

Analysis of Cost Estimation

Book : *Plant Design and Economics for Chemical Engineers*, M.S. Peters and K. D. Timmerhaus

Estimation of Revenue

- Revenue generated from the plant comes from the sale of the product or products produced by the plant

$$\text{Annual sales revenue (Rs/yr)} = \sum (\text{Sales of product, kg/yr}) (\text{Product sales price, Rs/yr})$$

- Usually production capacity of the first year is 50% of the design capacity
- In the later years, the design plant capacity is used as the plant capacity
- Operating time for a plant is taken as 300 to 330 days per year
- Product prices are often determined from market study

Estimation of Total Product Cost

***Total Product Cost = Manufacturing Cost (operating/production cost)
+ General Expenses***

Manufacturing Cost = Variable Cost + Fixed Cost + Overhead Costs

- Total product cost is often calculated on
 - (a) a daily basis
 - (b) unit of production basis
 - (c) annual basis
- Annual basis is often the best choice for economic analysis
- Total Product Cost can be estimated from data from similar projects, with adjustments for increased cost due to inflation, differences in plant site and geographic location
- In absence of such data, total product cost is determined by considering each component

Manufacturing Cost

- All expenses directly connected with manufacturing operation or the physical equipment of a process plant itself

(a) Variable costs

- (1) Raw material – Materials required to make the final product; **raw material costs** are obtained from **direct price quotations from suppliers or market prices**; material balance gives us raw material required per unit time or per unit product

Raw materials account for 10-60% of the total product cost

- (2) Operating Labour: Includes skilled and unskilled labour; **hourly wage rates for these are different in different industries and different locations**; quantity of operating labour requirement is obtained from similar industry data;

The relationship between labour requirement and production rate has a 0.2-0.25 power of the capacity ratio

(a) The work required to be done may be analysed from the flowsheet. Operating labour may be estimated from the type of work to be performed to the typical labour requirement for different processes

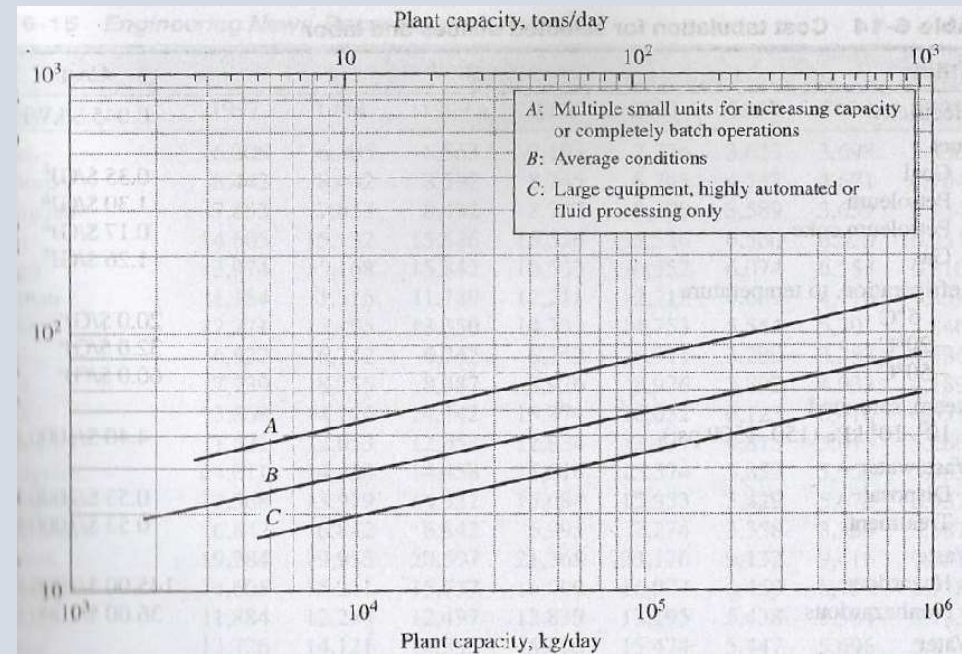
Table 6-13 Typical labor requirements for process equipment[†]

| Type of equipment | Workers/unit/shift |
|--|--------------------|
| Blowers and compressors | 0.1–0.2 |
| Centrifugal separator | 0.25–0.50 |
| Crystallizer, mechanical | 0.16 |
| Dryer, rotary | 0.5 |
| Dryer, spray | 1.0 |
| Dryer, tray | 0.5 |
| Evaporator | 0.25 |
| Filter, vacuum | 0.125–0.25 |
| Filter, plate and frame | 1.0 |
| Filter, rotary and belt | 0.1 |
| Heat exchangers | 0.1 |
| Process vessels, towers (including auxiliary pumps and exchangers) | 0.2–0.5 |
| Reactor, batch | 1.0 |
| Reactor, continuous | 0.5 |

(b) Another way of estimating the labour requirement is based on adding the main processing steps on the flowsheet

- A process step is any unit operation or process
- Knowing the plant capacity and type of plant, the no. of employee hours/day/processing step is determined
- This is multiplied by the number of processing steps to get no. of employee hours/day

Operating labour, employee-hour/(day)(processing unit)



(c) As a rule of thumb, the labour requirements for a **fluid processing plant** is in the range of **0.33-2 employee hours per 1000 kg of product**, for a **solid - fluid plant** is in the range of **2-4 employee hours per 1000 kg of product**, and for a **solid processing plant** it is in the range of **4-8 employee hours per 1000 kg of product**

(3) Operating Supervision and Clerical Assistance:

Depends on total number of operating labour, complexity of the process operation and product quality standard
 Averages about 15% of the cost for operating labour

(4) Utilities: Utility requirements are determined from mass and energy balances

Cost of utilities (electricity, steam, process and cooling water) depend on **amounts required, plant location and source**

Utilities may be purchased or generated in house in the plant

Utility costs for ordinary chemical processes amounts to 10-20% of total product cost

(5) Maintenance and Repairs: In process industries, total plant cost per year for maintenance and repairs range from 2-10% of FCI

(6) Operating supplies: Consumable items such as charts, lubricants, test chemicals fall under this category

Annual costs amounts to 15% of the total cost for maintenance and repairs

(7) Laboratory charges: Cost of laboratory tests for control of operations and quality control fall under this category

This is about 10-20% of operating labour

(8) Patents and Royalties: If the plant uses patents owned by others, it is necessary to pay for patent rights and royalty

This is about 0-6% of total product cost

(9) Catalysts and solvents: Costs for these are based on actual requirements and prices

(b) Fixed charges

These are **expenses independent of production rate**; fixed costs amount to about 10-20% of total product cost

- (1) Depreciation – Equipment, buildings and other material objects of a manufacturing plant require an initial investment, and this is charged as a manufacturing expense

Depreciation changes from year to year or might use a constant yearly depreciation

- (2) Financing : Interest is the compensation paid for the use of borrowed capital

A fixed rate of interest is established when money is borrowed and this is a definite cost

Annual interest rate amounts to 5-10% of the total value of borrowed capital

- (3) Local taxes: Local property taxes depend on the locality of the plant and regional law

Annual property tax for plants in highly populated area is ~ 2-4% of FCI and in less populated areas is 1-2% of FCI

- (4) Property Insurance: Depends on type of process and extent of available protection facilities

Amounts to 1% of FCI per year

- (5) Rent: annual costs for rented land and buildings amounts to 8-12% of the value of the rented property

(c) Overhead charges

These are expenses for hospital, medical services, plant maintenance, safety services, payroll overhead including provident fund, LTC, retirement plans, medical and life insurance, control laboratories

This is about 50-70% of the total expenses for operating labour, supervision and maintenance for chemical plants

General Expenses

- (1) Administrative Costs – Costs connected to executive and administration activities (salaries, wages for administrators, secretaries, accountants, engineering and legal staff, cost of office supplies and equipment)

Administrative costs may be approximated as 15-25% of operating labour

- (2) Distribution and Marketing Costs : Costs depend on selling and distributing products (wages, salaries and supplies of sales office, travelling expenses of sales personnel, shipping expenses, advertising expenses, technical sales service)

These costs for most chemical plants are in the range of 2-20% of total product cost

Costs are low for bulk chemical plants while more for new products, small production rates

- (3) Research and Development Costs: Costs include salaries, wages of personnel connected to R & D, fixed and operating costs of all machinery and equipment involved, costs of materials and supplies, consultant's fees

These costs for most chemical plants are in the range of 2-5% of every sales dollar or 5% of total product cost

Gross Profit, Net Profit and Cash Flow

- The gross profit (or gross earnings) is the total sales revenue (s_j) minus total product cost (c_{oj})

$$g_j = s_j - c_{oj}$$

g_j : gross profit without including depreciation in year j

$$G_j = s_j - c_{oj} - d_j$$

G_j : gross profit including depreciation in year j

**At the *break-even point*,
the total product cost
equals the total income
(total sales revenue)**

- Net profit (or net earnings) is the amount of the profit retained after paying income taxes

$$N_{pj} = G_j(1 - \varphi)$$

φ : rate of income tax

N_{pj} : net profit in year j

- The cash flow resulting from process operations is

$$A_j = N_{pj} + d_j$$