Replacement Problems

Introduction:-

The replacement problems are concerned with the situations that arise when some items such as men, machines and usable things etc need replacement due to their decreased efficiency, failure or breakdown. Such decreased efficiency or complete breakdown may either be gradual or all of a sudden.
If a firm wants to survive the competition it has to decide on whether to replace the out dated equipment or to retain it, by taking the cost of maintenance and operation into account. There are two basic reasons for considering the replacement of equipment.

(i) Physical impairment or malfunctioning of various parts.

The physical impairment refers only to changes in the physical condition of the equipment itself. This will lead to decline in the value of service rendered by the equipment, increased operating cost of the equipments, and increased maintenance cost of the equipment or the combination of these costs.

(ii) Obsolescence of the equipment.

Obsolescence is caused due to improvement in the existing Tools and machinery mainly when the technology becomes advanced therefore; it becomes uneconomical to continue production with the same equipment under any of the above situations. Hence the equipments are to be periodically replaced. Sometimes, the capacity of existing facilities may be in adequate to meet the current demand. Under such cases, the following two alternatives will be considered.

1. Replacement of the existing equipment with a new one
2. Argument the existing one with additional equipments.

Type of Maintenance

Maintenance activity can be classified into two types

i) Preventive Maintenance –

Preventive maintenance (PN) is the periodical inspection and service which are aimed to detect potential failures and perform minor adjustments a requires which will prevent major operating problem in future.

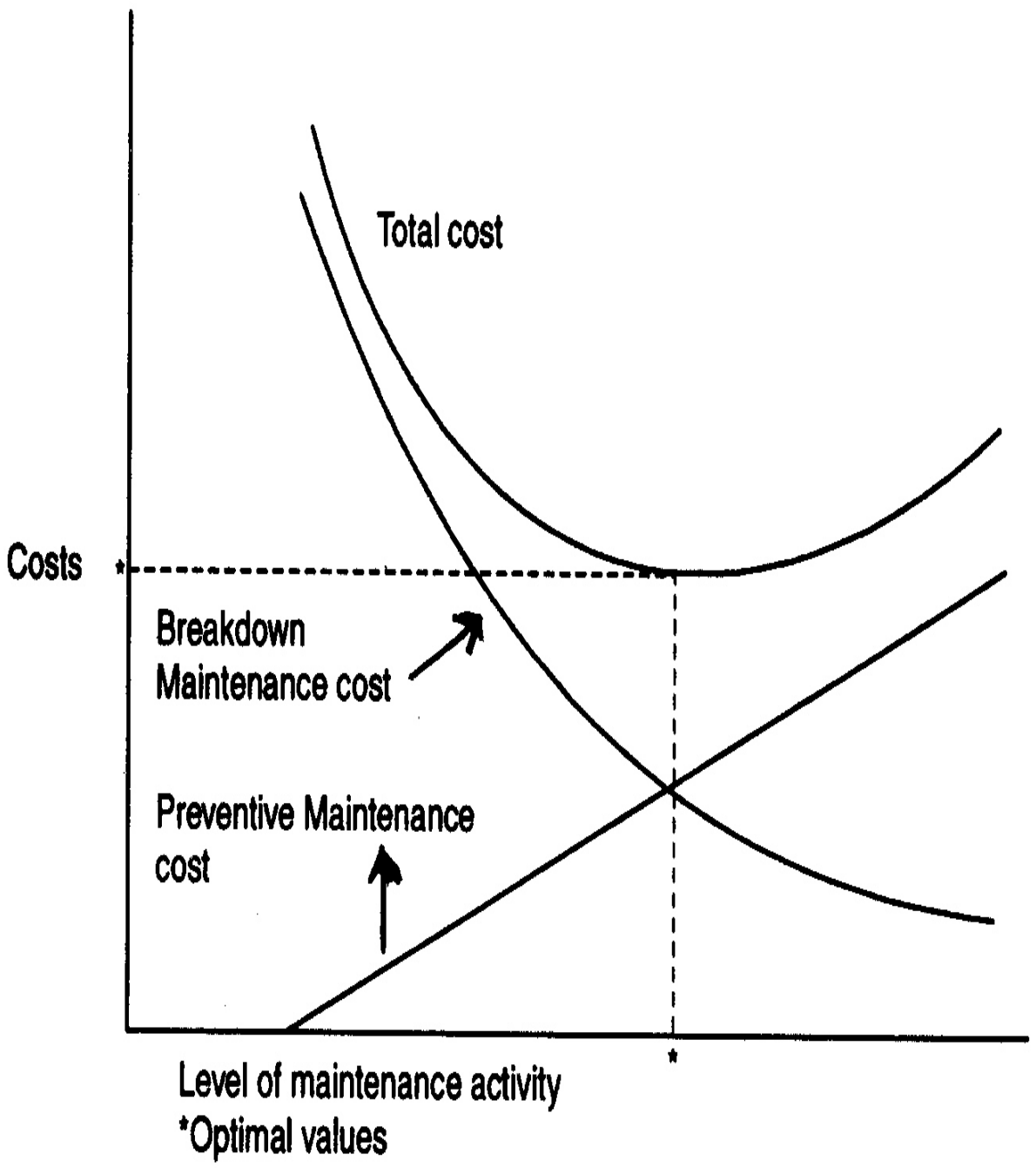
ii) Breakdown Maintenance

Breakdown maintenance is the repair which is generally done after the equipment breaks down. It is offer an emergency which will have an associated penalty in terms of increasing the cost of maintenance and downtime cost of equipment, Preventive maintenance will reduce such costs up-to a certain extent.

Beyond that the cost of preventive maintenance will be more when compared to the cost of the breakdown maintenance.

Total cost = Preventive maintenance cost + Breakdown maintenance cost.

This total cost will go on decreasing up-to P with an increase in the level of maintenance up-to a point, beyond which the total cost will start increasing from P. The level of maintenance corresponding to the minimum total cost at P is the Optional level of maintenance this concept is illustrated in the follows diagram:-



Types of Replacement Problem

The replacement problem can be classified into two categories.

i) Replacement of assets that deteriorate with time (replacement due to gradual failure, due to wear and tear of the components of the machines) this can be further classified into the following types.
   a) Determination of economic type of an asset.
   b) Replacement of an existing asset with a new asset.

ii) Simple probabilistic model for assets which will fail completely (replacement due to sudden failure).

Determination of Economic Life of an asset

Any asset will have the following cost components

i) Capital recovery cost (average first cost), Computed form the first cost (Purchase price) of the asset.

ii) Average operating and maintenance cost.

iii) Total cost which is the sum of capital recovery cost (average first cost) and average operating and maintenance cost.

A typical shape of each of the above cost with respect to life of the asset is shown below

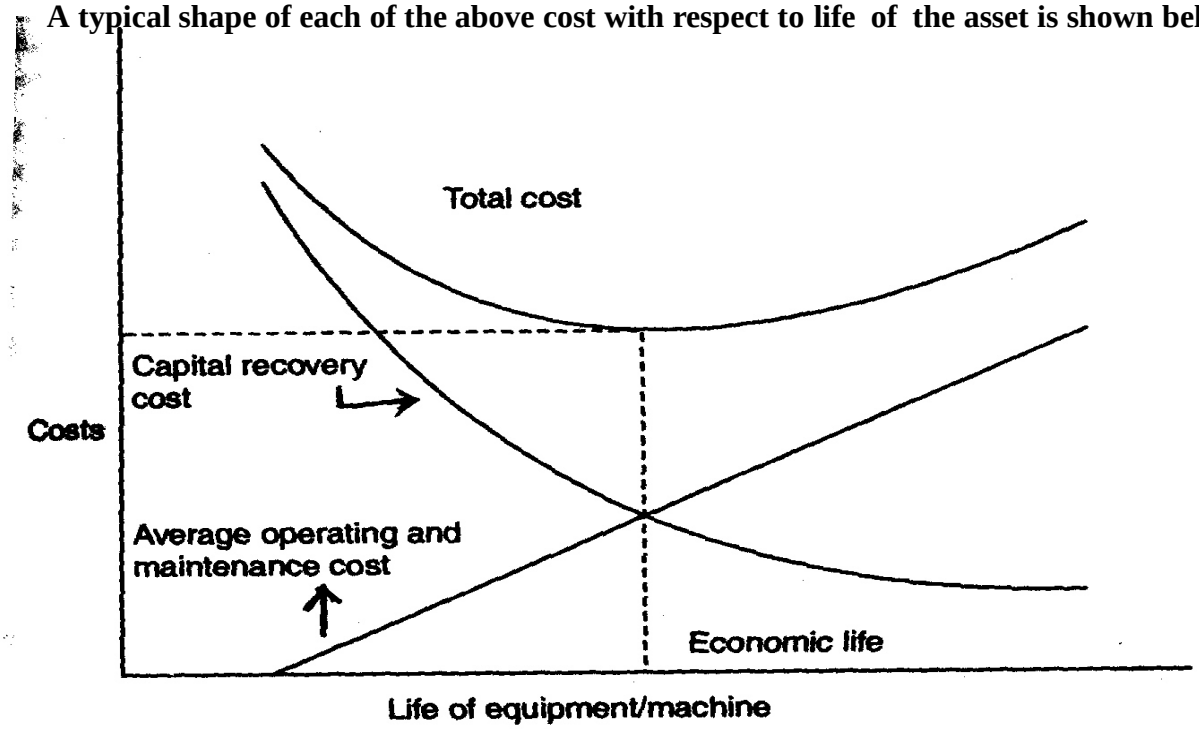


Fig. 13.2 Chart showing economic life.

From figure, when the life of the machine increases, it is clear that the capital recovery cost (average first cost) goes on decreasing and the average operating and maintenance cost goes on increasing. From the beginning the total cost goes on decreasing up to a particular life of the asset and then it starts increasing. The point P was the total cost in the minimum is called the Economic life of the asset. To solve problems under replacement, we consider the basics of interest formula.

Present worth factor denoted by (P/F, i,n). If an amount P is invested now with amount earning interest at the rate i per year, then the future sum (F) accumulated after n years can be obtained.

P - Principal sum at year Zero

F - Future sum of P at the end of the n^{th} year

i - Annual interest rate

n - Number of interest periods.

Then the formula for future sum $F = P (1 + i)^{n}$

$P = F/(1 +i)^{n}$ = Fx (present worth factor)

If A is the annual equivalent amount which occurs at the end of every year from year one through n years is given by

$$A = \frac{P \times i(1+i)^{n}}{(1+i)^{n} - 1}$$

$= P (A / P, i, n)$

= P x equal payment series capital recovery factor

Example:-

A firm is considering replacement of equipment whose first cost is Rs. 1750 and the scrap value is negligible at any year. Based on experience, it is found that maintenance cost is zero during the first year and it increases by Rs. 100 every year thereafter.

i) When should be the equipment replaced if (a) i = 0% & (b) i = 12%Solution :

Solution:

Given the first cost = Rs 1750 and the maintenance cost is Rs. Zero during the first years and then increases by Rs. 100 every year thereafter. Then the following table shows the calculation.

Calculations to determine Economic life

(a) First cost Rs. 1750 Interest rate = 0%

End of year (n)	**Maintenance cost at end of year**	**Summation of maintenance**	**Average cost of maintenance through the given year**	**Average first cost if replaced at the given year and**	**Average total cost through the given year**
		Cost			
A	**B (Rs)**	**C (Rs)**	**D (in Rs)**	**E (Rs)**	**F (Rs)**
		C = □B	**C/A**	**1750 / A**	**D + E**
1	0	0	0	1750	1750
2	100	100	50	875	925
3	200	300	100	583	683
4	300	600	150	438	588
5	400	1000	200	350	550
6	**500**	**1500**	**250**	**292**	**542**
7	600	2100	300	250	550
8	700	2800	350	219	569

The value corresponding to any end-of-year (n) in Column F represents the average total cost of using the equipment till the end of that particulars year.

In this problem, the average total cost decreases till the end of the year 6 and then it increases.

Hence the optimal replacement period is 6 years i.e. the economic life of the equipment is 6 years.

(b) When interest rate i = 12%

When the interest rate is more than 0% the steps to get the economic life are summarized in the following table.

Calculation to determine Economic life

First Cost = Rs. 1750 Interest rate = 12%

End of year (n)	**Maintenance cost at end of years**	**(P/F,12v,n)**	**Present worth as beginning of years 1 of maintenance costs**	**Summation of present worth of maintenance costs through the given year**	**Present simulator maintenance cost and first cost**	**(A/P, 12%,n) =i (1+i)^n (1+i)^n-1 G**	**Annual equipment total cost through the giver year**
A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
	B (iR)	**C = 1 (1+12/100) ^{n}**	**BxC**	**□D**	**E+ Rs. 1750**		**FxG**
1	0	0.8929	0	0	1750	1.1200	1960
2	100	0.7972	79.72	79.72	1829.72	0.5917	1082.6
3	200	0.7118	142.36	222.08	1972.08	0.4163	820.9
4	300	0.6355	190.65	412.73	2162.73	0.3292	711.9
5	400	0.5674	226.96	639.69	2389.69	0.2774	662.9
6	500	0.5066	253.30	892.99	2642.99	0.2432	642.7
7	600	0.4524	271.44	1164.43	2914.430	0.2191	638.5
8	700	0.4039	282.73	1447.16	3197.16	0.2013	680.7

Identify the end of year for which the annual equivalent total cost is minimum in column. In this problem the annual equivalent total cost is minimum at the end of year hence the economics life of the equipment is 7 years.

Simple probabilistic model for items which completely fail

Electronic items like bulbs, resistors, tube lights etc. generally fail all of a sudden, instead of gradual failure. The sudden failure of the item results in complete breakdown of the system. The system may contain a collection of such items or just an item like a single tube-light. Hence we use some replacement policy for such items which would minimize the possibility of complete breakdown. The following are the replacement policies which are applicable in these cases.

i) Individual replacement policy: - Under this policy, each item is replaced immediately after failure.

ii) Group replacement policy:- Under group replacement policy, a decision is made with regard the replacement at what equal internals, all the item are to be replaced simultaneously with a provision to replace the items individually which fail during the fixed group replacement perio**d.**

Among the two types of replacement polices, we have to decide which replacement policy we have to follow. Whether individual replacement policy is better than group replacement policy. With regard to economic point of view. To decide this, each of the replacement policy is calculated and the most economic one is selected for implementation.

Assignment

1. List and explain different types of maintenance
2. Discuss the reasons for maintenance.
3. Distinguish between breakdown maintenance and preventive maintenance.
4. Distinguish between individual and group replacement polices.
5. A firm is considering replacement of equipment whose first cost is Rs.4000 and the scrap value is negligible at the end of any year. Based on experience, it has been found that the maintenance cost is zero during the first year and it is Rs.1000 for the second year. It increases by Rs.300 every year thereafter.
   a) When should the equipment be replace if i = 0%
   b) When should the equipment be replace if i = 12%

   Ans . a) 5 years b) 5 years
6. A company is planning to replace an equipment whose first cost is Rs.1,00,000. The operating and maintenance cost of the equipment during its first year of operation is Rs.10,000 and it increases by Rs. 2,000 every year thereafter. The release value of the equipment at the end of the first year of its operation is Rs.65,000 and it decreases by Rs.10,000 every year thereafter. Find the economic life of the equipment by assuming the interest rate as 12%.
   [Ans : Economic life = 13 years and the corresponding annual equivalent cost = Rs. 34,510]

7. The following table gives the operation cost; maintenance cost and salvages value at the end of every year of machine whose purchase value is Rs. 12,000. Find the economic life of the machine assuming.
   a) The interest rate as 0%
   b) The interest rate as 15%

End of year	**Operation cost at the end of year (Rs)**	**Maintenance cost at the end of year (Rs)**	**Salvage value at the end of year (Rs)**
1	2000	2500	8000
2	3000	3000	7000
3	4000	3500	6000
4	5000	4000	5000
5	6000	4500	4000
6	7000	5000	3000
7	8000	5500	2000
8	9000	6000	1000

Ans :

a) Economic life of the machine = 2 years
b) Economic life of the machine = 2 years