

**Al-Mustaqbal University College  
Chem. Eng. Petroleum Industries  
Dept.**

**Chem. Eng. Economics  
4<sup>th</sup> Stage**

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**Lecture 7**

## Estimation of Production Costs

The third major component of an economic analysis is the total of all costs of operating the plant, selling the products, recovering the capital investment, and contributing to corporate functions such as management and research and development. These costs usually are combined under the general heading of **total product cost**. The latter, in turn, is generally divided into two categories: **manufacturing costs** and **general expenses**. Manufacturing costs are also referred to as **operating or production costs**. Accuracy is as important in estimating total product cost as it is in estimating capital investment costs. The most important contribution to accuracy is to include all the costs associated with making and selling the product. Figure 6-7 displays a suggested checklist of all the costs involved in chemical processing operations to calculate the total product cost. The required user inputs include fixed-capital investment, annual amounts and unit prices of raw materials, operating labor, utilities, catalysts, and solvents.

### Manufacturing Costs

All expenses directly connected with the manufacturing operation or the physical equipment of a process plant itself are included in the manufacturing costs. These expenses, as considered here, are divided into three classifications: (1) **variable production costs**

(2) **fixed charges**

(3) **plant overhead costs**



Raw materials	
Operating labor	
Operating supervision	
Utilities	
Electricity	
Fuel	
Refrigeration	
Steam	
Waste treatment and disposal	
Water, process	
Water, cooling	
Maintenance and repairs	
Operating supplies	
Laboratory charges	
Royalties (if not on lump-sum basis)	
Catalysts and solvents	
	Subtotal: Variable production costs
Depreciation	
Taxes (property)	
Financing (interest)	
Insurance	
Rent	
	Subtotal: Fixed charges
Medical	
Safety and protection	
General plant overhead	
Payroll overhead	
Packaging	
Restaurant	
Recreation	
Salvage	
Control laboratories	
Plant superintendence	
Storage facilities	
	Subtotal: Plant overhead costs
	Total of above = Manufacturing costs
Executive salaries	
Clerical wages	
Engineering	
Legal costs	
Office maintenance	
Communications	
	Subtotal: Administrative expenses
Sales offices	
Sales personnel expenses	
Shipping	
Advertising	
Technical sales service	
	Subtotal: Distribution and marketing expenses
Research and development	
	Total of administrative, distribution and marketing, R&D = General expenses
	Total of all above = Total product cost



**Figure 6-7**  
Costs involved in total product cost for a typical chemical process plant

**1) Variable production costs** include expenses directly associated with the manufacturing operation. This type of cost involves expenditures (expenses) for raw materials (including transportation, unloading, etc.), direct operating labor, supervisory and clerical labor (office) directly applied to the manufacturing operation, utilities, plant maintenance and repairs, operating supplies, laboratory supplies, royalties (money paid for a patent), catalysts, and solvents. These costs are incurred for the most part only **when the plant operates**, hence the term variable costs.

**Raw Materials** in the chemical industry, one of the major costs in a production operation is for the raw materials used in the process. The category raw materials refer in general to those materials that are directly consumed in making the final products; this includes chemical reactants and constituents and additives included in the product. Materials necessary to carry out process operations but which do not become part of the final product, such as catalysts and solvents, are listed separately.

**Direct price quotations from prospective suppliers** are desirable for the raw materials. When these are not available, **published prices** are used. For preliminary cost analyses, market prices are often used for estimating raw material costs. Prices for many commercial chemicals are published weekly in the Chemical Market Reporter. Prices for some commodity chemicals, such as gases as hydrogen, oxygen, and nitrogen, are published occasionally in Chemical and Engineering News and Chemical Week.

Chemical prices are usually quoted on an f.o.b. (free-on-board) basis. Any transportation charges should be included in the raw material costs when available; they may be estimated as 10 percent of the raw material cost, but are highly variable.

The amounts of raw materials that must be supplied per unit of time or per unit of product are determined from process **material balances**. In chemical plants, raw material costs are usually in the range of **10 to 60 percent of the total product cost**.

**Operating Labor** In general, operating labor may be divided into skilled and unskilled labor. Hourly wage rates for operating labor in different industries at various locations can be obtained from the U.S. Bureau of Labor publication

entitled Monthly Labor Review. For chemical processes, **operating labor** usually amounts **to about 10 to 20 percent of the total product cost**.

In preliminary cost analyses, the quantity of operating labor can often be estimated either from company experience with similar processes or from published information on similar processes.

**Table 6-13** Typical labor requirements for process equipment<sup>†</sup>

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

**Utilities.** The cost for utilities, such as steam, electricity, process and cooling water, compressed air, natural gas, fuel oil, refrigeration, and waste treatment and disposal, varies widely depending on the amount needed, plant location, and source. A detailed list of ranges of rates for various utilities is presented in Appendix B. Some typical costs for utilities are given in Table 6-14. The required types of utilities are established by the flowsheet conditions and determined from material and energy balances calculated for the process.

**Other issues of the variable cost can be read from** Fig 6.7.

**Table 6-14** Cost tabulation for selected utilities and labor

Utility	Cost
Electricity	0.045 \$/kWh <sup>a</sup>
Fuel	
Coal	0.35 \$/GJ <sup>b</sup>
Petroleum	1.30 \$/GJ <sup>b</sup>
Petroleum coke	0.17 \$/GJ <sup>b</sup>
Gas	1.26 \$/GJ <sup>b</sup>
Refrigeration, to temperature	
5°C	20.0 \$/GJ <sup>c</sup>
-20°C	32.0 \$/GJ <sup>c</sup>
-50°C	60.0 \$/GJ <sup>c</sup>
Steam, saturated	
10 <sup>3</sup> -10 <sup>4</sup> kPa (150-1500 psi)	4.40 \$/1000 kg <sup>e,d</sup>
Wastewater	
Disposal	0.53 \$/1000 kg <sup>e</sup>
Treatment	0.53 \$/1000 kg <sup>e</sup>
Waste	
Hazardous	145.00 \$/1000 kg <sup>c</sup>
Nonhazardous	36.00 \$/1000 kg <sup>c</sup>
Water	
Cooling	0.08 \$/1000 kg <sup>e,f</sup>
Process	0.53 \$/1000 kg <sup>e</sup>
Labor	
Skilled	33.67 \$/h <sup>g</sup>
Common	25.58 \$/h <sup>g</sup>

<sup>a</sup>Based on U.S. Department of Energy, Energy Information Administration, Form EIA-861, 2001. U.S. energy facts...

**2) Fixed charges** are expenses which are practically independent of production rate. Expenditures) cost) for depreciation, property taxes, insurance, financing (loan interest), and rent are usually classified as fixed charges. These charges, except for depreciation, tend to change due to **inflation**. As a rough approximation, these charges amount to about 10 to 20 percent of the total product cost.

**3) Plant overhead costs** are for hospital and medical services; general plant maintenance and overhead, safety services, payroll overhead including social security and other retirement plans, medical and life insurance, and vacation allowances, packaging, restaurant and recreation facilities (relaxation or play), salvage services, control laboratories, property protection, plant superintendence, warehouse and storage facilities, and special employee benefits. Nonmanufacturing machinery, equipment, and buildings are necessary for many of the general plant services. Other components of the overhead are listed in Fig. 6-7. These charges are closely related to the costs for all labor directly connected with the production operation. The plant

overhead cost for chemical plants is about 50 to 70 percent of the total expenses for operating labor, supervision, and maintenance

## General Expenses

In addition to the manufacturing costs, other general expenses are involved in the operations of a company. These general expenses may be classified as (1) administrative expenses, (2) distribution and marketing expenses, and (3) research and development expenses.

In the absence of more accurate cost figures from company records, or for a preliminary estimate, the administrative costs may be approximated as 15 to 25 percent of operating labor.

### Example

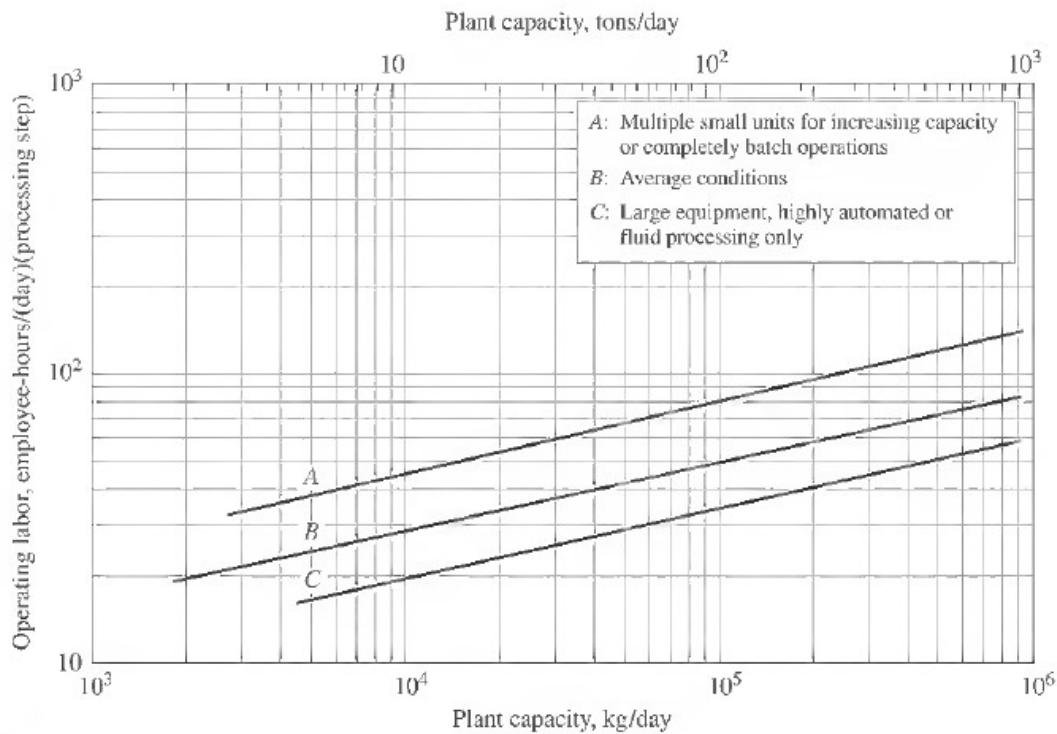
Estimation of Labor Requirements. Consider a highly automated processing plant having an output rate of 1.0 kg/s of product and requiring principal processing steps of heat transfer, reaction, and distillation. What are the operating labor requirements for an annual operation of 300 days?

#### ■ Solution

The process plant is considered to require three process steps. From Fig. 6-9, for a capacity of 1 kg/s ( $8.6 \times 10^4$  kg/day) the highly automated process plant requires approximately 33 employee-hours/(day)(processing step). Thus, for 300 days of annual operation, operating labor required =

$$(3)(33)(300) = 29,700 \text{ employee-hours/year.}$$





**Figure 6-9**  
Operating labor requirements in the chemical process industry

**Table 6-14** Cost tabulation for selected utilities and labor

Utility	Cost
Electricity	0.045 \$/kWh <sup>e</sup>
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5°C	20.0 \$/GJ <sup>c</sup>
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