232.81 x 10 ⁶ /- = Rs. 9.3124 x 10 ⁶ /-

Distribution and Selling Costs (D & SC):

	RANGE	= 2-20% of Total Product Cost which includes costs for sales offices, salesmen, shipping, and advertising.
Let the Distribution and selling costs	D & SC	= 15% of Total Product Cost = 18% x Rs. 232.81 x 10 ⁶ /- = Rs. 41.9058 x 10 ⁶ /-

Research and Development costs (R & DC):

$$\begin{aligned} \text{RANGE} &= 5\% \text{ of Total Product Cost} \\ \text{Let the Research and development costs} &= 5\% \text{ of Total Product Cost} \\ \text{R \& DC} &= 5\% \times \text{Rs. } 232.81 \times 10^6 \text{ /-} \\ &= \text{Rs. } 11.64 \times 10^6 \text{ /-} \end{aligned}$$

Financing (interest) (FC):

$$\begin{aligned} \text{RANGE} &= 0\text{-}10\% \text{ of Total Capital Investment} \\ \text{Let the interest} &= 6\% \text{ of Total Capital Investment} \\ \text{FC} &= 6\% \times \text{Rs } 340.152 \times 10^6 \text{ /-} \\ &= \text{Rs. } 20.409 \times 10^6 \text{ /-} \end{aligned}$$

$$\begin{aligned} \text{Thus,} \\ \text{Total General Expenses} &= \text{Rs } 83.2672 \times 10^6 \text{ /-} \end{aligned}$$

$$\begin{aligned} \text{Total Product cost} &= \text{Manufacturing Cost} + \text{Total General Expenses} \\ &= \text{Rs } 242.5994 \times 10^6 \text{ /-} + \text{Rs } 83.2672 \times 10^6 \text{ /-} \\ &= \text{Rs. } 325.8653 \times 10^6 \text{ /-} \end{aligned}$$

Gross Earnings/Income:

Market Selling Price of Sulfuric Acid per ton = US\$ 30

Conversion: 1 USD = Rs. 48 /-

$$\begin{aligned} \text{Total Income} &= \text{Selling price} \times \text{Quantity of product manufactured} \\ &= 30 \times 48 \times 1000 \text{ (T/day)} \times 320 \text{ (days/year)} \\ &= \text{Rs. } 460.8 \times 10^6 \text{ /-} \end{aligned}$$

$$\begin{aligned} \text{Gross Income} &= \text{Total Income} - \text{Total Product Cost} \\ &= \text{Rs. } 460.8 \times 10^6 \text{ /-} - \text{Rs. } 325.8653 \times 10^6 \text{ /-} \\ &= \text{Rs. } 134.94 \times 10^6 \text{ /-} \end{aligned}$$

As available in the literature that the Tax rate is generally taken as 45%

$$\begin{aligned} \text{Taxes} &= 45\% \text{ of Gross Income} \\ &= 45\% \times 134.94 \times 10^6 \text{ /-} \\ &= 60.7230 \times 10^6 \text{ /-} \end{aligned}$$

$$\begin{aligned} \text{Net Profit} &= [\text{Gross income} - \text{Taxes}] \\ &= \text{Rs. } [134.94 \times 10^6 \text{ /-} - 60.7230 \times 10^6 \text{ /-}] \\ &= \text{Rs. } 74.217 \times 10^6 \text{ /-} \end{aligned}$$

Rate of Return:

$$\begin{aligned} \text{Rate of Return} &= [\text{Net profit} \times 100] / \text{Total Capital Investment} \\ &= \text{Rs. } [\{ 74.217 \times 10^6 \text{ /-} \times 100 \} / \text{Rs } 340.152 \times 10^6 \text{ /-}] \\ &= 21.8 \% \end{aligned}$$

Break-Even Analysis:

Data that are available for the determination of Break Even Analysis are:

Annual Direct Production Cost	= Rs 184.396 x 10 ⁶ /-
Annual General Expenses & Over Head Expenses	= Rs. 106.547 x 10 ⁶ /-
Total Annual sales	= Rs. 460.8 x 10 ⁶ /-

$$\begin{aligned} \text{Direct Production Cost per Ton of Sulfuric Acid} &= 184.39 \times 10^6 \times 1440 / 460.8 \times 10^6 \\ &= \text{Rs. } 576.23 / \text{Ton} \end{aligned}$$

Let 'B' TPA be the Break-Even Production Rate.

Break-Even Point Production is given by

$$(106.547 \times 10^6) + (576.23 \times B) = (1440 \times B)$$

Solving for B, we have,

$$\begin{aligned} B &= 123352 \text{ Tons/yr} \\ &= 385 \text{ TPD} \end{aligned}$$

Hence, the Break-Even Point Production Rate is 385 TPD and this value is 38.5% of the designed Sulfuric Plant Capacity.

Thus the Economic Aspects of 1000 TPD Sulfuric Acid Plant is detailed out.