Faculty of Engineering
Mechanical Engineering Department

Cost Estimation

Cost Estimation

- Cost estimation is a major activity performed in the initial stages of virtually every effort in industry, business, and government.
- In general, most cost estimates are developed for either a *project* or a *system*; however, combinations of these are very common.
- A project usually involves physical items, such as a building, bridge, and manufacturing plant.
- A system is usually an operational design that involves processes, software, and other nonphysical items.

Direct and Indirect Costs

- Costs are comprised of *direct costs* (humans, machines, and materials) and *indirect costs* (mostly support functions, utilities, management, taxes, etc.).
- Normally direct costs are estimated with some detail, then the indirect costs are added using standard rates and factors.
- Direct costs in many industries have become a relatively small percentage of overall product cost, while indirect costs have become much larger.

Direct Costs Estimation

- **Direct cost** components are the first cost *P* and the annual operating cost (AOC), also called the maintenance and operating costs (M&O).
  - **First cost component P:** Equipment cost, delivery charges, installation cost, insurance coverage, initial training of personnel for equipment use.
  - **AOC component:** Direct labor cost for operating personnel, direct materials, maintenance (daily, periodic, repairs, etc.), rework and rebuild.

- Each component will have several *cost elements*, some that are directly estimated, others that require examination of records of similar projects, and still others that must be modeled using an estimation technique.

Cost Estimation Techniques

- Methods such as expert opinion and comparison with comparable installations serve as excellent estimators.
- The use of the *unit method* and *cost indexes* base the present estimate on past cost experiences, with inflation considered.
- Models such as *cost-capacity equations*, the *factor method*, and the *learning curve* are simple mathematical techniques applied at the preliminary design stage.

Unit Method

- The unit method is a popular preliminary estimation technique applicable to virtually all professions.
- The total estimated cost C_T is obtained by multiplying the number of units *N* by a per unit cost factor *U*.

$$C_T = U \times N$$

- Examples:
  - Cost of constructing interstate highway ($6.2 million per mile).
  - Cost of house construction per livable area ($225 per square foot).

Example 1

- A mechanical engineer, has been asked to make a preliminary estimate of the total cost to manufacture 1500 sections of high pressure gas pipe using an advanced centrifugal casting method. Use the following resource and unit cost factor estimates to help him.

- Materials: 3000 tons at $45.90 per ton
- Machinery and tooling: 1500 hours at $120 per hour
- Direct labor in-plant:
  - Casting and treating: 3000 hours at $55 per hour
  - Finishing and shipping: 1200 hours at $45 per hour
- Indirect labor: 400 hours at $75 per hour.

Example 1

- **Solution**
- Apply equation to each of the five areas and sum the results to obtain the total cost estimate of $566,700.

Resource	Amount, N	Unit Cost Factor, U	Cost Estimate, $U \times N$
Materials	3000 tons	$ 45.90 per ton	$137,700
Machinery, tooling	1500 hours	$120 per hour	180,000
Labor, casting	3000 hours	$ 55 per hour	165,000
Labor, finishing	1200 hours	$ 45 per hour	54,000
Labor, indirect	400 hours	$ 75 per hour	30,000
Total cost estimate			**$566,700**

Cost Indexes

- A cost index is a ratio of the cost of something today to its cost sometime in the past.
- The index is a dimensionless number that shows the relative cost change over time.
- One such index that most people are familiar with is the ***Consumer Price Index*** (CPI), which shows the relationship between present and past costs for many of the things that "typical" consumers must buy.

Cost Indexes

- The general equation for updating costs through the use of a cost index over a period from time t = o (base) to another time t is:

$$C_t = C_0\left(\frac{I_t}{I_0}\right)$$

- Where C_t = estimated cost at present time t
  C_o = cost at previous time t_o
  I_t = index value at time t
  I_o = index value at base time o

Example 2

- In evaluating the feasibility of a major construction project, an engineer is interested in estimating the cost of skilled labor for the job. The engineer finds that a project of similar complexity and magnitude was completed 5 years ago at a skilled labor cost of $360,000. The ENR skilled labor index was 3496 then and is now 4038. What is the estimated skilled labor cost?

- **Solution**

- The base time t_o is 5 years ago. The present cost estimate units:

$$C_t = 360{,}000\left(\frac{4038}{3496}\right)$$
$$= \$415{,}812$$

Cost Indexes

- In the manufacturing and service industries, tabulated cost indexes may be difficult to find.
- The cost index will vary, perhaps with the region of the country, the type of product or service, and many other factors.
- The development of the cost index requires the actual cost at different times for a prescribed quantity and quality of the item.

Cost-Estimating Relationships

- Design variables (speed, weight, thrust, physical size, etc.) for plants, equipment, and construction are determined in the early design stages.
- Cost-estimating relationships (CER) use these design variables to predict costs.
- Thus, models such as *cost-capacity equations*, the *factor method*, and the *learning curve* are simple mathematical techniques applied at the CER method.

Cost-Capacity Equations

- One of the most widely used CER models is a cost-capacity equation.
- As the name implies, an equation relates the cost of a component, system, or plant to its capacity.
- This is also known as the *power law and sizing model*.
- Many cost-capacity equations plot as a straight line.

Cost-Capacity Equations

- A common form is:

$$C_2 = C_1\left(\frac{Q_2}{Q_1}\right)^x$$

- Where C_1 = cost at capacity Q_1
  C_2 = cost at capacity Q_2
  x = correlating exponent

- The value of the (x) for various components, systems, or entire plants can be obtained from a number of sources, including handbooks, technical journals, professional and trade organizations, consulting firms and equipment companies.

Factor Method

- The factor method is based on the premise that fairly reliable total plant costs can be obtained by multiplying the cost of the major equipment by certain factors.

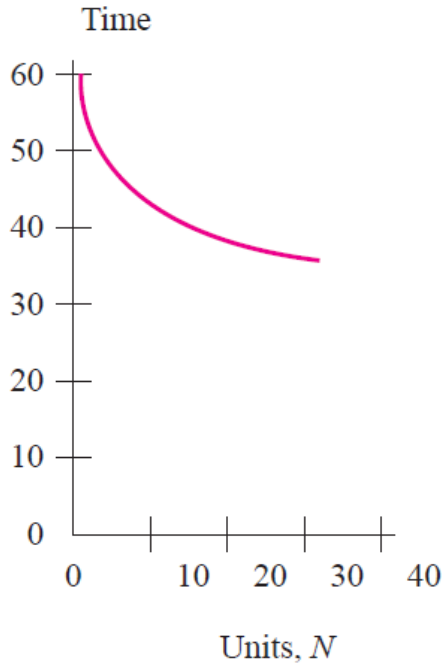
- The factor method relation has the same form as the unit method.

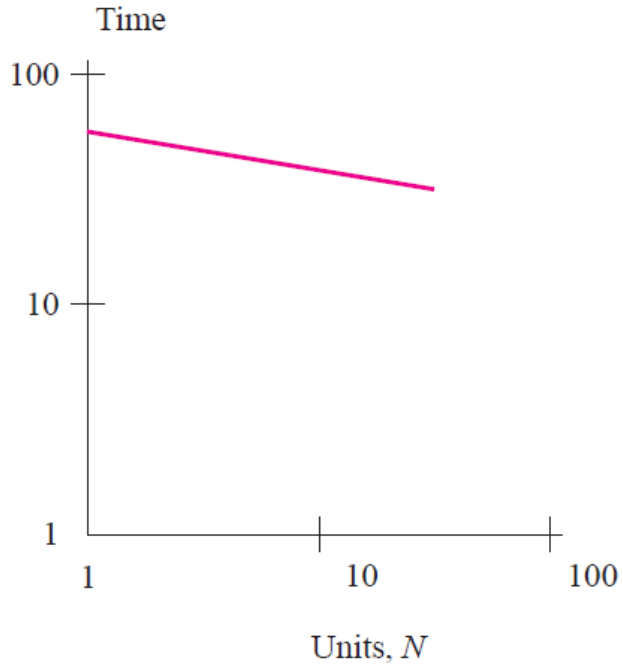
$$C_T = h \times C_E$$

- Where C_T = total plant cost
  h = overall cost factor or sum of individual cost factors
  C_E = total cost of major equipment

Learning Curve

- The learning curve, primarily used to predict the time to complete a specific repeated unit. The model incorporates a constant decrease in completion time every time the production is ***doubled***.





Indirect Costs

- **Indirect costs** - commonly referred to as (*overhead*), those that are not directly connected with a specific project, machine, or product.
- These costs include support and infrastructure expenses such as maintenance, human resources, quality, safety, supervision and administration, planning and scheduling, taxes, legal, payroll, accounting, utilities, and a host of other costs.
- Indirect costs are too difficult to track in detail; some allocation method must be developed and applied.

Indirect Costs Estimation

- Using the traditional method, indirect costs are estimated using an indirect cost rate that is allocated on some basis.
- The rate is calculated using the relation:

$$\text{Overhead or indirect cost rate} = \frac{\text{estimated total indirect costs}}{\text{estimated basis level}}$$