

# Analysis of Cost Estimation

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

# Cash flow for industrial operations

**Cash flow** shows the **flow of funds for an overall industrial operation** based on a corporate treasury serving as source and reservoir for capital

**Input to the capital reservoir is in the form of (1) loans, (2) stock issues, (3) bond sales and (4) cash flow from project operations**

**Output from the capital reservoir include (1) capital investment in projects, (2) dividends to stock holders, (3) repayment of debt, (4) other investments**

**Total capital investment = Fixed capital investment (manufacturing and non-manufacturing) + Working capital**

Fixed capital investment is for physical equipment, facilities required while Working capital is for paying salaries, raw materials etc

**Cash flow for Fixed capital investment is usually spread over the entire construction period.**

**Since income from sales and costs of operation may occur on an irregular basis, a reservoir of working capital must be available at all times**

**Working capital funds are maintained at an acceptable level in the operation phase of the project for efficient operation**

**Total income from sales coming in as cash flow =  $s_j$**

**Annual cost for operation (without depreciation) =  $c_{oj}$**

**Gross profit before depreciation charges =  $(s_j - c_{oj})$**

**Depreciation is charged as a cost before calculation of income tax =  $(s_j - c_{oj} - d_j)$**

**Income tax charged =  $(s_j - c_{oj} - d_j)\phi$**

**Net profit =  $(s_j - c_{oj} - d_j)(1 - \phi)$**

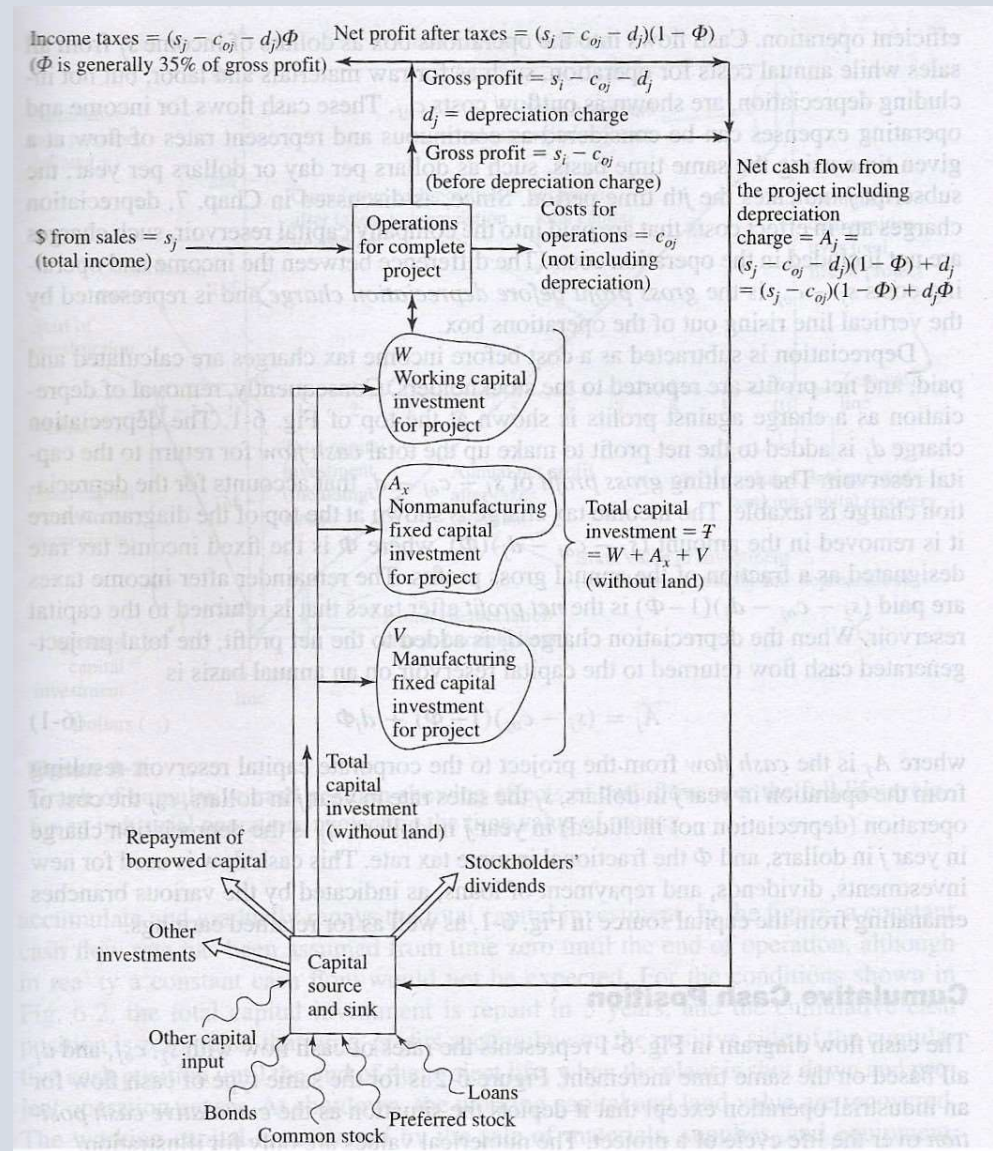
**Depreciation is added to the net profit to form the total cash flow for return to the capital reservoir**

$$A_j = (s_j - c_{oj})(1 - \phi) + d_j\phi$$

**[cash flow from project to reservoir]**

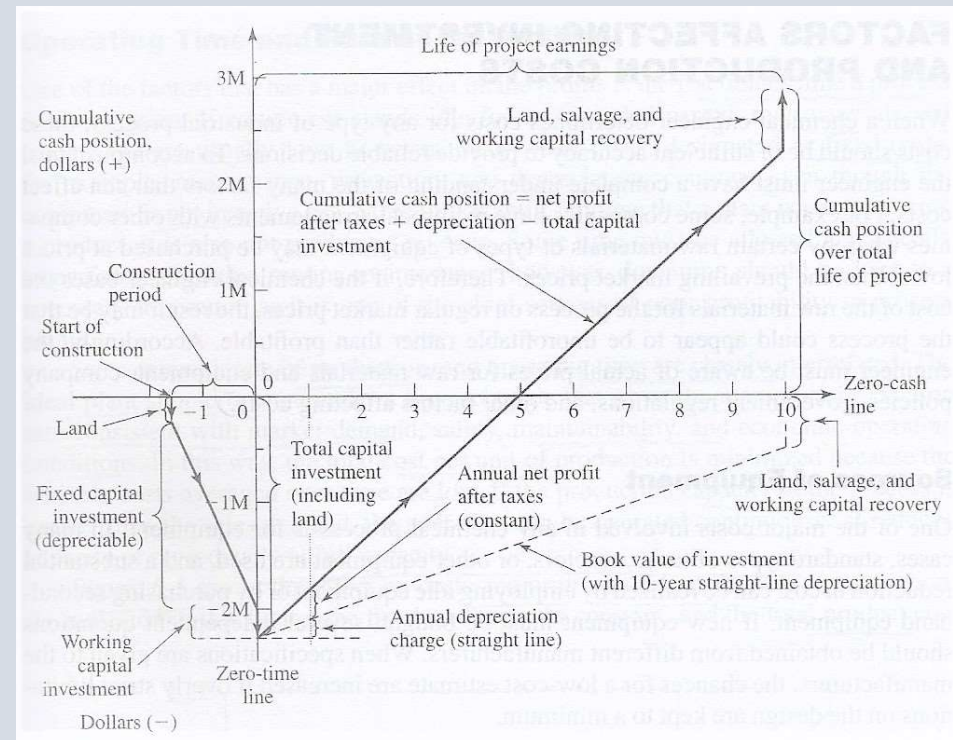
The diagram shows the steady-state situation for cash flow with  $s_j$ ,  $c_{oj}$ ,  $d_j$  all based on the same time increment (jth time period)

Cash flows are continuous



# Cumulative cash position

- The **zero point on the time co-ordinate** represents the **time at which the plant has been completely constructed** and is ready for operation.
- The **total capital investment** at the zero point in time includes **land value, fixed-capital investment, and working capital**.
- The cash position is negative by an amount equivalent to the total capital investment at zero time.
- For ideal situations, **revenues come in from the operation as soon as time is positive**.
- Cash flow to the company, in the form of **net profits after taxes and depreciation charges, starts to accumulate and gradually pays off the full capital investment**. (Here a constant cash flow is assumed though may not be true in real situations)
- In the fig, the **full capital investment is paid off in five years** and cumulative cash position is zero.
- After that time, **profits accumulate on the positive side of the cumulative cash position** until the end of the project life when the project theoretically is shut down and the operation ceases.
- At shutdown, the land value and working capital can be recovered by sale of materials, supplies, equipment



Cash flow of an industrial operation

It is the cumulative cash position over the life cycle of a project (10 years)

# Factors affecting investments and production costs

- **Sources of equipment:**

- Cost can be reduced by using (1) equipment of standard size, (2) reusing idle equipment in the plant, (3) purchasing second hand equipment
- Custom made equipment with rigid specifications are more expensive
- Tenders, quotations are invited from manufacturers to compare prices of equipment

- **Price fluctuations:**

- The chemical engineer must be up-to-date on price and wage fluctuations
- The govt norms regarding present prices and wages for different types of industries must be considered

- **Company policies:**

- Policies of individual companies have a direct effect on costs. For example, some concerns have particularly strict safety regulations and these must be met in every detail
- Companies also vary in terms of labour policies (overtime charges, type of work done) , accounting procedures, depreciation calculations etc

- **Government policies:**

- The national government has many regulations and restrictions which have a direct effect on industrial costs. Eg., import and export tariff regulations, restrictions on permissible depreciation rates, income-tax rates, environmental and safety regulations.



- **Operating Time and Rate of Production:**

- One of the factors that has an important effect on the costs is the fraction of the **total available time the process is in operation**.
- When equipment stands idle for an extended period of time, the raw material and labour costs are low but costs, such as maintenance, protection, and depreciation continue
- **Anytime the plant is not producing a product, it is also not generating revenue.** Downtime should be kept to minimum.
- Operating time, rate of production, and sales demand are closely interrelated.
- The ideal plant should operate under a time schedule which gives the **maximum production rate while maintaining economic operating methods**.
- This way, the total cost per unit of production is kept near a minimum
- If the production capacity of the process is greater than the sales demand, the operation can be carried on at reduced capacity or periodically at full capacity.

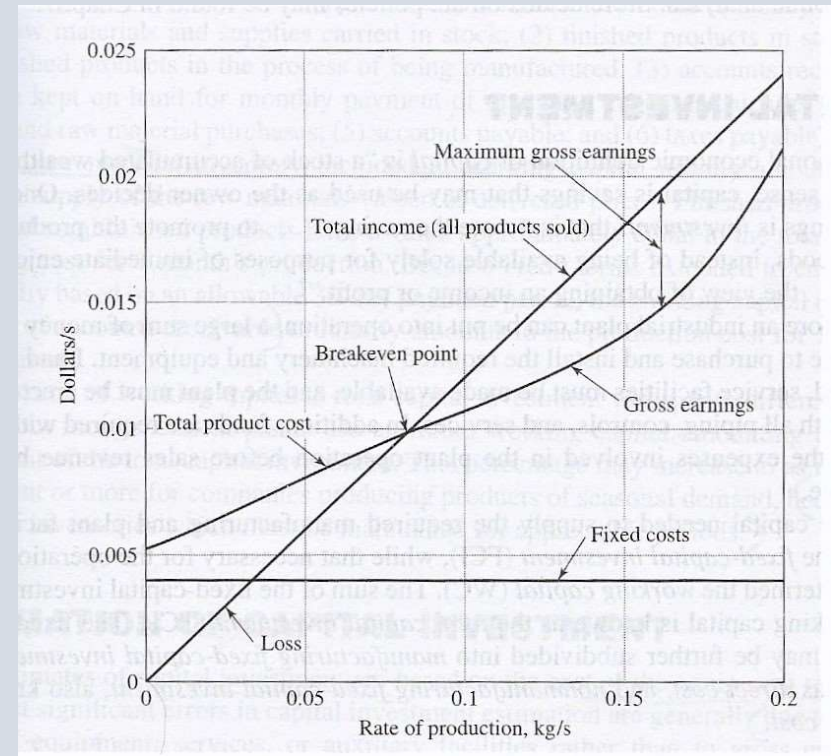


Figure shows the effect on costs and profits when the rate of production varies.

The fixed costs remain constant and the total product cost increases as the rate of production increases. **The point where the total product cost equals the total income is known as the *break-even point*.** Under the conditions shown in Fig., an ideal production rate for this chemical processing plant would be approximately 0.165 kg/s

# Analysis of Cost Estimation

## Capital Costs (Investment)

- Fixed capital
  - Manufacturing (Direct)
  - Non-manufacturing (Indirect)
- Working capital

## Product Costs

- Manufacturing costs
  - Variable costs
  - Fixed costs
  - Overhead costs
- General expenses
  - Administrative expenses
  - Distribution and marketing costs
  - Research and development

Capital needed to supply the necessary plant and manufacturing facilities is called the ***fixed-capital investment***  
Capital that necessary for the operation of the plant is termed the ***working capital***

The sum of the fixed-capital investment and the working capital is known as the ***total capital investment***

The fixed-capital investment may be further subdivided into

***manufacturing fixed-capital investment (also called direct cost)***

***non-manufacturing fixed-capital investment (also called indirect cost)***

## Types of cost estimates

- An estimate for capital investment for a process may vary from predesign estimate based on limited information to detailed estimate prepared with complete drawings and specifications

<b>Name</b>	<b>Accuracy</b>	<b>Application</b>	<b>Nature</b>
<b>Order of magnitude estimate</b>	<b>-40 to +40%</b>	<b>Screen investments</b>	<b>Predesign</b>
<b>Study estimate</b>	<b>-30 to +30%</b>	<b>Finalize major choices</b>	<b>Predesign</b>
<b>Preliminary</b>	<b>-20 to +20%</b>	<b>Budget authorization</b>	<b>Predesign</b>
<b>Definitive</b>	<b>-10 to +10%</b>	<b>Project control</b>	<b>Design</b>
<b>Detailed</b>	<b>-5 to +5%</b>	<b>Contracting</b>	<b>Design</b>

- As the estimate accuracy increases, so does the cost of obtaining the estimate for a project
- Predesign estimates provides a basis for requesting and obtaining a sanctioned amount from the company management
- Firm estimates calculated later may indicate that the project will cost more or less than the previously sanctioned amount
- Management is the requested for the variance (positive or negative)



# Fixed Capital Investment

Manufacturing fixed capital (Direct Costs)	% of FCI
<p><b><i>Purchased equipment</i></b>            All equipment listed on a complete flow sheet; Spare parts; Surplus equipment,; Inflation cost allowance; Freight charges; Taxes, insurance, duties;</p>	<b>15-40</b>
<p><b><i>Purchased-equipment installation</i></b>            Installation of all equipment listed on complete flow sheet; Structural supports, equipment insulation, paint</p>	<b>6-14</b>
<p><b><i>Instrumentation and controls</i></b>            Purchase, installation, calibration, computer control with supporting software</p>	<b>2-12</b>
<p><b><i>Piping</i></b>            Process of suitable material; Pipe hangers, fittings, valves; Insulation-piping,</p>	<b>4-17</b>
<p><b><i>Electrical equipment and materials</i></b>            Electrical equipment -switches, motors, conduit, wire, fittings, feeders, grounding, instrument and control wiring; lighting, panels; electrical materials and labour</p>	<b>2-10</b>
<p><b><i>Buildings (including services)</i></b>            Process buildings (substructures, superstructures, platforms, supports, stairways, ladders, access ways, cranes, monorails, hoists, elevators); Auxiliary buildings (administration and office, medical or dispensary, cafeteria, garage, product warehouse, parts warehouse, guard and safety, fire station, change house, personnel building, shipping office and platform, research laboratory, control laboratory)            Maintenance shops (electric, piping, sheet metal, machine, welding, carpentry, instrument); Building service (plumbing, heating, ventilation, dust collection, air conditioning, building lighting, elevators, escalators, telephones, painting, sprinkler systems, fire alarm)</p>	<b>2-18</b>

Manufacturing fixed capital (Direct Costs)	% of FCI
<p><b><i>Yard improvements</i></b> Site development (site clearing, roads, walkways, railroads, fences, parking areas, landscaping)</p>	2-5
<p><b><i>Service facilities</i></b> Utilities (steam, water, power, refrigeration, compressed air, fuel, waste disposal); Facilities (boiler plant incinerator, wells, river intake, water treatment, cooling towers, water storage, electric substation, refrigeration plant, air plant, fuel storage, waste disposal plant); Non-process equipment (office furniture and equipment, cafeteria equipment, safety and medical equipment, fire extinguishers, hoses, fire engines); Distribution and packaging raw-material and product storage and handling equipment, product packaging equipment, blending facilities)</p>	8-30
<p><b><i>Land</i></b> Surveys and fees; Property cost</p>	1-2
Non-manufacturing fixed capital (Indirect Costs)	% of FCI
<p><b><i>Engineering and supervision</i></b> Engineering costs-administrative, process, design and general engineering, computer graphics, cost engineering, procuring, communications, scale models, consultant fees, travel; Engineering supervision and inspection</p>	4-20
<p><b><i>Construction expenses</i></b> Construction, operation and maintenance of temporary facilities, offices, roads, parking lots, railroads, electrical, piping, communications, fencing; Construction tools and equipment; Construction supervision, Warehouse personnel and expense, guards, Safety, medical, Taxes, insurance, interest</p>	4-17
<p><b><i>Legal expenses</i></b></p>	1-3
<p><b><i>Contractor's fee</i></b></p>	2-6
<p><b><i>Contingency</i></b></p>	5-15

# Working Capital Investment

**Raw materials and supplies** - Includes one month's supply of raw material

**Finished products in stock and semi-finished products in the process of being manufactured** – Stock has value equal to total manufacturing cost for one month production

**Accounts receivable** – credit facility given to dealers and distributors (30 day credit, money comes back from 31<sup>st</sup> day)

**Cash in hand** – for monthly payment of operating expenses such as salaries, wages and raw material purchases, equipment repair

**Accounts payable** – money owed by company to its creditors

**Taxes payable** – tax to be paid before hand and later adjusted as per sales

*For most chemical plants, the **initial working capital amounts to 10-20% of total capital investment***

*This is about 50% for companies producing products with seasonal demand as large inventories need to be maintained*