

A DECISION SUPPORT SYSTEM ON EQUIPMENT REPLACEMENT

By

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Chapter 1

INTRODUCTION

1.1 Objective

Industrial enterprises, since the inception of operation, are faced with equipment maintenance, repair, change of parts and components and lastly replace the equipment. The replacement may be done with another equipment of similar design features or one, which has better output, less maintenance cost, less power consumption or technologically advanced one in one or the other way. The questions that arise during replacement of equipment are:

- To what extent is the upkeep of a machine to continue and when is it appropriate to replace the existing equipment?
- What are the driving forces for equipment replacement?
- What should be considered during equipment replacement?
- What preparations do we make before replacing an equipment?

These and the like problems should be dealt with, before the decision for replacement is made.

To reach the decision of replacement all the factors that affect the decision should be enumerated and analyzed. The analysis can be subjective or objective. However, in most

circumstances the objective factors are given less emphasis. This is because of the improper handling and processing data to get meaningful information that aids objective analysis and leads replacement to be at most economical time. In short, the idea of replacement should be raised when it is most economical rather than when the operational cost is very high.

On the other hand, the replacement of equipment from the economic point of view should be compared with the economy of an existing actual and realistic book value of the equipment rather than with its original first cost [2]. That is when replacement is considered (contemplated); the analysis should reveal the present realities and consider the future. Based on this framework the objectives of the thesis are:

- To investigate the economic advantages in implementing appropriate replacement process of equipment with physical impairment,
- To develop a system that can facilitate the decision making activities on the replacement of deteriorating equipment,
- To show how systematic data recording is advantageous on decision making,
- To strengthen systematic approach in analyzing problems related with equipment replacement.

1.2 Methodology

Even though the problem of equipment replacement was clear, understood and experienced by the student there has to be concrete data to portray this. To do so the following methodologies were employed to get necessary information.

- Data were collected from two industries such as review reports on maintenance related activities, capital budget etc.,
- Literature survey were made,
- Electronic information retrieval on relevant issues collected,
- Discussion with experienced professionals and entrepreneurs were made,
- Review the existing methods and policies employed on equipment replacement and,
- Data analysis (desktop research) was made.

1.3 The Importance of Replacement System

A valid replacement theory and application is important in [18]:

- Providing the organization with a means for controlling the borrowing and expenditure of capital,
- Establishing and controlling better operating rates and costs,
- Offering solutions to the scheduling of equipment maintenance and the design of system-reliability problems,
- Offering opportunities in organizations for sizable payoffs at reasonable levels of investigative effort.

Chapter 2

LITERATURE REVIEW

This chapter indicates brief historical development of equipment replacement systems and some of the attempts and models of replacement problems that have been formulated for equipment that are subjected to degradation or deterioration through operation. Further the application of principles of replacement, assumptions made on equipment replacement tools and methods employed on equipment replacement are covered.

2.1 Historical Development of Equipment Replacement

The theory of renewal and replacement and mathematical theory of failure have been developed over the past 100 years. The early replacement decision rules that were in use were not based on the development and solutions of mathematical models. These rules, such as replace when equipment is fully depreciated, replace when the unit cost of production is maximum or replace when equipment is worn out etc. which are in use even today, have never been established as an optimal solution to any situation[2].

Today the theory is related to the characterization of a process as one of an established class and the estimation of the values of the relevant functional parameter. The early developer of a theory for equipment replacement model based on explicitly stated assumptions of a linear operating-cost function that is time dependent with known constant parameters values was Terborgh in 1949. It was after Terborgh that extensive studies and models formulated on equipment replacement depending on the prevailing situations. The studies followed have divided equipment replacement studies to be for items that deteriorate and items that fail suddenly with out remarkable decrease in performance [2].

2.2 Assumptions of Replacement models of Items that Deteriorate

Deterministic models have been developed for most problems. An analytic or mathematical form is established,

$$E = E(X_i, Y_j)$$

which relates the system's performances as measured by E to the values of the control variables X_i and the uncontrollable variables Y_i . The Y_j are usually expressed in terms of the time parameter t where $Y_i(t)$ is assumed to be a known function of t. The major assumptions made for measuring of system performance and developing a model were generally based on one of the following objective functions in quantitative terms[2].

- The cost or return during a specified period of time.
- The average cost or return per time period.
- The present value of the discounted future costs or returns,

- The average number of items produced or used per maintenance

The control variables are specified as one or more of the following:

- The life of an item,
- The selection of alternative items to acquire,
- The methods or procedures for replacement or maintenance,

In some cases, solutions have been developed in policy form. That is, the solution is expressed as criteria for replacement or as procedures to be employed in solving a class of similar problems. In most cases the data required to solve replacement problems can be found in the history of the system's previous performance supplemented by estimates of its future performance[2].

2.3 Some Models Developed

Terborgh's Model

Terborgh (1949) was the first to develop a theory for equipment replacement based on explicitly stated assumptions of a linear operating cost function that is time-dependent with known constant parameter values. He presented procedures for comparing current equipments with challengers and descendants[31].

$$E = \frac{(n-1)}{2} c + \left[\frac{A-S}{n} + \frac{r}{2} (A+S) \right] \dots\dots\dots 2.1$$

Where C = the inferiority gradient, or the constant rate of cost accumulation due to operating inferiority

A = the acquisition cost

S = the salvage value

r = the rate of return on capital investments within the firm

n = the age of the equipment

The combined cost per year E is a sum of two terms; the first increases with equipment age (operating inferiority) and the second decreases with increasing age (capital cost). The first term in the brackets of 2.1 is the average capital cost per year. The second term in the bracket is approximately the average yearly cost of money over the period calculated by taking the cost of $(A-S)$ for a period of $n-i$ years, in which payments are made annually, plus the cost of borrowing S amount of money for n years.

In a research project conducted by the Machinery and Allied Products Institute (MAPI), Terborgh extended his earlier work to cover general problems of capital investment. The reformulation and extension of the basic principles are applied to the acquisition of plant and equipment for the purposes of improving existing processes and of introducing new processes.

Grant's Model

Grant (1950) discusses in qualitative terms the problem of when existing equipment should be replaced on the basis of inadequacy, obsolescence, excessive maintenance, and declining efficiency. He summarizes the qualitative formulations to date and presents procedures for analyzing and reaching solutions to the economic-replacement problem where:

- More efficient equipment is introduced before replacement,

- The value of money is constant over the life of the equipment, and
- The annual operating costs are non-decreasing.[14]

Dean's Model

Joel Dean (1951) was the first to state explicitly that capital investments for replacement purposes ought to compete with other investments the firm is capable of making. He argues that the return on investment should be used to evaluate alternative possibilities of capital investment. The combined cost for current equipment (the sum of relevant operating costs and the capital-wastage cost) is expressed as a function of equipment age. Replacement occurs when the combined costs equal the average cost per year of the new equipment plus the annual return on the capital outlay for the new equipment less the salvage value of the old equipment. The point of replacement occurs after the annual cost of the old equipment exceeds the average cost per year of the new equipment.

Orenstein's Model

An interesting result developed by Orenstein (1956) in the event of equal depreciation payments is that the economic life is independent of rate of return for an annual-cost-minimization model. Orenstein considers three costs [27]:

1. Acquisition cost, A .
2. Annual rate of return on capital, r .
3. Linear operating cost, $F+dt$.

He defines the economic life as one that minimizes the average annual sum of the above,

$$E = \frac{A}{t} + r \frac{A}{2} + \left[F_t + \frac{t(t+1)}{2} d \right] \frac{1}{t}$$

$$\frac{dE}{dt} = -\frac{A}{t^2} + \frac{d}{2} = 0 \quad \dots\dots\dots 2.2$$

$$t_o = \sqrt{\frac{2A}{d}}$$

The economic life is then the value of t_0 such that

$$\frac{dt_0}{2} = \frac{A_0}{t_1} \quad d = \text{increase in operating cost}$$

or the average increase in operating cost is equal to the annual depreciation value of the equipment. The selection of alternative equipments would depend on the minimum values of the total average costs over the life of each. Obsolescence is considered to be introduced by increasing the interest rate, decreasing the life expectancy, or decreasing the salvage value.

Sandiford, Bernholtz, and Shelson Model

The models considered so far have assumed analytic forms for the cost functions. Sandiford, Bernholtz, and Shelson (1956) considered arbitrary values for the annual costs and developed numerical, iterative procedures for determining the economic life of vehicles. The measure of performance chosen was the average annual cost over the replacement interval. The optimal policy was use of that replacement interval which minimized the average annual cost, to be determined for each group of vehicles [30].

The total average cost C was considered to be the sum of capital wastage (acquisition cost less salvage value), interest, repair costs, and un-serviceability costs. Values of C were calculated

from historical data for each vehicle class by taking the cumulative averages and the minimum obtained by inspection. The authors used historical data to obtain optimum replacement intervals.

Clapham's Model

A cost-minimization model that neglects opportunities for alternative investments was developed and solved by Clapham (1957) [2]. He determines the economic lives of locomotives and cars used in English coal mines by minimizing the average annual sum of capital depreciation and maintenance costs $K(t)$ where;

$$K(t) = \frac{A}{2} + \frac{1}{t} \int_0^t f(x) dt \quad \dots\dots\dots 2.3$$

A is the acquisition cost, A/t is the annual capital depreciation, t life of the equipment and $f(x)$ is the annual maintenance cost of equipment of age x . This model doesn't consider discounting.

The Analogue of Fetter and Goodman

Fetter and Goodman (1957) have developed an electronic analogue of the equipment-replacement model and have used it to solve the cost-minimization model formulated by Terborgh as one application. In addition, a number of models are developed where the solution is that replacement interval that maximizes the present value of all future returns from the firm's use of equipment[12].

Rilas's Model

Rilas (1957) has developed a discrete-replacement theory that compares alternative policies for replacement on the basis of discounted value of all future costs associated with each policy.

Elmaghraby's Stochastic Conversion

Elmaghraby (1958) has indicated the need for considering obsolescence of equipment and, therefore, for converting deterministic models into ones that are stochastic. His method of converting an exact-replacement model into a stochastic one involving uncertain demand is to assign confidence weights to the demand parameter in accordance with company expectation and to compute a replacement policy that maximizes the expected return.

Barber's Probabilistic Returns

Barber (1958) has presented a method for introducing probabilistic functions for returns, as forecasted by manufacturing engineers, to determine the economic feasibility of purchasing an automatic machine. By weighting the possible payoffs with the probability of achieving the payoff, and comparing the expected return with the rate of return on other corporate investments, the machine to be purchase is decided.

2.4 Latest Developments

The importance and cruciality of equipment replacement decisions is one of the major challenges to organizations where the outcome is directly reflected on the organizations change on production costs/rate, changes on the financial statement or change on capacity of proper utilization of throughput etc. Latest development on equipment replacement decisions is fully supported with the available tools, computers, to handle and process data to get meaningful information. Due to its importance by this time the historical data handling system is made to be accessible to every one who is ready to use it. To mention one is the Asset tracking template presented by Microsoft Corporation, Database in Microsoft Access fig.2.1.

Nowadays the study on equipment replacement is focusing on implementation method and systems. Due to this the studies made are more specialized to specific firms.

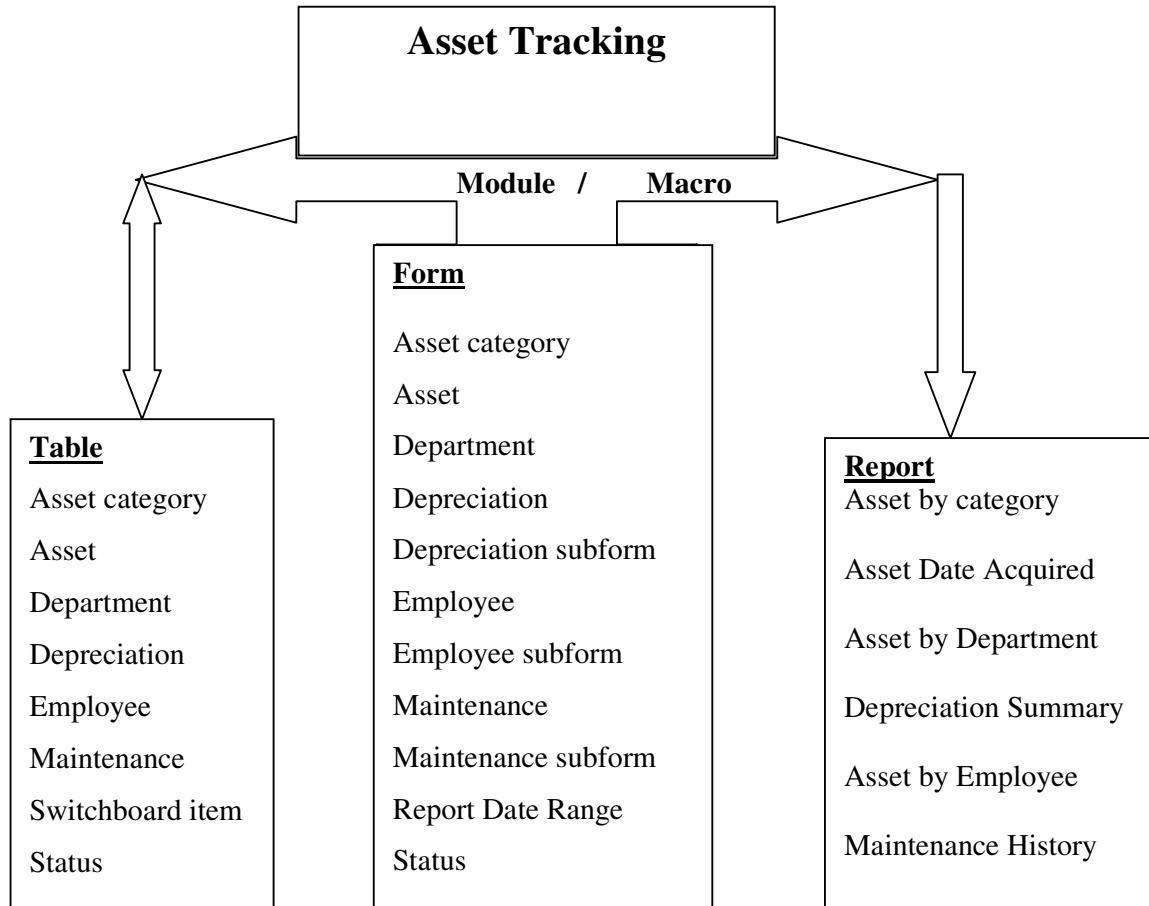


Figure 2.1 Asset tracking

Chapter 3

PRINCIPLES OF EQUIPMENT

REPLACEMENT

3.1 The Problem of Replacement

The problem of replacement arises after an industrial enterprise or project has been in operation. The rate of replacing of equipment may vary due to internal factors such as, sensitivity of the working area, and external factors such as competition. Depending on the internal and external factors replacement problem can be due to the following reasons [7].

1. Replacement because of inadequacy

Equipment that is inadequate in capacity to perform the required service is a logical candidate for replacement. The inadequacy in the amount and type of service requirements can be due to:

- An increase or decrease in the amount of service required from the asset,
- An increase or decrease in the demand for its product or service,
- Changes that may arise from competitive situations either from competition among producers on a single industry or competition, which may arise with substitute products,
- Act of public authority etc.

2. Replacement because of excessive maintenance (wear and tear)

A machine rarely has all of its elements worn out at one time. Due to this, it is economical to repair many types of parts in order to maintain and extend the life of the equipment and its usefulness. Some of the repairs are minor in extent while some are periodic and extensive. The sum of these maintenance costs may be big enough to demand replacing the equipment.

3. Replacement due to obsolescence

Obsolescence can be economically or functionally. A new and improved design can render existing equipment obsolete economically. A decrease/increase in demand might result in the present equipment (having higher/lower capacity) being obsolete functionally

since new equipment having higher/lower capacity is available to accommodate the new demand level. On the other side the availability of improved machines performing the same service with more economical ways and methods will pay to replace old assets with new ones or to relegate them to stand-by purposes or other inferior uses for better economical advantage. Further equipment can be obsolete if it is no more under manufacturing.

4. Physical impairment

Equipment may be out of operation or perform less than expected due to damage or improper handling.

5. Rental or lease possibilities

The development of equipment rental firms has caused some owners to change from an ownership role to a lease role with regard to some expensive but infrequently used equipment.

6. Change in public requirements regarding the machine or the product.

7. Sudden failing equipment

These equipment perform at about full capacity until failure.

The main reasons for equipment replacement can be divided into three broad categories:[14]

- Wear out (equipment that deteriorate with time),
- Sudden failures,
- Obsolescence.

3.2 *Wear out items*

The problem of replacing various worn out spare parts of equipment is one, which arises in every Organization. In some cases, instead of changing spare parts of an equipment, it may be more economical to replace the equipment altogether specially if it has deteriorated with constant use. To know whether it is feasible or not, economic analysis is very important.

As equipment gets worn out with time and usage it functions with decreasing efficiency. Failure of equipment that are subjected to wear and tear (deterioration) is easily predictable. On this type of failure, maintenance or upkeep of this equipment is usually practiced. Due to the predictability of failure behavior changes on operating or maintenance cost or both can easily be guessed. Likewise replacement policy should focus in analyzing the operating and maintenance cost. Based on the analysis two conditions may be anticipated [3].

- If the cost of operating and maintenance remains the same or decreases with time the best policy is never to replace the item. This condition is hardly met in real situation.
- If the costs fluctuate with time, the equipment should be replaced only when the cost is in increasing trend.

Generally, costs of industrial equipment increase with time or age. Even though the increase in cost necessitates replacement of the equipment, the rate of increase in cost may vary from item to item. Due to varying rate in cost increase during operation, there is no clear and defined time, which indicates the replacement of the equipment. Replacement of equipment requires calculating the increase in operating costs, maintenance costs, forced idle time costs and costs for replacing by new equipment.

Thus, at some stage it may be more economical to discard the old equipment and replace it with a new one. The following factors should be taken into consideration while formulating an appropriate system for replacing equipment [23].

3.2.1 Rate of Inflation

The price of an equipment does not remain steady with time. Thus, while formulating a replacement policy, this factor should be taken into consideration. It can be considered by assuming a certain rate of inflation. Thus, if the rate of inflation is (i) percent, then the price of the equipment C_n after n years given that the present price C is

$$C_n = C(1+i)^n$$

3.2.2 Discount Factor

As the money value changes with time the calculation of equipment replacement should include the interest rate (rate of inflation to have the present value of the money to be spent in the future). [23]

Suppose the interest rate available in the market is r percent. Then, instead of spending an amount C today we may obtain $C_1 = C(1 + r)$ a year from now, $C_2 = C(1 + r)^2$ two years from now and $C_k = C(1 + r)^k$ k years from now. Looking from another point of view, an amount C_k spent k years from now is equivalent to spending an amount C today. That is

$$\begin{aligned}
C &= C_k (1 + r)^{-k} \\
&= C_k V^k
\end{aligned}$$

where $V = \text{the discount factor } (1+r)^{-1}$

3.2.3 Operating Cost

Equipment incurs certain costs while in operation. It may be due to the application of some ingredients like lubricant or fuel or due to maintenance etc. There are empirical evidences that such operating costs increase with increasing age due to a variety of reasons such as deterioration of components or wear and tear. Basic data on operating costs are necessary to ascertain whether it is too high compared to acquisition cost or not [7].

3.2.4 Depreciation

Depending on its use depreciation has different meanings. Some of them are [14].

1. Decrease in value. This concept implies that the value (market value or value to the owner) of one asset is computed at two different dates. The difference is the depreciation regardless of what combination of causes may have been responsible for the value change. This is the meaning generally implied on every day speech.
2. Amortized cost. It is an accounting concept of depreciation where the cost of an asset is a prepaid operating expense to be apportioned among the years of its life by some more or less systematic procedure. It should be emphasized that it is the cost not the value that is allocated.

"Depreciation accounting is a the system of accounting which aims to distribute the cost or other basic value of tangible capital assets, less salvage (if any), over the estimated useful life of the unit(which may be a group of assets) in a systematic and rational manner.

It is a process of allocation not of evaluation."[18]

3. Difference in value between an existing old asset and a hypothetical new asset taken a standard of comparison. This is an appraisal concept of depreciation and money appraisals of old assets. Appraisal depreciation means the value of inferiority at some particular date (date of appraisal) of one asset, the existing old one being appraised to another asset, a hypothetical new one used as basis of valuation.
4. Impaired serviceableness. As machines become older they are often unable to hold a close tolerance as when they were new. Similarly, the strength of structures may be impaired by the decay of the corrosion of metal members. This is sometimes called as depreciation to refer impaired functional efficiency. It is not commonly used.

Common depreciation accounting methods

There are many different methods of writing-off cost. One common way of classifying depreciation accounting method is:

1. Methods that aim to give a greater write-off in the early years of life than in the final years of life such as declining- balance method, the sum of-the-digits method, Multiple-straight-line method.
2. Methods that aim to give a uniform write-off through out the entire service life, straight-line method.

3. Methods that aim to give a smaller write-off in the early years of life than in the final, sinking-fund method.

a. Declining-Balance Depreciation Accounting

It is common practice for assets to be used as stand-by or inferior uses during their final years of their lives. Due to this their contribution is decreased. Equally the writing-off also is made to decrease by using the declining-balance depreciation method. In declining-balance depreciation method a given depreciation rate is applied each year to the remaining portion of the cost of the asset (book value). For example, if a 10% rate is applied to an asset that costs \$35000.00 first year depreciation will be $\$35000.00 \times 0.1 = \3500 . The second year cost will be $(35000.00 - 3500.00) \times 0.1 = \3150.00 and the third year cost will be $(35000.00 - 3500.00 - 3150) \times 0.1 = \2835 and so on.

b. Sum of- the-Years-digits Deprecation Accounting

The digits corresponding to the number of years of estimated life are added together. For example, considering a machine having estimated life of 20 years, initial cost of \$35000, and salvage value of \$3500 the sum of the digits from 1 to 20 is 210. The depreciation charge for the first year is $20/210$ of the $(\$35000 - \$3500)$ and in the second year the depreciation charge is $19/210$ of $(\$35000 - \$3500)$ and so on. This method writes-off about $\frac{3}{4}$ of the depreciable cost in the first half of the estimated life.

c. **Straight-Line Depreciation Accounting**

In straight-line method, the full service life and the net salvage value at the end of its life are estimated. The annual depreciation rate to be applied to the first cost of the asset being written-off is computed as follows:

$$\text{Straight – line depreciation charge} = \frac{\text{Initial cost – estimated Salvage value}}{\text{estimated service life in years}}$$

Straight-Line depreciation method is the most conservative practice in evaluating the depreciation cost in economic studies.

d. **Sinking-Fund Depreciation Accounting**

A real or imaginary sinking fund is established and a fixed deposit is made in the fund at the end of each year (annual depreciation cost) in the life of the asset. The deposit is so computed that the amount put into the fund plus the interest earned on it will just equal the amount by which the asset is to be depreciated. The amount in the fund at the end of the life period is to be equal to the depreciated value of the equipment or the difference b/n first cost and salvage value [7].

$$\text{Sinking fund amount} = \text{First cost} - \text{salvage value}$$

$$\text{Annual depreciation cost} = [\text{sinking-fund amount}] \times \left[\frac{i}{(1+i)^n - 1} \right]$$

Where i = Interest rate

n = estimated service life

When the rates of interest approaches zero the sinking fund method yields the straight line method.

3.2.5 Salvage Value

Salvage value is the secondhand value of equipment. It is determined after giving consideration to some or all of the following [7]:

- a. Present condition of the equipment; Good condition of the components of the equipment increases the salvage value, while poor condition reduces it.
- b. Selling price of new equipment of similar grade; If the price of new equipment remains at a uniform level, the salvage value will be equivalent to the original cost minus the depreciable value as affected by its condition. If, however, the price of the new equipment has increased materially, the salvage value may be equivalent to the present price minus the depreciable value as affected by its condition. Thus the salvage value may approach and even be greater than the original cost of the equipment. Of course, if the price goes down, the opposite will result and the salvage value will be very low.
- c. Reason for selling; The buyer of secondhand equipment is suspicious of the seller. He is afraid that a poor buy is being unloaded on him. He suspects that the reason for selling may be that the equipment has been inefficient in its operation or has some other objectionable feature.
- d. Cost of removal; The salvage value of the piece of equipment may be fairly high. The cost of removal may, however, be of sufficient amount to reduce materially the salvage value. The cost of removal will depend greatly on the location of the equipment. Removal from locations that are hard to get at or from those that involve shifting other

equipment may be very costly. If it is impossible to move other equipment easily, the ease with which the equipment may be disassembled or broken up will affect the cost of removal materially.

- e. Supply and demand; Supply and demand will affect the salvage value. The nature of the market helps materially to set the price or value. In a seller's market the buyer must pay if he wishes the equipment. In a buyer's market the seller is at the mercy of the buyer. If the market is about even, neither one has the advantage over the other. The market price thus arrived at is a fair price.
- f. Special or standard; The nature of the equipment-the degree to which it is specialized will affect its salvage value. Standard equipment, namely, one that does not change rapidly in its design or in its functions, may generally bring a higher salvage value than more specialized equipment.

Generally salvage value of equipment depends upon its age. The salvage value may be predicted from experience or by using a suitable rate. If it is assumed that the salvage cost reduces by a fraction k per year then an equipment having a value C will have a salvage value S_n after n years, where

$$S_n = C(1-k)^n$$

Sometimes the devaluation of machinery is compounded m times a year so that

$$S_n = C \left(1 - \frac{k}{m} \right)^n$$

A general replacement policy on deteriorating equipment indicates the best period of replacement from the financial point of view to be when the equivalent uniform annual cost starts to increase [31]. But for heavy capital-intensive equipment with little resale value such as a generator, it should be used as long as possible, until the maintenance cost becomes excessively high. A capital item with a significant resale value such as a car should be replaced keeping the resale value in mind.

3.3 Sudden failures

In real life there are situations where items do not deteriorate with time but fail suddenly. These equipments perform at about full capacity until sudden failure. These categories of items are mostly low cost items. The cost incurred due to failure of these items in operation may be quite higher than the cost of the items. The problem with these items is that until failure there is no any indication, which shows physical damage. Due to this preparation can't be done before unnecessary expense is incurred.

Therefore, it is important to know in advance as to when the failure is likely to take place so that the item can be replaced before failure. Quite often it is not possible to predict time of failure by direct inspection like that of wear out items. The time of failure can be predicted from the probability distribution of failure of past experience. The problem is then to optimize the time, which minimizes the total cost to be incurred. That is, it is to minimize the sum of the costs of the items, cost of replacing the items and cost associated with failure of the items. Such type of replacement system is called preventive replacement.

Preventive replacement is a procedure, which provides for replacement after a time when the effect of aging has become sufficiently critical, even if the actual failure has not yet occurred. It attempts to optimize the trade-offs between costs of pre-emptive replacement and costs of failure. Preventive replacement is desirable under the following conditions:

- The cost of sudden failure is high relative to that of preventive replacement.
- The component or the spare part which is being replaced during preventive maintenance has a life x which is a stochastic variable or the probability distribution of life has an increasing failure rate (IFR).

Based on this principle there are two types of replacement policies.

3.3.1 Individual replacement policy

It is a replacement policy in which replacement is performed individually depending on the failure rate or mortality table obtained from a large sample basis.

3.3.2 Group replacement policy

Sometimes an Organization contains a large number of identical low cost items that are increasingly liable to failure and there is a set up cost for replacement which is independent of the number replaced. In such cases, it may be more economical to replace all items in a group or block as a preventive measure. It is assumed in-group replacement that the value of individual item is so small that the cost of keeping records of individual ages of failure can't be justified. In the course of group replacement all items in the group are replaced including

some, which may be almost new. The typical example is the replacement of light bulbs in a large office where the replacement of every single bulb at failure becomes rather expensive. In this case, taking a specified time the entire group of items is replaced periodically. By using group replacement, individual failures and replacement between two successive periods become fewer in number.

3.4 Obsolescence

In addition to the reasons mentioned in section 2.2 equipment may become obsolete due to different reasons.

1. The equipment may be fit for operation intended or it may perform the designed standards. But due to technological advancement better equipment may be designed which performs the job with less cost and better safety or the manufacturer might have changed the product type so that spare part sourcing may be difficult.
2. Obsolescence may be created due to loss of market of the product of the equipment. That is the product may lose value because of new product came into the market which customers prefer.

The greatest obstacle in developing a replacement policy for equipment that fail due to obsolescence is that predicting the economic effect of future technological progress in that field. The progress in technology may be gradual, long run improvement or frequent dramatic advancement, which have revolutionary effect [21]. On the latter case it is very difficult to predict very far in the future. Better prediction of the future can be made of the more gradual types of technological advancement but only with great difficulties in some area. In some studies for equipment with gradual technological progress it is taken to be linear prediction,

which relatively is very simple to analyze. With this assumption it is possible to answer the question what is the economic life of equipment that is one of a technologically developing sequence having a constant rate of improvement over time.

As the nature of failures is of different types the replacement system is also different. This paper fully focuses on the first failure nature or on replacement of capital items that deteriorate with time and operation.

3.5 Life of an Equipment

The life of an equipment subjected to wear and tear can be determined by two ways [32].

1. Economic life time – it is the time where a durable item terminates to function at the point where repair and operation cost exceeds replacement cost.
2. Technical life – it is the time where a durable item ends its service/function at the moment when repair is physically impossible. Most items may continue to function for quite a long period if the technical life is considered as the criterion for replacement.

3.6 Assumptions in Equipment Replacement

The formulation and implementation of a good replacement policy plays a major part in the determination of technical and economical progress of an organization. Inadequate replacement policy, on the other side, may be disastrous to a firm. To defer the replacement of

equipment sometimes may lead to a decline in output and in the long run a business recession may be eminent.

Replacement of equipment depends on different factors and some of the factors are not easily determined or expressed and do not force us to take action at certain fixed time. Therefore an assumption, which can reflect the reality and simplify the analysis of replacement policy, is very important. Some of the major issues that need assumption are [21]:

1. Planning Horizon

It means the points of time furthest, in the future which is considered in the formulation of the policy. It can be divided into two.

- Finite planning horizon where the Industry/project will have a definite and predictable duration and that the formulation of replacement policy might be more realistically based upon.
- Infinite/indefinitely removed planning horizon- An assumption used when we simply are unable to predict when the activity under consideration terminate.

2. Technology

Refers to the development of the innovative measures made on machines, which are candidates to replace those under operation. If the assumption of future machines that replace the existing once were to be the same then we are saying there will be no technological progress in the area. However we may wish to recognize that machines which will be available in the future are more efficient, reliable, or productive than those on the market. This assumption leads to recognition of obsolescence. The problem is, of course, to quantify the phenomenon of obsolescence so that it can be applied analytically to the formulation of a policy.

3. Prediction of cost patterns over asset life

A variety of predictions might be made of revenue, cost, salvage value, and so on over the life of an asset. For example revenue can be assumed constant, costs non-decreasing etc.

The most accepted assumption is that operating and maintenance costs do not decrease with age and salvage values do not increase with age.

4. Interest rate

Interest rates are assumed to be non zero in order to obtain finite costs

5. Availability of capital

Replacement policy would have to recognize the limited availability of funds. It may need to introduce a pattern of capital availability over time and the cost of additional capital by various means. The major sources of funds for an industry are internally, depreciation and retained earning and externally commonly from stock, preferred stock, bonds leases, conditional sales, bank loans etc.

These varieties of issues may suggest to a large number of different possibilities for developing replacement policies and models. For example if an item is assumed to have no salvage value the model to be developed is different to from the one, which do have a salvage value.

3.7 Tools Used in Replacement Decision

3.7.1 Factors in the Replacement Problem.

Assuming that the proposal is to replace a machine by another one, the factors to be considered for both equipments will be somewhat as follows:[7]

<u>Present equipment</u>	<u>Proposed equipment</u>
1. First cost	First cost
2. Operating cost	Operating cost
3. Life, estimated	Life, estimated
4. Income, or expected profit and income tax	Income, or expected profit and income tax
5. Salvage value, end of life	Salvage value, end of life
6. Production rate per year, Number of pieces	Production rate per year, Number of pieces
7. Available funds in reserve for depreciation	Available funds in reserve for depreciation
8. Present age	Technology
9. Reasons for replacement.	compatibility
10. Salvage or resale value at present age (in-place value)	Availability Reasons why this is a good replacement

3.7.2 The Three Main Methods for Justifying Equipment

Replacement

It is mentioned that as a unit of equipment age increases, operating and maintenance costs increase. At the same time, the capital recovery cost decreases. The combination of decreasing capital recovery costs and increasing annual operating and maintenance cost results in the equivalent uniform annual cost.

By forecasting the operating and maintenance costs for each year of service, as well as the anticipated salvage values for various replacement ages, one can determine the replacement interval for an equipment. Based on this, there are three main methods of justifying equipment replacement

1. Calculate the average cost per hour of operation

Since each piece of equipment has its own identification number, the method of computing costs against each of the coded machines is to tabulate the total hours the machine has been utilized and the repair, maintenance, and fuel or power costs for the machine. This gives an average cost per hour of operation that can be compared to the repair and maintenance costs that have been tabulated for the whole equipment in the system. Equipment whose expenses are much higher than the average of the total equipment in consideration should be replaced. The estimate of the savings to be derived from replacing such older equipment would be the justification.

2. Calculate the increased operating costs per hour

Equipment replacement can be justified in another manner by increased cost per hour of operation. By carefully tabulating all of the costs incurred for each piece of equipment and making a chart for each equipment the curve that is formed by the cumulative costs per certain fixed intervals of operation will indicate the manner in which, as the equipment ages, it will increase in hourly operating costs per specified hours. In this method, equipment

replacement is justified when cumulative costs show a sharp increase over the prior fixed intervals.

3. Calculate the lowest total cost point (LTCP)

The lowest total cost point or the LTCP concept is based on the fact that a cost curve can be made for each of equipment as shown in figure 3.1. This total cost curve is derived by charting the sum of the cumulative maintenance cost per specific time and the cumulative ownership cost per specific time of operation. By projecting the total cost curve into future, it is possible by extrapolation, to plan an equipment replacement before major repair become necessary. It is possible to derive the ownership cost curve by decreasing the purchase cost at a certain declining rate. The cost curve for maintenance indicates the total amount spent in maintaining the unit in operating condition. All normal wear and tear items are included in maintenance costs except those repairs, which are caused by the operator's abuse.

The total cost curve for a particular unit is obtained by adding the maintenance cost curve to the ownership cost curve. The point needed is that period in which the equipment will be operating at its lowest total cost. After the lowest total cost point the equivalent uniform annual cost curve starts to rise that is the equipment starts to consume progressively the revenue generated. Even though the cost curve will begin to rise, and it is at this time that the equipment will be ready for replacement, it does not mean that it is the cutoff point for replacement of the equipment.

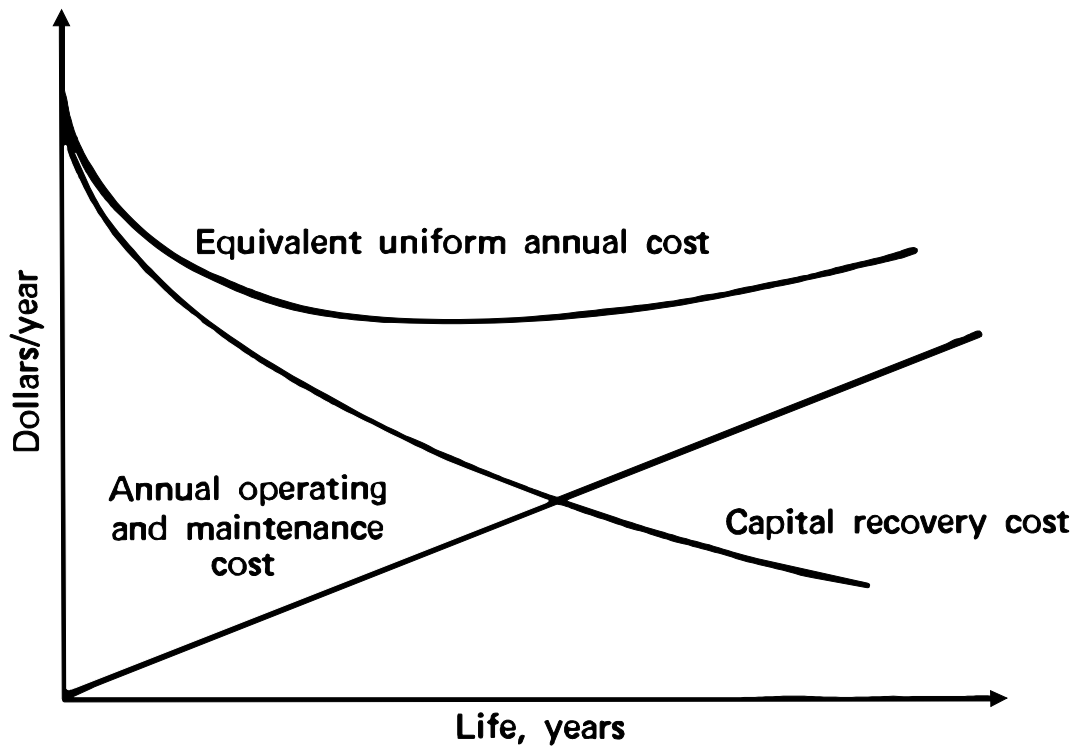


Fig.3.1 LTCP

In the first two methods the replacement of the equipment is made only after incurring expense to repair the equipment. This is the cost, which drives the price per hour of operation up beyond the economic range. Method three anticipates increased repair costs and recommends replacement before these expenses are incurred.

The benefits in using the LTCP method for equipment replacement are:

1. Consistency: the LTCP method provides a consistent way of determining when to trade in equipment. It eliminates the very subjective approaches that are sometimes made by plants in replacing equipment, since it provides definite guidelines and formalizes the entire procedure on a sound economic basis.

2. Eliminates costly major overhauls: when the LTCP is charted, you can predict trends in equipment behavior and make forecasts, thus enabling you to extrapolate to forecast equipment requirements. For example if the Equipment were nearing the LTCP, then it would not be advisable to spend large sums for major overhauls. On the other hand, if the LTCP is not forecasted to be imminent, then it might be decided to go ahead with an equipment rebuild than preparing for replacement of the unit.

3. It minimizes general maintenance

When the LTCP method is used the reports of maintenance and operation enable to single out high maintenance cost units. The LTCP charts provides an opportunity to look at the equipment in retrospect and examine specifications, the operating conditions, and to ascertain the reasons why the cost for particular equipment is either out of line or is working in a hostile environment.

4. Equipment justification

Using the LTCP method is one way of helping to prepare requests for capital funds, since it gives more credibility to the justification of equipment.

5. Budgeting

The LTCP method enables to forecast equipment requirement in a manner that tells when to replace the equipment. The knowledge of when the equipment will be required and the necessary funding that take place requires time. The LTCP gives time to place the request in budget, get approvals, and have the equipment placed in the manufacturer's schedule for construction, thus reducing sometimes delayed delivery times and higher prices. The advance notice that LTCP can give management serves as a much-needed forecast for equipment expense.

3.7.3 Equivalent Uniform Annual Cost

Putting in to account all costs that depend upon the choice or age of the equipment a replacement model can be developed. However, if the cost do not change with the age of the equipment (such as electric cost and labor cost in some special cases) it may not be included in the calculation.

Considering the general condition where maintenance and operation costs increase with time and money value also changes with time the present value of money to be spent a few years hence can be calculated.

- Let
- C = capital cost of the equipment
 - T_{ave} = average annual total cost of the equipment
 - S = salvage value of the equipment
 - n = number of years the item is to be in use
 - $f(t)$ = operating and maintenance cost of the item at time t .
 - i = sum of rate of interest and inflation
 - v = discount factor
 - $R_1, R_2, \dots R_n$ = running cost in first, second,.....nth years
 - P_n = the amount of money required now to pay all future costs of acquiring and operating the machine.

Present value of money n years hence is

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

$$= v^n$$

where

$$v = \frac{1}{1+i}$$

Assuming Salvage value to be zero and all payments are made at the beginning of each year, the present value of expenditure in n years is

$$P_n = C + R_1 + vR_2 + v^2R_3 + \dots + v^{n-1}R_n \dots\dots\dots$$

3.1

P_n increases as n increases which means that the present worth, if the machine is replaced after n+1 years is greater than after n years. Thus for any additional amount spent we get extra years service. We are there for, interested in finding some function of the replacement interval which allows for this.

Let us assume that the owner invests the amount P_n is borrowed money at the interest i and repaying it off in fixed annual payments, each of value x, throughout the life of the machine.

Thus after n years total cost P_n of the machine will have paid off.

The present worth of fixed annual payments, each of value x for n years is

$$x + vx + v^2x + \dots + v^{n-1}x = \frac{1-v^n}{1-v}x.$$

Since this is equal to the sum P_n borrowed,

$$P_n = \frac{1-v^n}{1-v}x.$$

$$x = \frac{1-v}{1-v^n} P_n \dots\dots\dots 3.2$$

Thus the best period to replace the machine is the period x which minimizes x. however, since

$1-v$ is a positive constant the period at which to replace the machine is the period which

minimizes $F_n = \frac{P}{1-v^n}$. Since n can have only discrete values, method of finite differences approximation can be used to calculate its optimal value. by this method, n will be optimal that is F_n will be minimum if

$$\Delta F_{n-1} < 0 < \Delta F_n \quad \dots\dots\dots 3.3$$

Now $\Delta F_n = F_{n+1} - F_n \quad \dots\dots\dots 3.4$

$$\begin{aligned} &= \frac{P}{1-v^{n+1}} - \frac{P}{1-v^n} \\ &= \frac{(1-v^n)P_{n+1} - (1-v^{n+1})P_n}{(1-v^{n+1})(1-v^n)} \\ &= \frac{1}{(1-v^{n+1})(1-v^n)} \left[(P_{n+1} - P_n) + (v^{n+1}P_{n+1} - v^n P_{n+1}) \right] \dots\dots\dots 3.5 \end{aligned}$$

Further $P_{n+1} = (C + R_1 + v R_2 \dots v^{n-1} R_n) + v^n R_{n+1}$

$$= P_n + v^n R_{n+1}$$

Therefore $\Delta F_n = \frac{1}{(1-v^{n+1})(1-v^n)} \left[(v^n R_{n+1}) + (v^{n+1}P_n) - v^n (P_n - v^n R_{n+1}) \right]$

$$= \frac{1}{(1-v^{n+1})(1-v^n)} \left[(v^n R_{n+1})(1-v^n) - v^n P_n (1-v) \right]$$

$$= \frac{1}{(1-v^{n+1})(1-v^n)} \left[\frac{1-v^n}{1-v} R_{n+1} - P_n \right] \dots\dots\dots 3.6$$

$$= \text{A positive constant.} \left[\begin{array}{c} \frac{1-v^n}{1-v} R_{n+1} - P_n \end{array} \right]$$

Therefore F_n has always the same sign as the quantity in bracket.

From equation 3.3, n will be optimal if

$$\left[\begin{array}{c} \frac{1-v^{n-1}}{1-v} R_{n+1} - P_{n-1} \end{array} \right] < 0 < \left[\begin{array}{c} \frac{1-v^n}{1-v} R_{n+1} - P_n \end{array} \right] \quad \dots\dots\dots 3.7$$

From inequalities of equation 3.7

$$\left[\begin{array}{c} \frac{1-v^n}{1-v} \end{array} \right] R_{n+1} - P_n > 0$$

$$R_{n+1} > P_n \frac{1-v}{1-v^n}$$

$$R_{n+1} > P_n \frac{1-v^n}{1-v}$$

$$R_{n+1} > \frac{C + R_1 + vR_2 + v^2R_3 + \dots + v^{n-1}R_n}{1+v+v^2+\dots+v^{n-1}} \quad \dots\dots\dots 3.8a$$

$$R_{n+1} > \frac{C + \sum_{r=1}^n R_r v^{r-1}}{\sum_{r=1}^n v^{r-1}} \quad \dots\dots\dots 3.8b$$

Or next periods cost is greater than the weighted average of the previous costs since the R.H.S in equation 3.8b is the weighted average of all costs up to and including period n-1.

$1+v+v^2+\dots+v^{n-1}$ are discount factors applied to the cost in each period.

The other part in equation 3.7 can similarly be expressed as

$$R_{n+1} < \frac{C + R_1 + vR_2 + v^2R_3 + \dots + v^{n-1}R_n}{1 + v + v^2 + \dots + v^{n-1}} \dots\dots\dots 3.9a$$

$$R_{n+1} < \frac{C + \sum_{r=1}^n R_r v^{r-1}}{\sum_{r=1}^n v^{r-1}} \dots\dots\dots 3.9b$$

Or next periods cost is less than the weighted average of the previous costs since the R.H.S in equation 3.9b is the weighted average of all costs up to and including period n-1.

From equation 3.8b and 3.9b

- The machine should be replaced if the next period's cost is greater than the weighted average of previous costs.
- The machine should not be replaced if the next period's cost is less than the weighted average of previous costs.
- The corresponding minimum annual payment x can be obtained from equation 3.2. further if x_1 and x_2 are the minimum annual payments for two machines A and B, A will be preferred if $x_1 > x_2$ and vice versa

On solving the equation 3.8 & 3.9 tabular method is preferred. as shown below

1	2	2	3	4	5
Year of service (r)	Salvage value (S)	Running cost(R_r)	Discount Factor v^{r-1}	Discount Factor v^r	Discount running cost $R_r v^{r-1}$

6	7	8	9	10
Discounted Salvage value ($S v^r$)	$C + \sum_{r=1}^n R_r v^{r-1}$	$C + \sum_{r=1}^n R_r v^r - S_r v^r$	$\sum_{r=1}^n v^r$	Equivalent Uniform annual cost (8/9)

Number 10 is the equivalent uniform annual cost

Salvage value is included in the table considering that it is given or assumed for each year.

Other special cases can be developed such as ignoring changes in the value of money, when time is discrete variable or continuous variable, tax are included, salvage value not zero etc.

3.8 *Reasons for delaying equipment replacement*

Even though it is possible to show logical and practical arguments that replacing an equipment at a certain specified time of its life considering all the factors is economical, many firms fail/delay to replace the equipment. Some of the reasons for delaying the replacement of items beyond the economic replacement time are [3].

- The firm is making a profit with its present equipment.
- The present equipment is operational and is producing an acceptable quality product.

- There is risk or uncertainty associated with predicting the expenses of a new machine, whereas one is relatively certain about the expenses of the current machine.
- A decision to replace equipment is a stronger commitment for a period of time into the future than keeping the existing equipment.
- Management tends to be conservative in decisions regarding the replacement of costly equipment.
- There may be a limitation on funds available for purchasing new equipment, but no limitation on funds for maintaining existing equipment.
- There may be considerable uncertainty concerning the future demand for the services of the equipment in question.
- Sunk costs psychologically affect decisions to replace equipment.
- An anticipation that technological improvements in the future might render obsolete equipment available currently; a wait-and-see attitude prevails.
- Reluctance to be a pioneer in adopting new technology; instead of replacing now, wait for the competition to act.

3.9 Common Errors in Replacement Studies

Observations of the practice of industrialists in such studies and of the published literatures of the subject indicate four errors which it seems are often made in dealing with replacement economy [14].

1. Considering the excess of present book value over the net realizable value of the old asset as an addition to the investment in the new asset. This error increases the apparent

cost associated with the new asset, and thus tends to prevent replacements that are really economical.

2. Calculating depreciation and interest (i.e., capital recovery) on the old asset on the basis of its original cost rather than its present net realizable value. This usually increases the apparent costs associated with the old asset, and thus tends to favor replacements that are really uneconomical.
3. Where indirect costs (burden) are allotted in the cost accounting system in proportion to direct costs (usually in proportion to direct labor cost), assuming without investigation that a reduction of direct expenditures will effect a corresponding saving in indirect expenditures. This error usually makes the apparent saving from proposed replacements greater than the saving that is actually possible to realize, and thus tends to favor replacements that are really uneconomical.
4. In cases where the proposed new asset provides more capacity than the old asset, comparing calculated unit costs realizable only with full-capacity operation, rather than comparing the actual costs realizable with the expected output. Where such excess of capacity is not likely to be used, this unit cost comparison tends to favor the asset with the surplus capacity, and is therefore favorable to replacements that are really uneconomical.

The first two of these errors cited result from a failure to recognize the true nature of depreciation accounting as a time allotment against future dates of money already spent. The third error results from a failure to understand clearly the nature of cost accounting allocations. The fourth is merely an unrealistic use of unit costs.

Chapter 4

SURVEY OF EXISTING REPLACEMENT SYSTEM

4.1 Existing Policies on Equipment Replacement

A formal written document, in Amharic, was prepared in 1975EC on a system of equipment replacement request, which was released under the heading of “Small capital requests “. According to the policy there are two phases on equipment replacement. The first is approval of removing the old machine and allocation of capital budget and the second is purchase process. The process of approval and purchase is slightly changed from the original guideline but those directly related to the machine are still working in industries. The unofficial interpretation of the policy is as follows [22]. [See appendix A]

"For equipment expected to be replaced the reasons for replacement supported with facts and figures of not less than three years should be presented. Bearing this in mind the important information that should be incorporated are:

For the Defender:

- Equipment type
- Reason for replacement, and
- Important information of the equipment such as:
 - ▶ Down time records due to machine failure,
 - ▶ Any wastage of product due to machine failure,
 - ▶ Purchase price,
 - ▶ Year of purchase,
 - ▶ Service years,
 - ▶ Capacity,
 - ▶ Book value of the machine during the time of request,
 - ▶ Annual maintenance cost for at least three years, and
 - ▶ Estimated cost if it is sold.

For the new equipment to be acquired

- Price and price source,
- Source of fund,
- Capacity,
- Expenses required for installation,
- Influences due to the changes on other machines,
- Other rearrangements required,
- Any additional expenses expected,

Further, based on the above information cost-benefit analysis should be presented."

The above enumerated factors are more or less related to the principles of replacement mentioned in chapter 3.

4.2 Actual Methods Employed on Equipment Replacement

4.2.1 General

To know the actual methods and reasons employed on machinery replacement data recording systems were assessed, request formats were collected and quite a number of questions were asked. Some of the questions asked were the following.

- Who initiates the problem?
- Who is responsible for capital item replacement?
- What are the basic reasons for selecting equipment as a candidate for replacement?
- Why requests on replacement are accepted or rejected?
- Is the equipment at hand and the one to be acquired compared?
- If replacement is contemplated what preparation is made and for how long?

The assessments show that major replacements employed in state owned industries could be divided into three:

- Forced replacement,
- Replacement for improving or maintaining production capacity,
- Replacement for diversification or change of product,

4.2.1.1 Forced Replacement

The replacement reason given to these equipments is that keeping the equipment in operation becomes difficult due to one reason or the other. Forced replacement can arise due to different reasons.

- The failure of a machine during production season may be repeated where significant loss is recorded. The basic failure of the machine may not be due to deterioration and end of its life. But it may be due to poor maintenance or some other reason. For example a pump expected to work for 6 years may fail repeatedly at the 3rd year. This failure can be due to poor erection, poor pipe connection, poor alignment or poor follow up while in operation (for example, leakage of oil may not have been given serious attention at the beginning which may result in the damage of bearing and then bearing housing). Once the bearing housing is damaged whatever spare is replaced failure rate will not be reduced and lastly shorten the life of the machine. So such unknowingly neglected problem will result in an imminent replacement before the machine reaches the expected life.
- On the other hand the machine may have design problem which results in replacement before it reaches its expected life. A good example for such replacement system is massecuite pumps (sugar grain pumping) which have high wear rate at the tip of rotor and housing due to pumping sugar grains. On some designs due to having liner on the rotor and housing, replacing the liner will bring the pump to the required standard capacity. During wear out the liners are replaced. If there is no liner in any one of the maintained parts, it is a must to change the rotor and housing before completing one production season. Purchase of these parts is too expensive and further on the middle of production the wear and tear of these parts may result in decrease in capacity where production may be hampered. So due to these

problems even though the machines are relatively new replacement or design change becomes inevitable.

- Replacement may be initiated due to lack of spares. Even though a machine is working perfectly to the satisfaction of the organization due to shift of production type, bankruptcy, or else the supplier may stop production of such spare parts. Due to this sourcing of spare will be impossible. For lucky areas batch-producing companies may take the responsibility to supply spares. But over all the cost of spares will be extremely high where it is not bearable to continue. Due to this replacement will be imminent.
- During operation machines may fail due to technical problems or mal-operation. In such cases replacement is initiated not on the formal way of replacement system.
- Machines may be replaced after completing their life. The changes may not be planned and programmed due to being beyond maintainability.

4.2.1.2 Replacement for Improving or Maintaining Production Capacity

From the commencement of production industries strive at least to meet the design capacity of their industry if not improvement. To meet this requirement the bottle neck machines are replaced or additional machines are installed. Overall carrying out technical and process audit of the factory and machinery for identifying deficiencies which hinder achieving of the designed capacity and optimum efficiency, or for further increase of production capacity or change of the production system, are some of the reasons for replacement of equipment.

4.2.1.3 Replacement for Product Diversification and increase in product type or Change of Product type

Most industries either slowly or at a fast rate make changes in production rate or production system, type of product to meet the demand level. To do these changes it is inevitable to change the layout of the machinery, tools etc. These changes bring about a complete replacement of small or large machineries. With this type of revolution the machines to be replaced may not be at the state of replacement stage either technologically or physically. Whether a machine is in a good state or not if there is expansion in any aspect the equipment may be removed, or will be allowed to work in parallel, put as a standby or transplanted. During this time the amount of capital on these machines is considered in the following way.

- Some of the equipments may have good salvage values so that the market may absorb them and others may be discarded as a scrap.
- Some of the machines may be rebuilt/rehabilitated and start a new life with the system,
- Some of the machines may not be touched at all. Only additional machines in parallel be installed.

For example the expansion of Metahara sugar industry from 3000 TCD (tones of cane per day) to 5000 TCD brought about a change in all the middle factory and back factory process equipment to handle the on coming capacity of the two mills out put.

4.2.2 Procedures for Replacement of Capital Items

In most industries even though there is no proper equipment history recording and analyzing there are some ways, which show whether a machine is performing good or not. For example management holds meetings at different levels. During the meeting performance of the factory is evaluated and the major reasons for downtime, performance decline etc. are discussed. This

discussion starts from the lower rank technical and production personnel. It is based on daily records and reasoning generated by production/ technical personnel or reports from both. These immediate responsible bodies discuss on the issues of down time, decline in efficiency and conclude that the problem is either machine problem or mal-operation. Hierarchical by this process continues up to the top management on weekly or monthly bases with different depth. The analysis of the record is mostly used at the first stage to alleviate the day-to-day activities and cumulative of this, even though it is not produced in a convenient way, to some extent it is used for equipment replacement especially in short period basis.

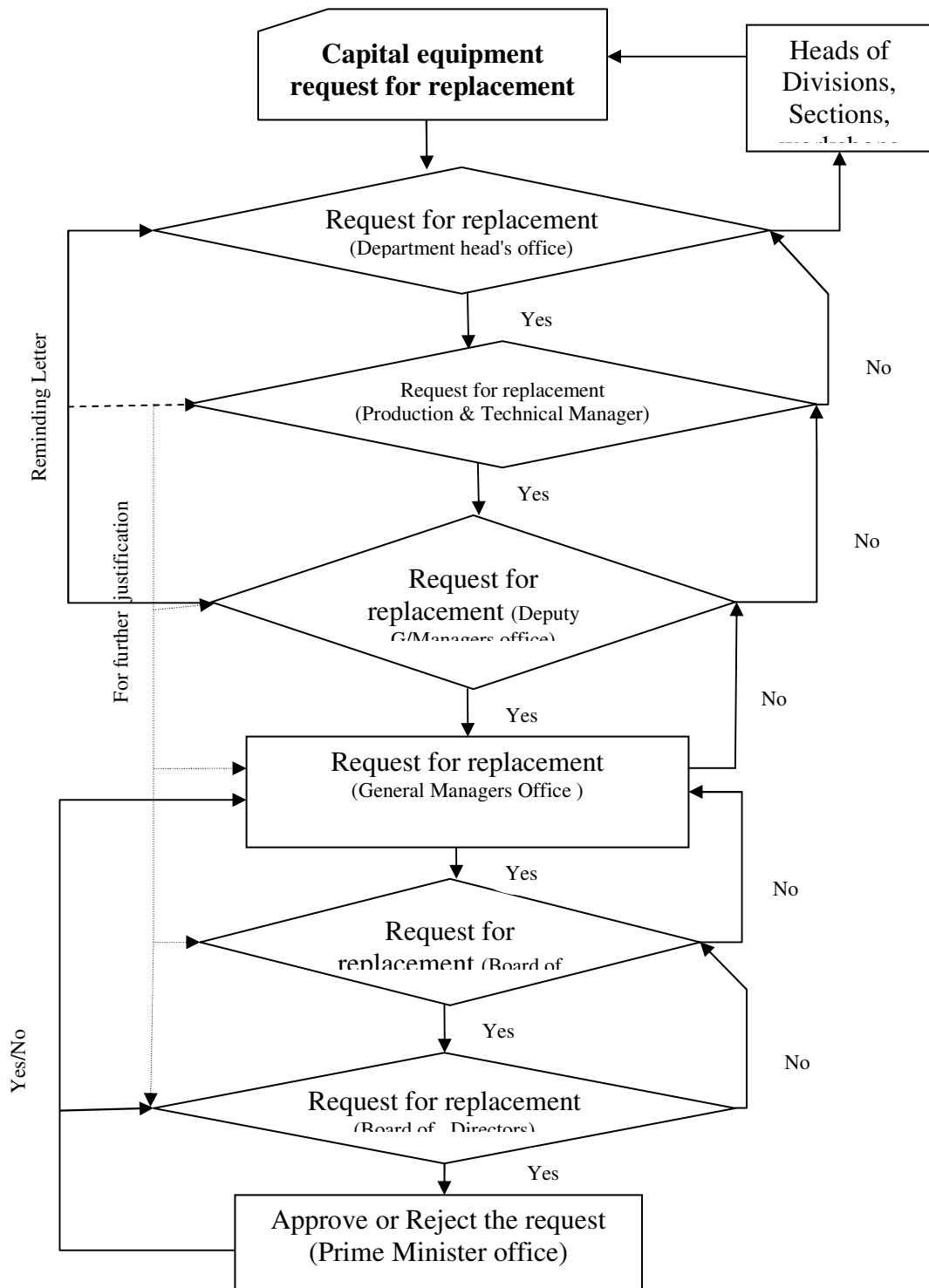
4.2.2.1 Procedures followed for approval of request for replacing the defender

The procedure followed for replacing a machine is more or less related to process of capital budget approval. The major activities are as follows (Fig 4.1).

1. Annually capital budget is requested in every organization. A reminding letter from the General Manager to every department to present their requirement, within a specified time, for the next year, initiates the annual budget request.
2. Based on the letter each department informs their sections to forward capital equipment requirement. Each section assesses the data at hand, discusses within their staff and presents their requirement for the coming year to their immediate boss (department). For example under the technical department there may be four divisions, such as in case of Addis Tyre, maintenance, design and planning, power and utility, and services and in case of Metahara Sugar Industry, under the technical department there are electrical, mechanical workshop, instrument workshop, fabrication workshop and maintenance. All these divisions and workshops present their requirement to department head. The technical head collects all the requests and calls meetings with his subordinates and discusses on the budget request jointly.

By crosschecking, commenting and suggesting other alternatives some of the requests may be slashed off or others may be included for the budget year.

3. The final result of the department is presented to Deputy Manager. Equally the Deputy Manager discusses the capital budget presented with his subordinates and makes necessary changes.



Note 'Yes' indicates the request is accepted, 'No' Indicates the request is not accepted

Fig 4.1 Capital equipment replacement approval process

4. The final result of the department is presented to Deputy Manager. Deputy Manager discusses the capital budget presented with his subordinates and makes necessary changes.
5. The result of the discussion is the request of capital equipment for the year. This is presented to the General Manager office.
6. The General Manager calls his subordinates and discusses on overall capital budget requests and the capital estimates, source of funds, etc. and reaches a certain conclusion about which equipment to defer, completely drop, or to accept the proposal as a whole.
7. The capital budget request of the organization is compiled and presented to board of directors. At this stage more or less the financial aspect of the budget request is given emphasis.
8. The accepted draft capital budget request is then presented to the branch of Prime Minister Office that is responsible to state owned industries. Here the final acceptance or rejection of the request is made. What so ever the decision the document is sent back to the industries.
9. After the approval of the capital budget a complete document under the heading of Capital Budget Proposal of the coming year is released and each department is made to know it. Sample is attached in appendix B. Then after the process of purchase starts.

4.2.2.2 Procedures for purchase of equipment

Once it is decided to replace the equipment, and estimated budget allocation is made. The purchase is done after passing quite a lot of activities. The following are the major activities in purchase of a capital item [Fig 4.2].

1. Based on the capital budget approved, the design and planning office or any responsible body prepares a tender document. This document contains technical specification and evaluation method. The technical specification and evaluation method is prepared in two

sections. The first section contains points of fundamental compliance and the second section all other criteria. Sample is shown in table 4.1. On the other side the sources of purchase is divided into 3 categories. Items which can be bought from local; Items which can be bought from sole manufacturers (non-standard) and items which can be bought from any where (standard items).

2. At the same time based on the capital budget document each section generates a formal request. The request is checked against the capital budget and presented to the General Manager's office and is approved as necessary. It is then transferred to marketing.
3. Based on the technical specification the tender is released or sent to organizations known for the type of items, which are recommended by technical department. The tender floats with dead line.
4. Proforma invoice is collected from all suppliers and opened by the tender committee put their signature and it is delivered to design and planning office/ to some of the committee members depending on the organization setup.
5. Based on the technical specification tender is released or sent to organizations known for the type of items, which are recommended by technical department. The tender floats with dead line.
6. Proforma invoice is collected from all suppliers and opened by the tender committee with their signature and it is delivered to design and planning office/ to some of the committee members.
7. Design and planning office/ some of the committee members prepare tender evaluation table. The table contains on the first column the specification prepared by the organization, and then after responses of the competitors.

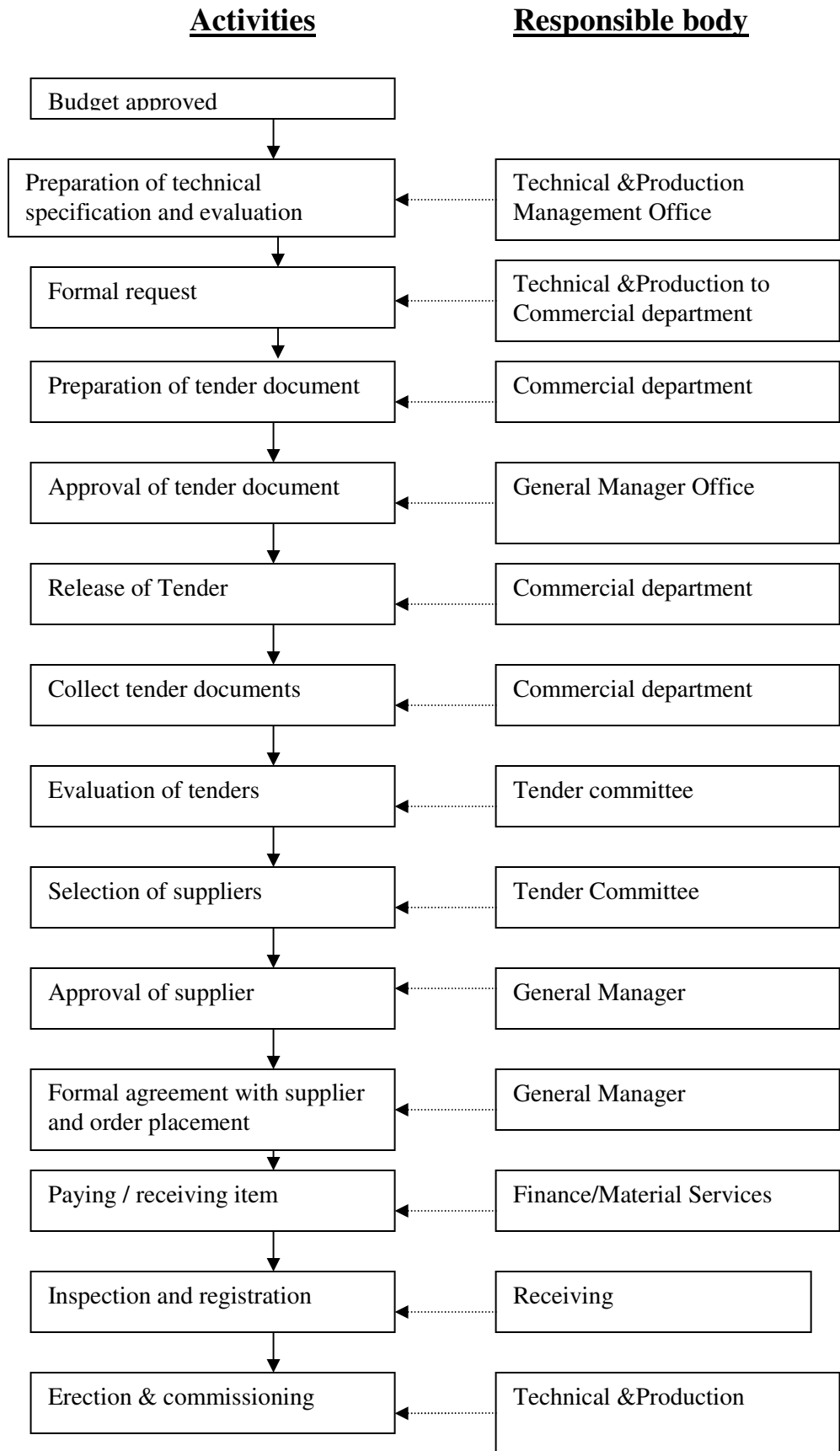


Fig 4.2 Capital Equipment Purchase Process

8. The prepared tables and the documents are presented to tender committee. Members of the tender committee may change from plant to plant but always the production and technical manager / technical manager is one of the members during evaluation of technical requests. The committee shares the document and each member checks one or more competitors, depending on the quantity and comments on the table prepared by design and planning office.
9. Based on the final correction made by each committee and thorough discussion of the members, grading is done for each point on the tender evaluation document based on previously prepared grading system. Sample is shown in Table 4.2.
10. The Technical evaluation at last is reduced to be out of 60%-70%. The other 40%-30% for financial and other issues shown in table 4.3 do not normally differ from order to order.
11. Besides this the committee gives its recommendation and it is presented to the General Manager.
12. Based on the amount of purchase, the winner from the suppliers will be notified and process of purchase continues or the decision is presented to board of directors for further approval.
13. On receiving the equipment visual inspection is made.
14. As per the schedule the process of installation commissioning and putting in to operation follows.

Sample evaluation criteria prepared before opening tender documents.

TENDER EVALUATION CRITERIA FOR MASSECUITE PUMPS
E I 13 - 4342

Detail point allocation

S/n	Evaluation criteria		Weight given
1	Requirement		20%
	Medium massecuite	5%	
	Capacity 50m ³ /hr	5%	
	Pressure 70 mtr head	5%	
	Viscosity -90 Bx - 1000	5%	
2	Technical specification		25%
	Manufacturer - well-known	4%	
	Pump type - rotary pump	5%	
	Pump speed - low speed	4%	
	Duty power to be efficient	4%	
	Special feature - pp to be durable	8%	
3	Materials of construction		15%
	PP casing - C.I	3%	
	Rotor bronze	3%	
	Shaft S.S	2%	
	Staffing box - mechanical seal	3%	
	Sealing arm - S.S	2%	
	Bearings - standard rolling brg	2%	

4	Accessories		20%
	Degree of protection min IP54	5%	
	Insulation class F	5%	
	Gear box-Coaxial with pp	5%	
	Coupling - shear pin or v-belt	5%	
5	Other Factors		20%
	Technical information - complete	5%	
	Spare parts - availability	5%	
	Documentation	5%	
	Quality & standards	5%	
	TOTAL		100%

Table 4.1 technical specification and evaluation method

Table 4.2 Commercial evaluation format

Table 4.3 Detail tender evaluation criteria

4.3 Comments and Discussion

The capital equipment replacement request systems, purchase process, evaluation format and evaluation system discussed are more or less existent in every organization. From the principles of replacement in all books and the policy mentioned in section 4.1, the criteria have some deficiencies to be fulfilled. The discussion and comment will limit on those issues believed to be most important once.

4.3.1 Capital Budget Proposal

Justifications of the capital budget requests shown in table 4.4 [see detail in appendix B] indicate that the reasons given are 16.05 % due to obsolescence, 45.68% due to old age and 38.27% due to other cases.

Obsolescence: In most cases the obsolescence observed are lack of spare part. True, this is one of the reasons for obsolescence. The manufacturers might have developed a new design to replace the existing machine and stopped to manufacture any part of the machine. The question arises is the machine within the expected life economically? Most of the machines are beyond the expected life so it is difficult to say that the mentioned 16.05 % of machines were replaced due to obsolescence. From the 16.05 % given some of the machines were requested for replacement due to obsolescence and old age. In short, the obsolescence mentioned is more or less happened to be at about the end of the technical life of the equipment.

Further, if the age of the machines is studied thoroughly most of them are aged enough. In other words almost all of the machines might not become obsolete within estimated age but the obsolescence came late after their expiration of their economic life. If the same machine is required it is true that the equipment is obsolete (out of market). The unavailability arises due to long service years, which is more than expected depreciation years so that even a very slow technological development makes the equipment obsolete. Due to this it is difficult to say that the equipment is changed due to obsolescence. It is better to say that replacement is initiated when the technical life comes to an end or the machine becoming beyond repair.

Old age: About 45.68% of the justification given includes the machine are aged. If the machines are aged either they are beyond repair or spares are manufactured with a special order or partly within the organization. With these facts if there was a proper data handling system during the life of a machine, it would have been possible to get the appropriate time when replacement will be advantageous and state the exact reason for replacement.

Estimated capital budget: From the estimated annual budget requirement for replacement, shown in table 4.5, it can be seen that the amount of money is not small. Including other annual capital investment requests, which is not included in the study, is significantly high were assigning manpower to deal with it is of advantage.

Reason of replacement	Obsolescence	Old age and long service years	To improve capacity and performance	Other reasons (damage, loss in accuracy, Unreliability etc.)	Request with data	Without any justification
Quantity	13	37	20	6	1	4
In %	16.05%	45.68%	24.69%	7.41%	1.23%	4.94%

Table 4.4 Justifications of the capital budget requests

Budget year	1996/7	1997/8	1999/2000	2000/2001	
Estimated price (Birr)	4,002,000.0	3,592,000.0	7,970,000.0	9,350,000.00	Metahara
	0	0	0		
				10,009,000.00	AddisTyr e

Table 4.5 Estimated annual budget requirement for replacement

If spare is not manufactured at the original supplier, using reverse engineering it can be manufactured somewhere else but at expensive cost. Some times the spares are manufactured in

the original manufacturer with especial order where the charge rate is increased if the supplier have shifted product type.

From replacement proposals made on capital items the following facts can easily be identified on request for equipment replacement.

- Obsolescence of machines – from the capital budget requests it can be shown that obsolescence is due to long service years not due to technological shoot. It is a gradual development nature. There is nothing eternal.
- Most of the machines requested for replacement have completed their expected life. They are at the least book value economically.
- In most organizations there is no specialized group or individual who follow equipment status.
- The data collected from industries mostly show that replacement is not based on a certain set guide lines. It is based on the level of problem created by the machine. If the department or the section responsible on the machine operation and maintenance believes to replace an equipment it is not a simple task to get rid off it and bring another one. The first thing to get approval to replace it, which is difficult due to poor historical data handling of the machine. The level of discussion made is the indications that replacement is made not on data analysis but on memory of individuals who are responsible and to some extent from data recorded for the last years of operation. Another constraint for equipment replacement is capital. The nature of capital allocation is more or less like rationing where the level of urgency dictates equipment replacement.

- The justifications given are of general nature due to which it is difficult to understand the losses incurred or revenue decline by not replacing the machine or the revenue decline.

4.3.2 Challenger

The challenger is not computed with an existing machine but with other challengers. It is mentioned on evaluation format that this equipment has got merit to assume this position. So,

1. The evaluation method shown on table 4.1, tender document evaluation system, can be questioned whether the evaluation criterion is complete or not. On the literature survey and principles of replacement it is shown that the life of the equipment should be approximated during selection. Even though the design aspect and the materials are mentioned the life expectancy, life cycle cost or annual expense are not mentioned at all. For equipment in operation replacement is made mostly due to obsolescence, operational interruption etc. but the technical and financial evaluation criteria did not consider these basic assumptions for the new equipment. Even it can be said that the major part of the mathematical models and formulas are directed towards this condition. On the contrary the tender evaluation system in application does not give any attention to this issue.
2. There are some cases where durability is mentioned but it is not in the sense of the principles of replacement. That is there is no comparison method. Because of these reasons the challenger assumed position will be the final. There is no method or way to check whether appropriate equipment is bought or not if the problem, which was prevailing with the old equipment, is solved some how.

3. Every machine need some parts to be replaced on certain specified time depending on the maintenance type, small, medium or overhauls that is the equipment need certain amount of operating capital. The operating capital, which is very crucial, is not analyzed during the tender evaluation phase.

4.3.3 Spare consumption

One of the reasons of obsolescence is the development of new designs by the manufacturers where spare manufacturing of the old ones will be stopped, so spare supply guarantee should be considered in the evaluation criteria. If there is a guarantee period of supply of spares the rate of replacement due to spare can be anticipated. In some of the evaluation criteria reputation of the organization is rated. Yet this does not guarantee the supply time of spare parts.

Spare consumption can be found from material stores control cards. All spares are fetched by filling request form and getting approval of the immediate technical boss and the chief of technical personnel, and then requesting it at the store. So spare consumption are recorded but, they are not in such a way that the consumption of each machine is separated. The parts, which are not standard can be found easily from the spare part balance sheet in store. But standard items can not be identified easily. Still there is another case where the spares are manufactured within the industries. The manufacturing is made for two reasons.

1. For annual requirement requested from spares part stores.
2. For immediate use. The requests are made formally by preparing drawings or providing samples and requesting on preparing logbook.

For both cases the data is registered in the workshop. The problem is to collect and record on a way to show the statues of the machine.

4.3.4 Manpower

For every machine failure during operation requests are made for maintenance. The manpower is assigned to do the work. After finishing the job operation resumes. From this the man-hour spent to maintain the machine, the down time recorded due to this machine can easily be found.

4.4 Problem Identification

As mentioned above there are quite a lot of problems which need closer attention concerning equipment replacement methods in industries. Based on the capital budget request and discussions made the following are the major ones:

1. Equipment data collection and analysis is very low. This can be expressed by the justification given such as:
 - “Replacement of an old unit,
 - To replace the old equipment, it is problematic around clarification.
 - To reduce running cost, it is estimated to be 1.2 million/year for the items.
 - Due to frequent failure production is hampered.
 - Maintenance cost increased, long service years.”
2. Evaluation of the defender is first completed. There is no chance to compare the defender and the challenger. If it is possible to show the defender operating costs are very high then

the need to replace it would have been accepted but there is no way to compare the defender and the challenger. On theory of replacement it is shown that there should be a comparison system between the two. In actual practice the comparison is between different challengers.

3. Life cycle cost is not considered in the evaluation,
4. The final purchase decision more or less falls under the principle of less initial cost equipment.

From the above observations, an effort should be made to increase the level of confidence of the technical personnel about the machines at their control and specifically pin point the condition of machines in terms of money and vision on future performances. Efforts should also be directed to improve data handling and manipulating system in a way that portray the status of the machine. Due to lack of proper data collection and analysis the machines to be replaced may under go a major built up (extensive maintenance).

Even though nowadays the problem of data collecting and analysis may not be a basic problem in developed industries it is true that this problem is very crucial in our industries. This doesn't mean that industries are working randomly. The important point to be given emphasis is that on equipment replacement the series of meetings, the reasons given in capital budget request are indications of not having sufficient data about the machine.

Therefore the thesis will focus on methods of data handling and analysis, as this is the fundamental for taking appropriate decision. The other problems such as technological

advancement, shortage of capital, purchase analysis problem etc. can be considered as the successors of data handling and analysis.

Chapter 5

COMPUTER BASED SYSTEM DEVELOPMENT

5.1 GENERAL

As mentioned in chapter 4 the major problem in industries concerning equipment replacement is related to presentation of tangible and convincing reasoning that a machine is not working to the satisfaction of the organization. As shown on appendix B the justifications given are more or less of a general truth on a machine that can be requested for replacement. This indicates that there is no historical data to show how the equipment has been working. With the available tools in industries such as computers, factories categorized in plants/sections, coding system etc. a small input, developing a system, is believed to alleviate the problem of good information system barrier.

The system is to be used as a template which can be adapted to any industry. It is developed as a database management which is designed in Microsoft access. The reason of developing the system using access is that:

- It is simpler handled data's in Microsoft access,

- It is simpler to use Microsoft access for some one who wants to use the system and modify it to his need with small know how of the programming system,
- Microsoft access is loaded almost in every computer so using the system will need no special system.

5.2 SYSTEM STUDY

The present situation on equipment replacement system is surfaced in chapter 4. From that, information system is taken to be one of the major short-comings which do not go hand in hand with policy of the equipment replacement. Then the question comes to how can the historical data of equipment, that deteriorate gradually, be organized, and used to forecast on what to be done.

The equipment database is made to receive day to day data and synthesize the data to give results, which is directed towards showing equipment expense versus time. Basically, it is using the concept of LTCP discussed in chapter 3 section 3.7.2. The selection is made that the two alternatives given in section 3.7.2 are specific while LTCP is more general to be used for any equipment process type or not. It has the capacity to show the trend of future performance. At the same time the policy mentioned in section 4.1 requires to show all about the equipment including cost benefit analysis. So the proposed system is made to perform the following:

1. Receive data as an input,
2. Generate daily, weekly, monthly, quarterly, annual reports of each machine as required, in short, generate expense of each machine between any range of time,
3. Generate reports on each machine according to lubrication and spare consumption, labor, production loss, and other costs,

4. Generate expenses of machines categorized by plant or section,
5. Calculate the depreciation of machines based on straight line depreciation method,
6. Sum up the maintenance cost to ownership cost to give total cost and generates a graphs that show maintenance cost curve, ownership cost curve and total cost curve on annual basis

Total annual cost = Running cost + Ownership cost

Where Running cost = Maintenance and operation cost

$$\begin{aligned} \text{Maintenance and operation cost} = & \text{Spare part consumption cost} + \text{Lubricant} \\ & \text{consumption cost} + \text{Down time cost} + \text{Labor cost} + \\ & \text{Loss of production due to down time} + \text{Other costs} \end{aligned}$$

$$\text{Ownership cost} = \text{Book value of the equipment} - \text{Estimated Salvage value}$$

7. Remarks and other related reports as the need arise.

5.3 SYSTEM DESIGN

To get the above results the management database system is designed as follows:

5.3.1 Equipment database

It is divided into four main groups.

- Equipment basic data: Include some basic features and data that describe the equipment during installation as shown in table 5.1.
- Operational data: All data's that are fed into the database after the equipment is in operation such as maintenance and book value calculation as shown in table 5.2.
- Depreciation: when a machine is bought the initial cost (ownership cost) is estimated to be returned within a specified range of years or within estimated life of the machine. Based on this estimated life, the annual depreciation is deducted from the ownership

5.3.2 Input data to the system

Input data are made through forms. It is divided into the following

1. Equipment basic data input: the input form is used to be tab-controlled to divide the data's into convenient parts such as motor gearbox etc.

The screenshot shows a software window titled "Equipment basic data" with a sub-header "EQUIPMENT INITIAL DATA INPUT FORM". Below the header are several tabs: "Basic Data", "Drive System Data", "UTILITY", "COMMERCIAL DATA", "Miscellaneous", and "GEARBOX". The "Basic Data" tab is selected. The form contains the following fields and values:

Equipment ID	03-01-01/1
Equipment Description	Washing pump1
Equipment Category	03
Serial Number	
Type/Model	
Drawing No/Manual	
Capacity	0

At the bottom of the form, there are five buttons: "Equipment Catelogy", "Modify", "Save", "Undo", and "Close". Below the buttons, a record indicator shows "Record: 1 of 5" with navigation arrows.

Figure. 5.1 Equipment Initial data input form

2. Operational data input: for simplicity and clarity the input forms to the operational database are made through more than one form. Samples are shown below:

Spare part

SPARE PART CONSUMPTION DATA INPUT

Equipment ID	01-01-01/1	Voucher number	
Equipment Description	Drinking Water Pu	Part replaced	
Equipment Category	01	Quantity replaced	7
Date	2/3/1993	Spare unit cost	\$4.00
Type of maintenance		<input type="button" value="Undo"/> <input type="button" value="Save"/> <input type="button" value="Delete"/> <input type="button" value="Close"/>	
Remark			

Record: of 23

Figure 5.2 Spare part consumption input form

Lubrication1

LUBRICANT CONSUMPTION DATA INPUT

Equipment ID	01-01-01/4	Lubricated by	
Equipment Description	Cane Conveyor	lubricant type	Omla 81/82
Equipment Category	01	Measuring unit	Litres
Date	2/3/1993	Quantity used	47
Part lubricated		Lubricant Unit cost	\$10.00
Remark		<input type="button" value="Delete"/> <input type="button" value="Undo"/> <input type="button" value="Save"/> <input type="button" value="Close"/>	

Record: of 23

Figure 5.3 Lubricant consumption input form

3. Equipment catalogue: Input to the equipment database is through units detail, parts detail forms.

The screenshot displays two overlapping windows from the 'Equipment Catalogue' application. The background window, titled 'Equipment Catalogue', has a yellow header with the text 'EQUIPMENT DETAIL'. It features a vertical list of fields on the left: 'Equipment ID', 'Equipment Description', 'Equipment Specification', and 'Remark'. A 'Part' button is visible below the 'Remark' field. The foreground window, titled 'Equipment detail', has a yellow header with the text 'EQUIPMENT PARTS DETAIL'. It contains several input fields: 'EquipmentDescription' (a dropdown menu), 'Unit ID' (a dropdown menu), 'Part ID' (a text field containing '01-01-01-01/1'), 'Part Number', 'Part Description', 'Part Specification', and 'Remark'. To the right of these fields are buttons for 'Modify', 'Undo', 'Save', and 'Close'. At the bottom of the foreground window, there is a record navigation bar showing 'Record: 1 of 3'.

Figure 5.4 Equipment units and parts detail input form

4. Depreciation data input: Raw data input to depreciation database is made through depreciation data input form and depreciation sub form.

The screenshot shows a software window titled "Depreciation" with a subtitle "DEPRECIATION DATA INPUT FORM". The window contains the following elements:

- Equipment ID:** A dropdown menu.
- Equipment Description:** A text input field.
- Table:** A table with 5 columns: "Date Aquired", "Initial Cost", "Type of Deprecia", "Estimated salvage", and "Estimated service life". The first row contains the values "\$0.00", "", "\$0.00", and "0".
- Buttons:** "Book value", "Undo", "Delete", "Save", and "Close".
- Record Indicator:** "Record: 1 of 1" with navigation arrows.

Figure 5.5 Depreciation data input form

5.3.1 Output / Report from the system

Output from the system is the same as mentioned on section 5.1 (system study). Any report which is based on the data entered can be generated in a convenient way the organization needs except the remarks. Remarks are generated in detail. Samples, using hypothetical data, of the important reports are given on the following tables.

EQUIPMENT STATUS REPORT

Table 5.5 Equipment status report

SPARE CONSUMPTION COST BY EQUIPMENT					
Date: 01/01/2017					
Equipment	Date	Part Name	Quantity	Unit Cost	Total Cost
Machine 1	01-01-17		1	20000	20000
	01-01-17		1	20000	20000
	Total				40000
Machine 2	01-01-17		1	20000	20000
	01-01-17		1	20000	20000
	01-01-17		1	20000	20000
	01-01-17		1	20000	20000
	01-01-17		1	20000	20000
	01-01-17		1	20000	20000
	Total				140000

Table 5.6 Spare consumption by equipment

LUBRICANT CONSUMPTION COST BY EQUIPMENT						
Date: 01/01/2017						
Equipment	Date	Part Name	Quantity	Unit Cost	Total Cost	
Machine 1	01-01-17		1	20000	20000	
	01-01-17		1	20000	20000	
	01-01-17		1	20000	20000	
Total					60000	
Machine 2	01-01-17		1	20000	20000	
	01-01-17		1	20000	20000	
	01-01-17		1	20000	20000	
	01-01-17		1	20000	20000	
	01-01-17		1	20000	20000	
	01-01-17		1	20000	20000	
	01-01-17		1	20000	20000	
	01-01-17		1	20000	20000	
Total					160000	

Table 5.7 Lubricant consumption by equipment

Table 5.8 Annual Operational Expense by equipment

Table 5.9 Annual Operational Expense by category

5.4 Equipment coding system

Identification system is one of the most important but laborious to institutionalize and make familiar to the workers. In fact it is not new to state owned industries. They are using code system which may or may not be convenient to computer system. Even it can be generalized that there is no state owned industry working without code.

The codification used in this database is that recommended by consultants who have made audit survey of Metahara sugar industry with small changes to make it uniform and simple in using in computer system. The change made for all machines is that at the end of the code number a quantity expression is added that is to identify equipments of similar type.

The example given 08 26 01 10/3 will be used even for equipments which do not have a stand by or other similar units that is the suffix indicating number of installed units will be written even for one unit.

5.5 *Data collecting System*

Data collection system for input data can be as follows:

5.5.1 Spare and other materials consumption

Spare consumption can be found from material stores control cards. All spares are fetched by filling request pad, after approving the immediate technical boss and further the chief of technical personnel, then requesting it at the store. So, spare consumption are recorded but, they are not in such a way that the consumption of each machine is separated. The parts, which are especially required for individual machines, can be found easily from the spare part balance sheet in store. But those, which are general, can not be identified easily.

Still there is another case where the spares are manufactured within the industries

The manufacturing is made for two reasons.

- For annual requirement requested from spares part stores.
- For immediate use. The requests are made formally by preparing drawings or providing samples and requesting on workshop logbook.

In both cases the data is registered in the workshop. The problem is to collect and record on a way to show the statues of the machine. The following forms can be used as an input.

Equipment ID / Description	
-----------------------------------	--

No	Date	Unit/Part code	Voucher No.	Qty	Unit Price	Remark

Table 5.10 Equipment or parts replaced

5.5.2 Manpower

For every machine failure during operation requests are made for maintenance. The manpower is assigned to do the work. After finishing the maintenance job the operation resumes. From this the man-hour spent to maintain the machine, the down time recorded due to this machine can easily be found. It is more or less institutionalized. The following forms can be used as an input.

No	Employee Name	Employee ID	Equipment ID	Monthly income	Man-Hrs	Remark

Table 5.11 Man power Performance Report

5.5.3 Lubrication

Usually in industries there is a crew that follows the lubrication schedule of machines. Due to this it is very simple to collect data's related to lubricant consumed for each machine.

No	Machine ID/Name	Date	Lubricant Type	Qty Refilled	Remark

Table 5.12 Lubrication Report

5.5.4 Production Loss

No	Machine ID	Date	Production (Hours)			Other expenses	Remark
			Interrupted (hrs)	Resumed (hrs)	Difference		

Table 5.13 Production Loss

5.5.5 Depreciation

The depreciation system is taken to be a straight line depreciation as the present machinery depreciation system in Ethiopia is straight line depreciation method.

Note:

- All the data collection formats can be on one paper or separately depending on the convenience of the organizational structure.
- The formats are made as short as possible so that the responsible individuals will not be bored.
- Other materials such as fuel and power consumption, which may or may not differ from machinery to machinery, can be considered in the system if required [15].

Chapter 6

Implementation Methods

6.1 Implementation

Implementation of equipment replacement system is part of industrial management and asset tracking system where any organization should not bypass it. The importance of equipment management should be one of the major issues in industries if expenses are to be reduced. The seriousness can be guessed from the fact that in our computers, in Microsoft access one of the templates presented is about equipment data handling under the heading of Asset tracking mentioned in chapter three.

Equally whether there is computer system operation or not any organization strives to know the day to day activities of each machine, employee etc. and makes analysis of expenses. In industries visited, most of the important formats for data collecting are almost developed. But their functionality is limited and data analysis concerning equipment replacement is very low.

The system developed can help to store data and provide detailed or summarized reports about the machine expenses. So this is expected to be one of the major driving forces for acceptability of the software from the user's point of view.

For successful implementation and utilization of the software the following points cannot be overlooked:

- Determination and support of management,
- Change of attitude of management towards accepting new working method,
- Individuals engaged in this area should understand the system, its advantage and be able to modify it to their organizational need.

6.2 Justification

Beside the advantages mentioned in chapter 2 section 2.7.2.3 about LTCP, important points for justifying implementation of the software are:

- The availability of computers in every industry,
- The awareness of coding system in industries, which may need a small change to be used in computers,
- The fierceness' of the market dictates management to reduce cost of operation or improve operational methods,
- Simplicity of the system,
- The level of risk of failure is minimal and if there is any, the cost is not far-reaching.
- There is no need to change existing system. It is with small adaptation that the system can be implemented.

6.3 Method of Implementation

To implement the system to an organization the following need to be fulfilled.

- The naming of formats, the formats and any additional requirement of the organization should be modified or included.
- Individuals responsible for data collection and entry should be trained.
- Supervisors and foremen should be given a brief understanding of the new system.
- Popularize the system to all concerned.
- Give due considerations to human reactions.
- Codify equipments adhering as much as possible to existing system.
- Prepare list of machinery with the codification and feed to the system category/plant.
- The implementation should start from one category or plant then continue one after the other. The first plant will be used as a pilot plant to the others.
- Start routing activities collection such as down time, spare consumption etc. to the category completed codification and feeding.
- Weekly and monthly appraisal of the system and correction of errors and incorporation of any important suggestions until it is well established.
- Use the results or output from the system on management meetings.

The time limitation for implementation depends on how the existing system is favorable or organized to adapt to the new system.

Chapter 7

SCOPE FOR FUTURE WORKS, AND CONCLUSION

7.1 Scope for Future Works

As mentioned in existing system study in chapter 4 the problems in industries concerning replacement are multi-fold. The fundamental problem is not only of having sufficient operational data on the machines in operation. With the introduction of computers the data could have been analyzed in a meaningful way. Other problems such as lengthy processes of approval of equipment replacement, lengthy purchase processes, problems in evaluation system and criteria setting for evaluation etc. are some of the problems, which need attention.

The immediate and important future study areas related to this study are maintenance and operational planning systems which are the major reliable data source to the system. Further implementation can be one area of future work. As mentioned in chapter 6 changes and adaptation to fit to individual industries is one part which need continued follow up and correction.

7.2 Conclusion

- The Equipment replacement system is one of the industrial problems for management. The huge amount of annual capital investment needs concrete information for proper allocation and utilization. The effect of replacement timing, selection, and method used for reaching decisions are some of the important factors in the efficient operation and utilization of the resource. Replacement decisions are more important in market oriented economy where competition of the market is bringing profit margins to be minimal.
- As indicated in chapter 3 most of the mathematical decision models are dependent on the past performance of a machine. Thus, it shows that data collecting and analysis on equipment is one of the important factors on replacement decisions. To get a realistic data about the equipment proper maintenance management system, sensitiveness to cost variations through the course of its life is vital.
- It is believed that the study will give additional momentum to the industries and any interested body who wants to keep track of his asset status.

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* *Any part of it is not directly quoted in the thesis only the principles and ideas were used.*