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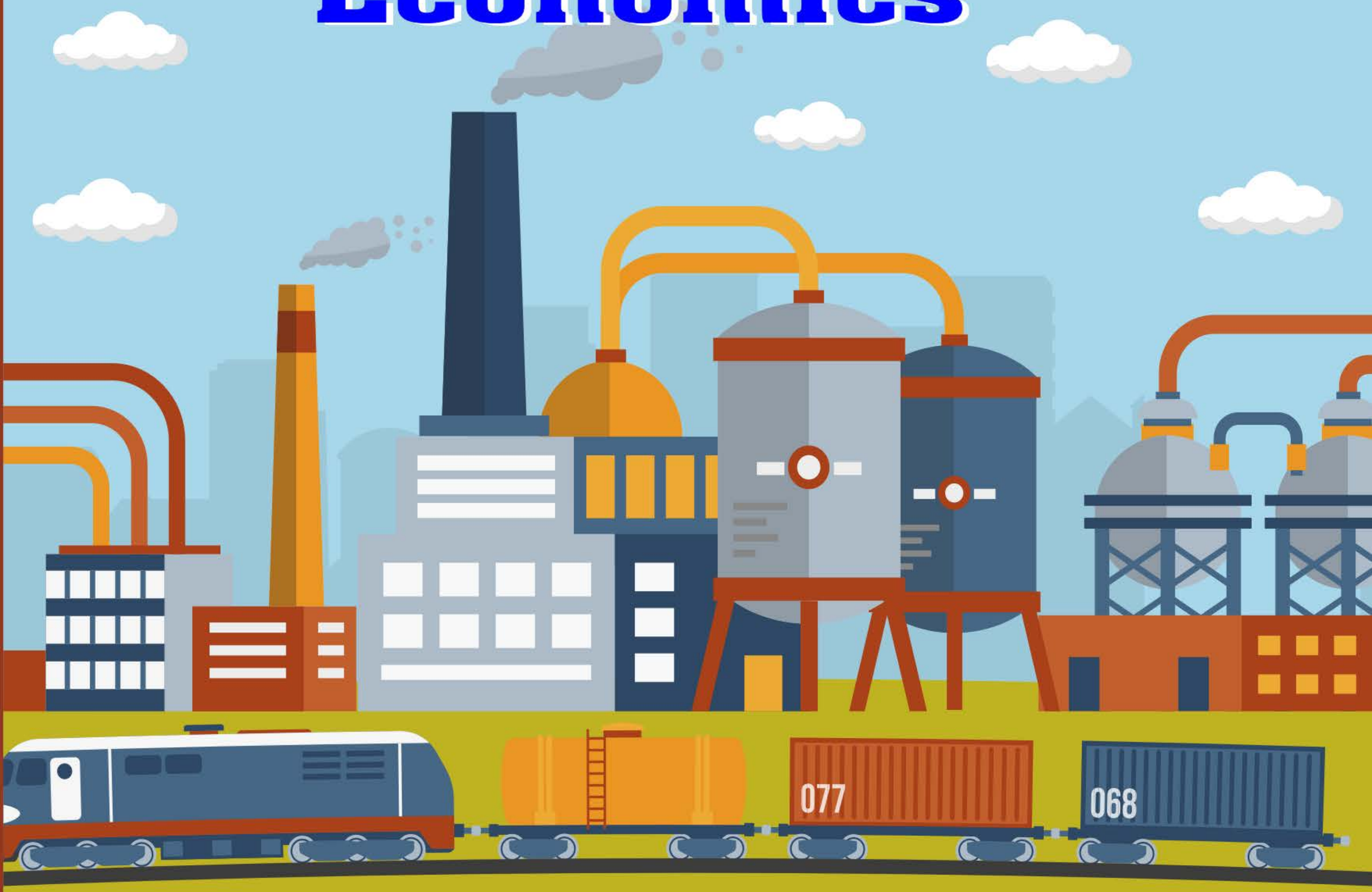
Plant Design and Economics



PLANT DESIGN AND ECONOMICS

CHEMICAL: GATE & PSUs

ENGINEERS INSTITUTE OF INDIA

India's Best Institute for CHEMICAL ENGINEERING

CHEMICAL ENGINEERING

REVISED AS PER NEW GATE Syllabus

STUDY MATERIAL

Plant Design & Economics-PDE

CONTENT

List of Topics in GATE 2024 paper from PDE

Depreciation, Block diagram reduction, Capitalized cost-K

Part 1

ECONOMICS

CHAPTER-1

INTRODUCTION

Membrane Stresses in Shells of Revolution:

A shell of revolution is the form swept only by a line or curve rotated about an axis. Most pressure vessels are made up from shell of revolution such as cylindrical and conical sections, and different types of heat such as hemispherical, ellipsoidal and torispherical heads.

The walls of thin vessels can be considered to be membranes, supporting load without significant bending or shear stresses.

Let P = Pressure on the shell.

t = thickness of the shall.

$\sigma_l =$ Longitudinal stress.

$\sigma_c =$ Circumferential stress.

$r_l =$ Longitudinal radius of curvature.

$r_c =$ Circumferential radius of curvature.

For any shell of revolution force balance provide the following equation

$$\boxed{\frac{\sigma_l}{r_l} + \frac{\sigma_c}{r_c} = \frac{P}{t}} \text{ also } \sigma_l = \frac{\Pr_c}{2t}$$

For cylinder of diameter D

$$r_l = \infty$$

$$r_c = \frac{D}{2}$$

$$\sigma_l = \frac{PD}{4t}, \sigma_c = \frac{PD}{2t}$$

For a sphere of diameter D

$$r_l = r_c = \frac{PD}{4t}$$

For a cone swept out by a straight line inclined at an angle α to the axis

$$r_l = \infty,\ r_c = \frac{r}{\cos\alpha}$$

$$\sigma_1 = \frac{\Pr}{2+\cos\alpha},\ \sigma_2 = \frac{\Pr}{t\cos\alpha}$$

For ellipsoidal head with major axis 2a and minor axis 2b

$$r_l = \frac{r_c^3 b^2}{a^4}$$

$$\sigma_l = \frac{\Pr_c}{2t}$$

$$\sigma_c = \left(\frac{P}{t} - \frac{\sigma_l}{r_l}\right) r_c = \frac{P}{t}\left(r_c - \frac{r_c^2}{2r_l}\right)$$

At the top

$$r_l = r_c = \frac{a^2}{b}$$

$$\sigma_l = \sigma_c = \frac{Pa^2}{2tb}$$

At the equator

$$\sigma_l = \frac{Pa}{2t}$$

$$\sigma_c = \frac{Pa}{t}\left[1 - \frac{a^2}{2b^2}\right]$$

Hence for ellipsoidal head

$$\boxed{\begin{aligned}\sigma_l &= \frac{Pa}{2t}\\ \sigma_c &= \frac{Pa}{t}\left[1 - \frac{a^2}{2b^2}\right]\end{aligned}}$$

For Torispherical head:

For the spherical portion

$\sigma_l = \sigma_c = \frac{PR_c}{2t}$, where R_c – crown radius

For torus $\sigma_l = \frac{PR_k}{2t}$, where R_k – knuckle radius

The minimum thickness of torispherical head required is given by

$$t = \frac{PR_c C_s}{2fJ + P(C_s - 0.2)}$$

Where C_s = stress concentration factor

$$C_s = \frac{1}{4}\left(3 + \sqrt{\frac{R_c}{R_k}}\right)$$, J = Joint efficiency

A hemispherical heat is the strongest shape.

Support for pressure vessels:

For vertical vessels:

Vertical vessels may be supported by means of brackets. Column or skirt support.

For horizontal vessels:

Horizontal vessel may be supported by means of saddle or ring support.

Summary:

- Skirt support is used for tall vertical vessel.
- For smaller vertical vessel with internal pressure lug support must be use.
- For a given thickness, hemispherical heads are the strongest of the formed leads.

CHAPTER-2

COST ESTIMATION

Aim of any process plant is to make profit. Hence an estimated cost of the investment is needed. **Remember**: The purpose of estimating is to develop cash flow projections and not to produce exact data about the future, which is virtually impossible. Production cost is needed before the profitability of a project can be assessed. When a new industry is set up, a large amount of money is required for various operations such as purchasing of land, equipment, etc. and also labour and other working capital is also needed. The approach to estimate the cost is shown in this chapter.

Total Capital Investment:

The capital required to supply the necessary manufacturing and plant facilities is called fixed capital investment. The capital required for the operation of plant is called working capital. The sum of the fixed capital investment and working capital investment is called total capital investment. Total capital investment is written as:

Total capital investment = fixed capital investment + working capital investment

Fixed Capital Investment (F.C.I.)

Fixed capital refers to the total cost of plant needed to start-up. It is the cost paid to the contractors and is a once-only cost that is not recovered at the end of the project life, other than scrap value. it can also be considered as depreciable asset (except for land). Fixed capital investment can be divided into-

(a) Manufacturing fixed capital investment
(b) Non-manufacturing fixed capital investment

Manufacturing fixed capital investment represents the capital necessary for installed process equipment with all auxiliaries that are needed for complete process operation. Examples are piping, instrument, insulation, foundation and site operations. Fixed capital required for construction, overhead and all plant components that are not directly related to the process operation is called non manufacturing fixed capital investment. Examples are land, processing building, administration and other offices, ware houses, laboratories, transportation, shipping and receiving facility, utility and waste disposal facilities. Construction overhead cost consists of field office and supervision expenses, home office expenses, engineering expenses, miscellaneous construction cost, contractor's fees and contingencies.

Working Capital (W.C.)

Working capital is the additional investment needed over the fixed capital to start the plant up and operate plant to the point where profit is earned.

The working capital for an industrial plant consists of the total amount of money invested in:

(a) Raw materials and supplies carried in stock.
(b) Finished product in stock and semi finished product in the process of being manufactured.
(c) Accounts receivable.
(d) Cash kept on hand for monthly payment of operating expenses such as salaries, wages and raw material purchase.

(e) Accounts payable and taxes payable.

The ratio of working capital to total capital investment varies with different companies but most chemical plant use an initial working capital amounting 10 to 20 percent of the total capital investment.

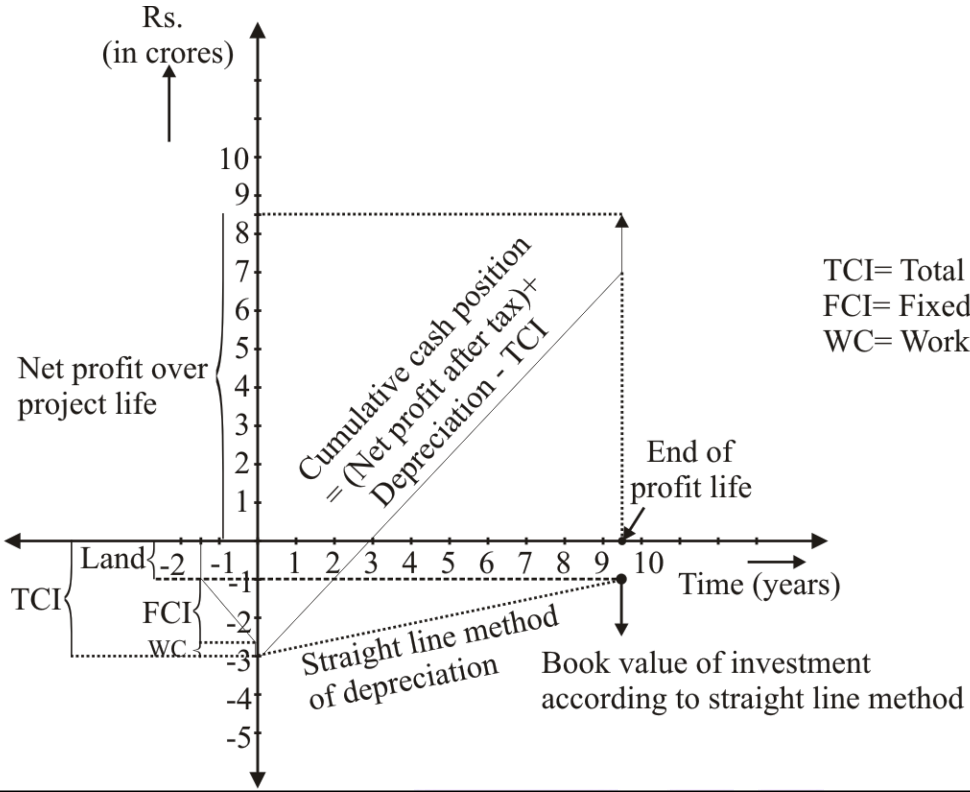


Fig.1. A typical Cumulative cash flow diagram

A typical list for complete estimation of the Fixed-Capital Investment (F.C.I.):

Direct Costs:

1. Purchased Equipment:

It includes all equipment listed on a complete flow sheet such as

- Spare parts and non installed equipment spares.
- Surplus equipment, supplies and equipment allowance.
- Inflation cost allowance
- Freight charges
- Taxes, insurance, duties
- Allowance for modification during start-up.

2. Purchased Equipment Installation:

The costs regarding installation of all equipment listed on complete flow sheet such as

- Structural supports.
- Equipment insulation and painting.

3. Instrumentation and Controls:

- Purchase, installation, calibration, computer control with supportive software.

KEY POINTS TO REMEMBER

(1.) Total capital investment = fixed capital investment + working capital investment

(2.) $\frac{\text{cost in year x}}{\text{cost in year y}} = \frac{\text{cost index in year x}}{\text{cost index in year y}}$

(3.) Six tenth rule :

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

Where, C_2 = capital cost of project with capacity Q_2

C_1= capital cost of the project with capacity Q_1

The value of index 'n' is taken as 0.6

(4.) Turnover ratio = $\frac{\text{gross annual sales}}{\text{fixed capital investment}}$

(5.) Turndown ratio= $\frac{\text{Fixed capital investment (FCI)}}{\text{Total capital investment (TCI)}}$

(6.) At breakeven point, total production cost = total income

$FC + n_B C_V = n_B C_S$

Where FC = fixed cost

C_V = production cost per unit

C_S = selling cost per unit

n_B = production capacity at breakeven point.

(7.) Cash flow = net profit after tax + depreciation

Cash flow = $(S – c – d) (1 - \phi) + d$

Where

S = total sale revenue

C = total product cost

d = depreciation

ϕ = tax rate

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NUMERICALS

(1.) The annual production costs for a plant is Rs 36.4 lakhs, while the sum of the annual fixed charge, overhead costs and general expenses is Rs 26 lakhs. What is the breakeven point in unit of production per year if the total annual sales are 72.8 lakhs and the product sells at Rs 520 per unit.

Solution:

Data given: annual production cost = Rs.36.4 lakhs

Sum of annual fixed charge, overhead costs and general expenses = Rs 26 lakhs

Total annual sales = Rs 72.8 lakhs

Product sell = Rs 520/unit

Number of unit produced = $\frac{72.8\times10^5}{520}$ = 14000 units

Production costs per unit = $\frac{36.4\times10^5}{14000}$ = Rs 260

We know that at break even points:

total production cost = total income

If x is the number of unit at breakeven points, then $520x = 260x + 26\times10^5$

On solving we get

x = 10,000 units

(2.) A heat exchanger of area $10m^2$ cost Rs 50,000 in the year 1985. What is estimated cost of a $15m^2$ exchanger in 1988. Assume that the cost index was 270 in 1985 and 320 in 1988.

Solution: Capacity of heat exchanger $(HE)_x = Q_x = 10m^2$

Capacity of $(HE)_y = Q_y = 15m^2$

From six-tenth rule,

$$\frac{C_x}{C_y} = \left(\frac{Q_x}{Q_y}\right)^n \left(\frac{I_x}{I_y}\right)$$

$$\frac{C_x}{50000} = \left(\frac{15}{10}\right)^{0.6} \left(\frac{320}{270}\right)$$

C_x= 75580.711

(3.) If the delivered cost of equipments of a fluid processing plant is 4×10^6. What is the capital cost of the plant? Given that, Lang multiplication factors for estimation of fixed capital investment or total capital investment are:

Type of plant	Lang Factor for	
	Fixed – capital investment	Total capital investment
Solid processing plant	3.9	4.6
Solid – fluid processing plant	4.1	4.9
Fluid processing plant	4.8	5.7

Solution: We know that,

(Fixed Capital Investment or Total Capital Investment)= (Lang factor) × (delivered equipment cost)

From table,

Total capital cost of the plant = $(4\times10^6)\times 5.7$

$= 22.8 \times 10^6$

$$\boxed{\text{total capital cost of the plant} = \text{Rs } 22.8\times10^6}$$

If only "cost" is mentioned in the question, it is always considered as the total cost

(4.) For a solid-fluid processing plant, the delivered equipment cost is 50 Lac. Using lang factor method find fixed capital investment and total capital investment …….. lac and ……. Lac respectively.

Solution: 205 and 245 lac

Hint: For solid-fluid process plant.

Lang factor is 4.1 and 4.9 for fixed capital investment and total capital investment respectively.

(5.) In cost estimation of a process plant multiplication of turnover ratio and turndown ratio is given by

(a) Gross annual sales / Fixed capital investment.

(b) Gross annual sales / Total capital investment.

(c) Fixed capital investment / total capital investment.

(d) Fixed capital investment / Grass annual sales.

Solution: b

Hint: Turnover ratio = Gross Annual sales / FCI , turndown ratio = FCI/TCI

CHAPTER-3
INTEREST AND INVESTMENT COSTS

Interest is the earning on money loaned or the extra money that you have to give on borrowed money. **Principle** amount means original amount borrowed on lent. Interest which is expressed as percentage per year or fraction is defined as the amount earned or paid on a unit of principal in a unit time. During business profitability analysis we also include interest paid as expenses during business operation. Interest is usually expressed in rate.

In case of investment made in the past, [Interest = total amount to be received – original investment]

In case of loan taken in past, [Interest = Present amount to be paid – original loan amount]

Simple Interest (SI):

Interest is said to be simple when it is charged on principle amount for the interest period.

The amount of simple interest (SI) accumulated during n interest period is given by

$SI = P \times I \times n$ ------------------------ (1)

Where P = Principal amount

n = number of interest periods or number of time units

I = Interest rate based on one interest period length

The entire principal amount plus simple interest due after n interest period is

$S = P + SI = P + PIn = P(1 + In)$ ---------------- (2)

Generally, interest is not simple interest but is paid semi-annually (twice a year), quarterly (4 times per year), monthly (12 times per year) or even daily (365 times per year).

Period	Principal at the start of period	Interest earned during period	Amounts (S) at the end of period
1	P	PI	P + PI = P (1 + I)
2	P	PI	P (1 + I) + PI = P (1 + 2I)
3	P	PI	P (1 +2I)+ PI = P (1 + 3I)
n	P	PI	P (1 + nI)

Table1. Amount calculation using simple interest

Compound Interest:

In most business transactions compound interest is used universally. Compound interest is defined as interest earned on accumulated, reinvested interest as well as the principal amount. The total amount is the principal (P) plus interest earned after n interest periods and is given by following equation:

$S = P(1+I)^n$ --------------(3)

$$= -(3\times10^5) - 20000\left[\frac{(1.5)^5 - 1}{0.1(1.5)^5}\right] + 125000 = -250815.7354$$

[The present value should be as high as possible. Hence positive value of larger magnitude and negative value of smaller magnitude is preferable.]

Hence alternative is preferable.

Example: Chetan deposits Rs 2000 at the end of each year in an account earning 10% compounded annually. Determine how much money he has after 25 years. How much interest did he earn?

Solution:

$$Future\ worth\ (F) = 2000\left[\frac{(1+0.1)^{25} - 1}{0.1}\right]$$

$$F = 2000\left(\frac{9.834706}{0.1}\right) = Rs\ 196,694.12$$

$$I = F - (25\times2000)$$

$$I = Rs\ 146,694.12$$

Example: What lump sum deposited today would allow payments of Rs 2000/year for 7 years at 5% compounded annually?

Solution:

$$i = 5\% = 0.05$$

$$P = 2000\left(\frac{(1+0.05)^7 - 1}{0.05(1+0.05)^7}\right)$$

$$P = 2000\left(\frac{0.407100}{0.0703552}\right)$$

$$P = Rs\ 11,572.71$$

Capitalized cost:

Capitalized cost is defined as the original cost of equipment plus the present value of renewable perpetuity. It represents the present worth of an alternative for a project that is going to serve for longer period of time i.e. For infinite period of time. It generally refers to the present worth of expenditure and revenue of an alternative over infinite period of time.

Eg. Assuming initial cost of equipment = V

Salvage value of equipment = V_s

For (10 years = n)

Then replacement cost (C_R) = V- V_s

i.e. ($V–V_s$) is the amount required for replacing the equipment.

Now, finding the annuity (A) for replacement cost (C):-

$$C_R = F = A\left[\frac{(1+i)^n - 1}{i}\right]$$

$$\Rightarrow\ A = \left[\frac{C_R i}{(1+i)^n - 1}\right]$$

Present worth for initial replacement is given by:

$$P = \frac{A}{i} = \left[\frac{C_R}{(1+i)^n - 1}\right]$$

$$\therefore\ \text{Capitalized cost} = V + \left[\frac{C_R}{(1+i)^n - 1}\right]$$

$$= V + \left[\frac{(V - V_s)}{(1+i)^n - 1}\right]$$

In some textbooks, the Capitalized cost (K) is represented by

$$\boxed{K = C_v + \frac{C_R}{(1+i)^n - 1}}$$

Where C_v = Original cost of equipment (sometimes denoted by V)

C_R = Replacement cost = $(V - V_s)$ i.e. (original cost – salvage value)

Example: (To understand the concept of capitalized cost)

Consider the original cost of a certain piece of equipment is Rs 100 (V).

The useful period is 10Years (n) and the scrap value at the end of useful life is Rs 5 (V_S) .In order to use the equipment for an indefinitely long period of time, how much money is needed? Given that interest rate is 2% per annum

Solution:

Rs (100 – 5) = Rs 95 (C_R) every 10 years to replace the equipment.

$\therefore$a fund is provided of sufficient size (x) so that it will earn enough interest to pay for the periodic replacement. This amount x accumulates to an amount $x(1 + i)^n = x(1.02)^{10}$ after 10 years.

Interest through amount x must be equal to the periodic replacement

$$i.e.\ x((1+i)^n - 1) = C_R$$

$$x = \frac{C_R}{(1+i)^n - 1} = \frac{95}{0.22} = 431.82\,Rs$$

Thus, at the end of 10 years, equipment can be replaced for Rs 95 (interest from Rs 431.82) and Rs 431.82 will remain in the fund.

The theoretical amount of total capital necessary at the start would be Rs 431.82 (x) for replacement fund and Rs 100 (C_V) for the equipment. Thus, the equipment perpetuates itself. The total capital determined in this manner is called capitalized cost (K), which comes out to be 431.82+100 = 531.82

Engineers use capitalized costs principally for comparing alternative choices.The choice which is having less capitalized cost is more ***economic****. Also, capitalized cost is for infinite lifetime period. So, it is used to equalize the timeline.*

Example: A reactor is designed. If it is made of mild steel, the initial installed cost will be Rs 5000 and useful life period will be 3years. Stainless steel is proposed as an alternative to mild steel. The stainless steel reactor would have an initial installed cost of Rs 15000. The scrap value at the end of useful life would be zero for either type of reactor and both could be replaced at a cost equal to the original price. On the basis of equal capitalized costs for both types of reactors, what should be the useful life period for the stainless steel reactor if money is worth 6 percent compounded annually?

Solution:

The capitalized cost for mild steel reactor is

$$K = C_V + \frac{C_R}{(1+i)^n - 1} = 5000 + \frac{5000}{(1+0.06)^3 - 1} = Rs5000 + 26{,}180$$

$$= Rs31{,}180$$

Therefore, the capitalized cost for the stainless steel reactor must also be Rs. 31,180 for stainless steel reactor:

$$Rs31{,}180 = 15000 + \frac{15000}{(1+0.06)^n - 1}$$

Solving for n:

n = 11.3years

Conclusion: If the stainless steel reactor has a useful life of more than 11.3years, it is the recommended choice, while mild steel reactor is recommended if useful life of stainless steel is less than 11.3years

Relations for continuous cash flow and continuous interest:

$\overline{S}$, $\overline{P}$, $\overline{R}$, etc means payments are done continuously throughout the time period under consideration.

$\overline{P}$ = Total amount of cash put into project on the basis of one year with a continuous flow of cash.

$$S_{\text{at end of 1 year}} = \overline{P}\left(\frac{e^r - 1}{r}\right) = P_{\text{at startup}}$$

$$S_{\text{after 'n' years}} = (P_{\text{at startup}})e^{rn} = P\left(\frac{e^r - 1}{r}\right)e^{rn}$$

KEY POINTS TO REMEMBER

(1) Simple interest:

SI = P×I×n

Where P= principal amount

SI= accumulated amount during n interest period

I= interest rate

Entire amount is given by :

$$S = P + SI = P + PIn = P(1 + In)$$

(2) Entire amount by compound interest is given by:

$$S = P(1+I)^n$$

(3) Effective interest rate is given by:

$$i_{eff} = \left(1 + \frac{r}{m}\right)^m - 1$$

Where r = normal interest

(4) Continuous interest compounded then:

$$S = Pe^{rn}$$

$$i_{eff} = e^r - 1$$

$$S = Pe^{rn} = P(1 + i_{eff})^n$$

(8) Relation between ordinary annuity and periodic payment is given by

$$Pi = A(1-(1+i)^{-n})$$

(9) Present worth of an annuity:

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

(10) Future worth of an annuity

$$F = P(1+i)^n = A\left[\frac{(1+i)^n - 1}{i}\right]$$

(11) Present worth of a perpetuity $(P) = \frac{A}{i}$

(12) Future worth of perpetuity $(F) = A\left[\frac{(1+i)^n - 1}{i}\right]$

(13) Capitalized cost $K = C_v + \frac{C_R}{(1+i)^n - 1}$

(14) Salvage value is the net amount of money obtainable from the sale of used property.

(15) The time value of money is related to capacity of money to earn money.

NUMERICALS

(1.) An amount of Rs 1500 is deposit in S.B.I. bank with an annual interest rate of 4.3% compounded quarterly. Find total amount after 6 years by using effective interest rate.

Solution:

Principal amount = P= Rs 1500

Total sum = $S = P\left(1+\frac{r}{m}\right)^m$

r = nominal interest rate= 4.3% = 0.0043

m = number of interest period per year = 4

$S = 1500\left(1+\frac{0.043}{4}\right)^{6\times4}$ S = 1938.84 Rs

(2.) If a loan given by a bank applies 1% interest per month, then calculate nominal interest rate and effective interest rate.

Solution:

Nominal interest rate = r = $12\times\frac{1}{100}$

= 12% yearly = 0.12 yearly

Effective interest rate = ieff

$i_{eff} = \left(1+\frac{r}{m}\right)^m - 1$ $i_{eff} = \left(1+\frac{0.12}{12}\right)^{12} - 1 = 12.68\%$ i_{eff} = 12.68% or 0.1268

(3.) A saving bond of government have a maturity value of Rs 10000 and paying discrete compounding interest at an effective annual rate of 3 percent. Calculate the following at time for 6 years before the saving bond reaches the maturity value:

(i) Percent worth of saving bond

(ii) Discount

(iii) Discrete interest which will be received by a purchaser, if the bond were obtain for Rs 8000

(iv) Repeat part (i) for the case when the nominee saving bond interest is 3% compounded continuously.

Solution:

S= Maturity amount = Rs 10,000

n= number of years = 6 years

(i) Percent worth of bond = P

$$P = \frac{S}{(1+i)^n} = \frac{10,000}{(1+0.03)^6} = Rs\,8374.8$$

$\simeq 8375$

(ii) We know

Discount = Future worth – Present worth

= 10,000 – 8375 = Rs 1625

(iii) If P = Rs 8000

$8000 = \frac{S}{(1+i)^n}$ $8000 = \frac{10000}{(1+i)^6} = 0.0377$ or 3.77%

(iv) $P = \frac{s}{e^{rn}} = \frac{10000}{e^{(0.03)(6)}} = 8352.7 \approx$ Rs 8353

(4.) It is a desired to borrow Rs 1000 to meet a financial obligation. This money can be borrowed from a bank at a monthly interest rate of 2 percent.

Calculate following:

(i) The total amount of principal plus simple interest due after 2 years

(ii) The total amount of principal plus compound interest due after 2 years if no intermediate payment is made

(iii) The Nominal interest rate if the interest is compounded monthly

(iv) The effective rate if the interest is compounded monthly.

Solution:

(i) Principal amount = Rs 1000

n= interest period = 2 year = 24 months

interest rate = i = 2% monthly

We know

$$\boxed{S = P\,(1 + i * n)}$$

S = total amount $S = 1000(1 + 0.02 \times 24)$ S = Rs 1480

(ii) $S = P(1+i)^n$ $S = 1000(1+0.02)^{24}$ S = Rs 1608

(iii) Nominal interest rate = $2\% \times 12 = 0.02 \times 12 = 0.24$ or 24%

(iv) Effective interest rate = $\left(1 + \frac{r}{m}\right)^m - 1$

m = number of interest period per year = 12

r = Nominal interest rate = 0.24 or 24%

Hence effective interest rate = $\left(1 + \frac{0.24}{12}\right)^{12} - 1 = 0.268 = 26.8\%$

(5.) A distillation column has been installed at cost of Rs. 1×10^6 and is expected to have working life of 15 years with scrap value of Rs. 30000. The capitalized cost of distillation column based on annual compound interest rate of 5% is …….. in rupees.

Solution: 164879

Hint: $K = C_v + \frac{C_R}{(1+i)^n - 1}$

(6.) It is expected to generate a net cash flow of Rs. 600000 / per year at the end of each year for a period of 3 years. The applicable interest rate is 15%. The net present worth of total cash flow is Rs. ………

Answer: Rs. 1369935

Hint: Present worth = yearly principle $\times \left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$

CHAPTER-4
DEPRECIATION

Basic Definitions:

1. Assets:

(i) In financial accounting assets are economic resources.

(ii) An item of economic value owned by individual or corporation especially which could be converted into cash.

(iii) Any tangible or intangible that is capable of being owned or controlled to produce value and that is held to have positive economic value is considered an asset.

(iv) In other words assets represent ownership of value that can be converted into cash.

2. Tangible Property:

Tangible property is the property that can be seen and touched. Eg: machines, vehicle, equipments, Furniture, etc.

3. Intangible Property:

A property, of which a person can have ownership of and can transfer ownership to another person, but has no physical substance, is known as intangible property. Eg: Copy right, Patent, Franchise, etc

4. Present value:

The present value of an assets may be defined as the value of assets in its condition at the time of valuation.

5. Service Life:

The period during which the use of property is economically feasible is known as service life of property.

6. Salvage Value:

Salvage value is defined as the value of product/assets after its useful life. (at the end of useful life) or it is the net amount of money obtained from the sale of used property over and above any charges involved in removal and sale.

Note: Salvage value is different from scrap value. The term salvage value implies that the asset can give some type of further service and is worth more than merely its scrap value. If the property cannot be disposed of as a useful unit, it is often sold as junk to be used again as a manufacturing raw material. The profit obtainable from this type of disposal is known as scrap or Junk value.

7. Amortization:

The process of allocating the cost of an intangible asset over a period of time. It is basically a method of spreading payments over multiple periods. "Amortization" is a word sometimes used interchangeably with depreciation and it has more restricted meaning in tax policy.

8. Book value:

It is the value of asset recorded on the accounting books of firm or organization of the given time period. It is the difference between the original cost of a property and all the depreciation charged upto a time. It is important because it include the values of all assets of a corporation and generally calculated at the end of each year. The book value at the end of each year equals to :

$$(\text{Book value}) = (\text{Initial cost}) - (\text{Total depreciation amount upto that year})$$

It is also called as unamortized cost.

9. Market value:

The price that can be obtained for an asset if it is sold in the open market is known as market value. It might be different from the book value and clearly is important for determining the true asset value of the company.

10. Recovery period:

The period over which the depreciation is charged is the recovery period, and this is established by the codes. Originally the recovery period was related to the service life, but now the reality is that there is little relationship between the two.

11. Impaired Asset:

An impaired asset is a condition in which an asset's market value falls below its carrying amount and not expected to recover.

12. Replacement value:

The cost necessary to replace an existing property at any given time with one at least equally capable of rendering the same service.

13. Depletion:

Capacity loss due to materials actually consumed is measured as depletion. This type of depreciation is particularly applicable to natural resources.

$$\text{Depletion cost} = (\text{Initial cost}) \times \left(\frac{\text{amount of material used}}{\text{original amount of material purchased}} \right)$$

14. Dividend:

A sum of money paid regularly (typically annually) by a company to its stake-holders out of its profit.

15. Inflation:

Inflation is the increase in value of the equipment with time.

NUMERICALS

(1.) The plant of a chemical company has an initial worth of Rs 50 lakhs and an estimated salvage value of Rs 2 lakhs in a service life of 8 years

(a.) Given a choice between the straight line and declining balance methods of depreciation which method would you recommended to save tax and why.

(b.) Estimated the book value of the plant at the end of 4 years for each of two methods of depreciation.

Solution:

(a.) Since decline balance method permit greater depreciation allowance in early life of property, than in the latter life,

Hence we recommend to choose decline balance method for tax saving.

(b.) Data given :

V = original value of property at the start of the service life period = 50 lakhs

V_S = Property salvage value at the end of service life = 2 lakhs

n = Service life in years = 8 years

Book value at the end of 4 years = ?

Case (i) Straight line method :

If annual depreciation cost d then

$$d = \frac{V-V_S}{n} \qquad d=\frac{50-2}{8} = \text{Rs 6 lakhs}$$

Book value at the end of 4 year

$$V_a = V - ad \qquad a = 4 \text{ years}$$

$$V_a = 50 - 4 \times 6 = \text{Rs 26 lakhs}$$

Case (II) Declining balance method –

The asset value V_a is given by following relation

$$\boxed{V_a = V(1-f)^a}$$

Where f represent fixed percentage factor

$$f=1-\left(\frac{V_S}{V}\right)^{1/n} \qquad f=1-\left(\frac{2}{50}\right)^{1/8} = 0.3313$$

And $V_a = 50\,(1 - 0.3313)^4$ $\quad V_a$ = Rs 10 lakhs

(2.) A reactor of special design is important item of any chemical plant. The initial cost of complete installed reactor is Rs 60,000 and scrap value at the end of useful life is calculated to be Rs 10,000. Excluding depreciation cost for the reactor, the total annual expenses for the plant are Rs 100,000. How many years of useful life should be estimated for reactor if 12% of the total annual expenses of the chemical plant are due to the cost for reactor depreciation? Straight line method for determining depreciation should used.

Solution:

Original cost of reactor = Rs 60,000 = V

Scrap cost of reactor = Rs 10,000 = V_S

Useful life of reactor = n = ?

Annexure 3
PRACTICE SET-II

(1.) For shell-and-tube heat exchangers, with increasing heat transfer area, the purchased cost per unit heat transfer area

(a.) Increases (b.) decreases

(c.) remains constant (d.) passes through a maxima

(2.) The total investment in a project is Rs. 10 lakhs and the annual profit is Rs. 1.5 lakhs. If the project life is 10 years, then the simple rate of return on investment is

(a.) 15% (b.) 10% (c.) 1.5% (d.) 150%

(3.) If an amount R is paid at the end of every year for n years, then the net present value of the annuity at an interest rate of *i* is

(a.) $R\left[\dfrac{(1+i)^n-1}{i}\right]$ (b.) $R\left[\dfrac{(1+i)^n-1}{i(1+i)^n}\right]$ (c.) $R(1+i)^n$ (d.) $\dfrac{R}{(1+i)^n}$

(4.) In cost estimation, the effect of inflation on equipment cost is taken care by using

(a.) Cost indices (b.) Six-tenths rule (c.) Lang factor (d.) Turnover ratio.

(5.) An investment of Rs. 100lakhs is to be made for construction of a plant which will take two years to start production. The annual profit from operation of the plant is Rs. 20Lakhs. What will be the payback time?

(a.) 5 years (b.) 7 years (c.) 12 years (d.) 10 years

(6.) Breakeven point is the production rate when … (a) … becomes exactly equal to the … (b) …

(a.) (a) total product cost (b) total income from sale of all product

(b.) (a) operating cost (b) total income from sale of all product

(c.) (a) annual operating cost (b) annual depreciation charge

(d.) (a) total product cost (b) net profit

(7.) A standard type of heat exchanger with a negligible scrap value costs Rs. 40,000 and will have a useful life of 6 years. Assuming an effective compound interest of 10% per year, the capitalized cost of the heat exchanger will be

(a.) Rs. 60,840 (b.) Rs. 90,840 (c.) 91,840 (d.) Rs. 81,840

(8.) The total capital investment for a chemical plant is Rs. 1,000,000 and the working capital is Rs. 100,000. If a turnover ratio is 1, the gross annual sales will be

(a.) Rs. 800,000 (b.) Rs. 900,000 (c.) Rs. 1,000,000 (d.) Rs. 1,100,000

(9.) In a manufacturing industry, break-even point occurs when

(a.) The total annual rate of production equals the assigned value

(b.) The total annual product cost equals the total annual sales

(c.) The annual profit equal the expected value

(d.) The annual sale equals the fixed cost.

(10.) Inflation

(a.) Refers to the increase in the prices of goods and services over time

(b.) Affects the time value of money

(c.) Does not affect the amount of money required to purchase goods and services
(d.) Concept is based upon the fact that physical facilities deteriorate and decline in usefulness with time.

(11.) Discounted cash-flow analysis is used to calculate
(a.) The present worth of future earnings
(b.) The future worth of present investment
(c.) The payback period
(d.) The life of project

(12.) If the effective interest rate i_{eff} is defined as the rate which, when compounded once per year, gives the same amount of money at the end of 1 year, as does the nominal interest rate r compounded m times per year, then

(a.) $i_{eff} = \left(1+\frac{r}{m}\right)^m - 1$ (b.) $r = (1+i_{eff})^m - 1$

(c.) $i_{eff} = e^{mr} + 1$ (d.) $i_{eff} = \ln\left(1+\frac{r}{m}\right) - 1$

(13.) A cash flow of A per year is received in one discrete amount at the end of each year for N years. For an annual interest rate i compounded annually, the future worth of this cash flow at the end of N years is equal to

(a.) $A\left[\frac{(1+i)^N - 1}{i}\right]$ (b.) $A\left[\frac{(1+i)^N - 1}{i(1+i)^N}\right]$ (c.) $A\left[\frac{(1+i)^N - 1}{(1+i)^N}\right]$ (d.) $A\left[\frac{(1+i)^N - 1}{(1+i)^{N+1}}\right]$

(14.) Two iron pipes of the same nominal diameter but different schedule number will have
(a.) The same inside diameter (b.) The same outside diameter
(c.) The same wall thickness (d.) None of the above

(15.) Book value of an equipment is equal to its original price minus
(a.) Current value of the equipment
(b.) Amount of money obtainable from sale of the equipment
(c.) Amount of money spent on its maintenance
(d.) Total depreciation charged

ANSWER KEY

1	2	3	4	5	6	7	8	9	10
b	a	b	a	b	a	c	b	b	A
11	12	13	14	15					
a	a	a	d	d					


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