MAINTENANCE OF PRODUCTION FACILITIES AND PROJECT MANAGEMENT

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Chapter 1

INTRODUCTION

1.0 Introduction

Maintenance is required in factories to

(i) keep plant in a serviceable condition so that work of the appropriate quality is produced

(ii) preserve the fixed assets in a satisfactory condition

(iii) reduce the cost of lost production due to plant breakdown.

The work of the maintenance department ranges from major overhauls and replacement of faulty parts to routine servicing and cleaning. The level of maintenance is determined by the demands of the production processes and controlled by the size of the maintenance budget.

Historically, maintenance is tended to be an emergency service performed in an ad hoc fashion and largely concerned with getting broken-down machines back into service as soon as possible. In recent years there has been a growing awareness of the deficiencies of maintenance and replacement policies. This has led to efforts to integrate them into a more comprehensive approach, known as terotechnology (1). Terotechnology is concerned with the complete responsibility for physical assets from installation to replacement, including those aspects of equipment design

that affect durability and maintenance. Some aspects of terotechnology are illustrated in Figure 1.1.

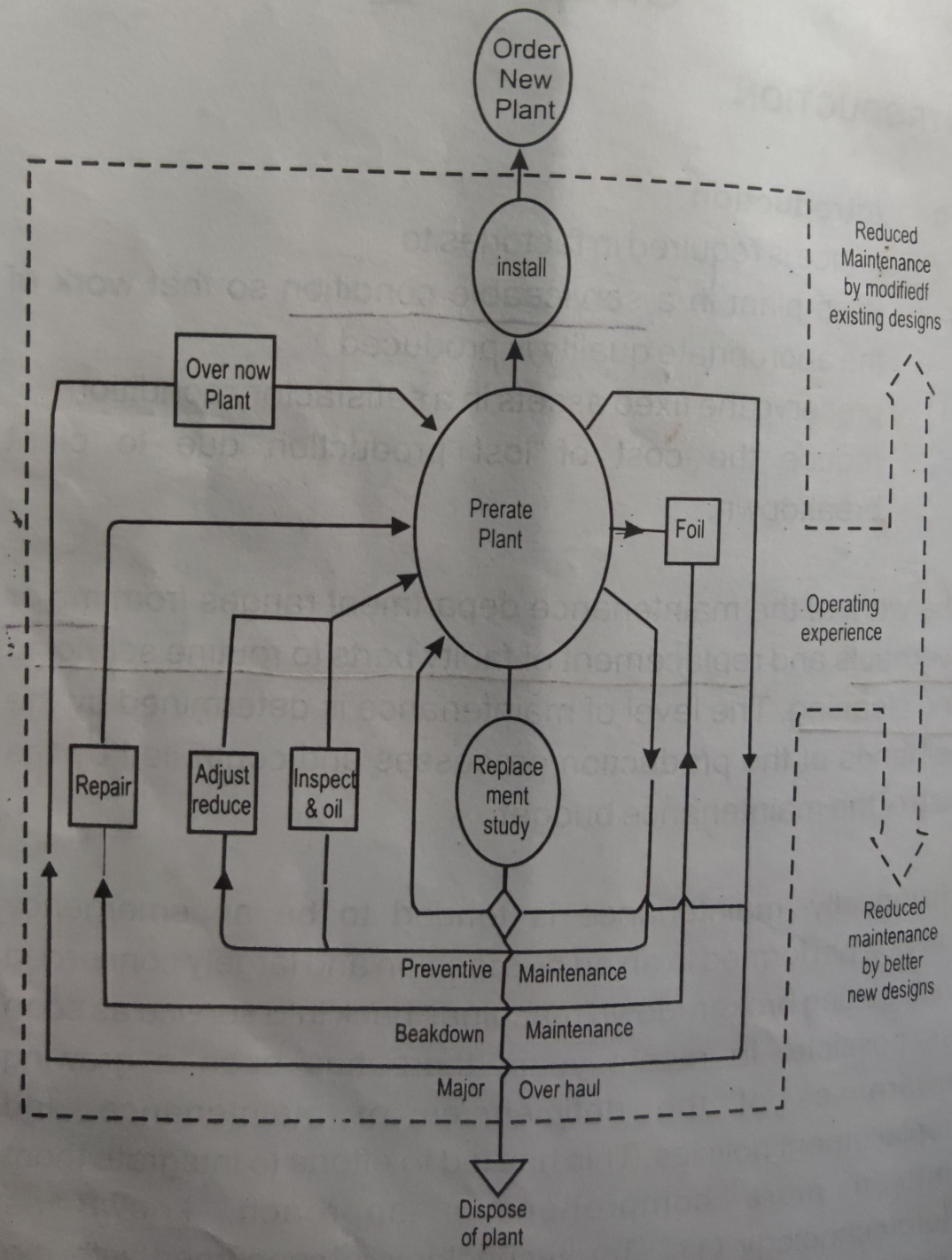

Figure 1.1: The terotechnology concept

The relative importance of the maintenance function depends on the type of product and the production layout on which it is made. In some process industries maintenance costs can be in excess of 10 per cent of the cost of goods sold. There is no generally accepted measure of maintenance efficiency; however, if the following parameters are calculated periodically they can provide useful trends.

(i) Annual maintenance cost/replacement value of plant maintained.
(ii) Annual maintenance cost/annual cost of goods sold.
(iii) Down time/total scheduled production time.

MAINTENANCE MANAGEMENT

1.1 Scope and objectives of Maintenance

Maintenance is necessary in all production and manufacturing establishments because; machines break down, parts wear out and even buildings deteriorate. Hence, the need to keep the equipment/machinery in good, operable and functional condition. All the segments that comprise the industrial enterprise require attention including the buildings, [land], machinery, material handling equipment, heating and air conditioning equipment, generating equipment, waste disposal systems, wash rooms, cafeteria, etc.

Economically the goal of any well run maintenance organisation is to have the lowest cost of the two quantities, that is;

a) Maintenance labour and material, and
b) Production loss cost resulting from an inadequate maintenance programme.

The achievement of this lowest cost is an optimisation technique (2) shown in figure below. It can be observed from the Figure 1.2 that production loss cost is naturally highest when the maintenance is lowest [zero]. As maintenance effort and hence maintenance cost is increased, the production loss cost reduces until the optimal or breakeven point when the total cost is minimal. Beyond this optimal point increased maintenance effort [cost] is not economical as it will increase the total cost. This optimisation technique is true even for service oriented organisation [say purchasing and stores] where its costs is the sum of its labour and natural cost plus the losses caused by inadequate service to her client.

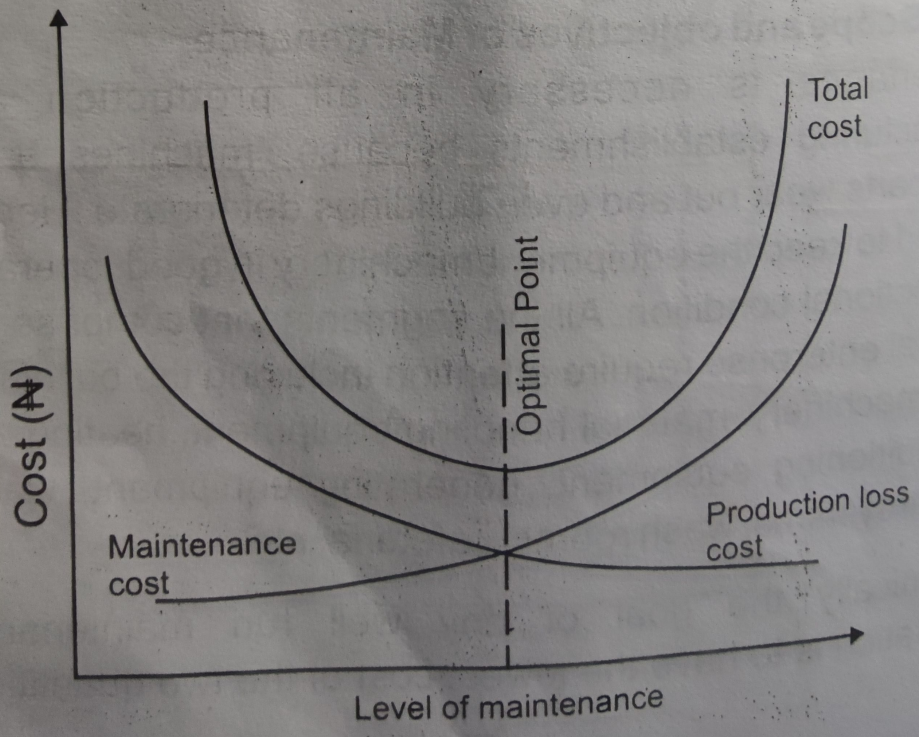

Figure 1.2: Maintenance Optimisation

Operationally, maintenance goals could be classified into primary and secondary functions.

The primary functions of maintenance include:

- Maintenance of existing plant equipment
- Maintenance of existing plant building and ground [land],
- Equipment statutory inspection and lubrication,
- Utilities generation and distribution,
- Modification of existing equipment and buildings

The secondary functions include:

- Stock keeping,
- Plant protection including fire,
- Waste disposal,
- Insurance administration,
- Property accounting,
- Pollution and noise abatement,
- Any other services delegated to maintenance by plant management.

Many activities are of such a specialised nature that they frequently can be done cheaper by outside contractors. Thus, many companies contract with outside firms to maintain their elevators, power plants, burnt out motors, computers, office equipment, etc. The washing of windows and care for the grounds are two other activities commonly performed by outside contractors. Much of the house keeping is commonly assigned to the individual production department or office. Each work man may be assigned the responsibility of keeping

his work area clean and free from debris, clips, oil or such items. It is the department foreman's responsibility to ensure that tidy conditions and good housekeeping are maintained in the factory.

Chapter 2

Maintenance Policies

2.0. Maintenance Policies

These vary from breakdown maintenance, in which the equipment is run until it fails and is then repaired, to preventive maintenance where an attempt is made to avoid breakdown by anticipating failure or wear and making a timely examination, replacement or adjustment.

Preventive maintenance is usually considerably more expensive to operate than breakdown maintenance; however, this additional expense must be set against the savings resulting from minimising the random breakdown of plant. There are overriding considerations of safety, such as in aircraft maintenance, preventive maintenance should be performed only when there is a total annual saving to the company. Breakdown and preventive maintenance are not mutually exclusive: some form of preventive maintenance, regular lubrication, inspection and adjustment, is normally practised on major items of equipment, even when the main policy is one of breakdown maintenance. Conversely, with preventive maintenance the unexpected breakdown will still have to be repaired.

2.1 Types of Maintenance (3)

Maintenance may be classified into three (3) broad categories namely; corrective (or breakdown), preventive and prognostic (or predictive) maintenance.

2.1.1 Corrective Maintenance

Also referred to as breakdown maintenance, it is the fix-it variety, the kind most of us think of when the word maintenance is mentioned. In this sense, maintenance becomes repair work. Repairs are made after the equipment is out of order say, an electric motor will not start, a conveyor belt is wrapped or a shaft has broken. In such cases, the maintenance department or crew analyses the failure, troubleshoots to ascertain the cause of failure and effect the necessary repairs. If the maintenance department does only corrective work or break down repairs, theoretically, she is idle (which maintenance crew men will see as period of rest) except when equipment is down and repairs are required.

Unplanned break down often pyramid into additional break downs with resultant higher cost. For instance, an unplanned failure of a motor bearing may cause the shaft to drop, and seizing of the rotating parts. So that there will be a cost rise from the cost of bearing replacement to the complete rebuilding charge. This increased burden on the maintenance crew could lead to a cross-fertilisation of idea during brainstorming sections among the crew men especially where there is no regular training programme. Improper scheduling of available maintenance resources, elongated diagnostic time, frequent and unpleasant emergency calls, purchase losses, poor purchase habits, rapid acquisition regardless of quality and price as well as anxiety and its associated hazards are some of the set-backs of this unplanned break-down maintenance. Some unpatriotic, selfish and greedy individuals also take advantage of this type

of situation to make more money at the expense of the company's account.

2.1.2 Preventive Maintenance

It is difficult to determine the correct level of preventive maintenance to apply. Often help can be obtained from the maintenance schedules proposed by equipment manufacturers, but a record of the frequency of unscheduled breakdowns and their cost, both direct and consequential, is really needed to institute and refine preventive maintenance programmes. This informal norm is rarely available in batch production factories, in fact in most of these factories there is little information available even concerning the number of hours individual machines have worked. As a result preventive maintenance schedules have to be compiled on a calendar, rather than on a running time basis.

It would be a relatively simple matter to design a preventive maintenance system if equipment were to fail without variation after a given usage. However, even simple items of equipment have fairly widely spread probability density functions of failure, for example, fluorescent tubes have an approximately normal distribution of failure with $\bar{X} \approx 1600$ hours and $u \approx 70$ hours. Complex equipment will normally have a wider distribution of failure.

If failure rate is relatively constant throughout the whole running period preventive maintenance is likely to be uneconomic. Preventive maintenance is advantageous when

components have all initially low failure rate, followed by a rapidly increasing failure rate owing to wear-out. With this pattern of failure servicing should be arranged to occur at a point when the failure rate starts to rise rapidly, that is, at the intersection between the B and C stages.

To summarise, preventive maintenance should be considered when.

(i) the failure rate of the equipment starts to increase rapidly after a period during which it has been low
(ii) the cost of preventive maintenance attention is less than the repair cost, both costs to include that of any lost production
(iii) equipment failure is likely to disrupt subsequent production operations or cause customer dissatisfaction
(iv) injury could result from equipment breakdown

In sharp contrast to the corrective or breakdown maintenance in which nothing is done unless someone calls the trouble desk to announce equipment failure is the preventive maintenance which is undertaken before the need arises and it's aimed at minimising the possibility of unanticipated production outages. Preventive maintenance consists of:

- Proper design and installation of equipment;
- Periodic inspection of plant and equipment to prevent breakdown;
- Repetitive servicing, up-keep and overall of equipment;

- Adequate and appropriate lubrication, cleaning and painting of equipment and building.

Preventive maintenance starts on the drawing board with those features included in the production process line which would minimise maintenance checks. The key to a good preventive maintenance programme is inspection. This should cover virtually everything including production machinery, motors, controls, material handling equipment, process equipment, lighting, building and plant services- depending on the order of criticality. As a general rule of thumb, if an equipment failure may harm an employee, stop production, or waste plant assets, then consideration should be given to including it in the preventive maintenance programme.

The policy factors to bear in mind when designing a new preventive maintenance programme include:

(i) At the start of the programme, people must be selected to design and implement the programme. The tendency to use the least competent persons for the fear that the most competent ones already have very serious commitment should be resisted. The most competent persons in the organisation should be used.

(ii) Preventive maintenance tasks will increase maintenance costs when firstly initiated, until the

beneficial effect of the preventive maintenance task has time to take effect because at initiation you have both the preventive maintenance cost as well as breakdown maintenance costs; simultaneously running.

(iii) A preventive maintenance programme may permanently increase costs, if its author(s) does/do not have enough about maintenance skills.

(iv) Maintenance cost should be optimised with production loss cost as in Figure 2.1 with the realisation that not all breakdowns cause a production loss but a loss in productivity.

(v) Preventive maintenance cost should be optimised with breakdown maintenance cost as in Figure 2.1.

(vi) The degree of preventive maintenance should be related to equipment criticality.

2.1.2.1 Implementation of Preventive Maintenance Programme Guidelines

(i) Assign the most competent persons to design the preventive maintenance programme.

(ii) Start with the most critical equipment and schedule the instruction writing and implementation task in accordance with the available manpower, incrementally, not to over stretch the available manpower.

(iii) The implementation rate should be designed to give time for the instructions to reap its benefit in reduced labour, material and production loss cost.

(iv) Concerted efforts should be made to optimise production loss cost with maintenance costs; as well as optimise preventive maintenance cost with breakdown maintenance cost.

2.1.2.2 Features of a well organised Preventive Maintenance Programme

A well conceived preventive maintenance programme should contain the following features:

(i) Proper identification of all items to be included in the programme.

(ii) Adequate records covering volume of works, cost, activity time (log), failure records, etc.

(iii) Inspection on a definite schedule-pot withstanding orders on specific assignments.

(iv) Use of check list by inspectors.

(v) An inspection frequency schedule-which may vary from hourly to annual checks based on criticality.

(vi) Well qualified inspectors should have craftsmen familiar with the items being inspected and capable of making simple repairs once trouble is observed or anticipated.

(vii) Use of repair budgets for major items of equipment.

(viii) Administrative procedures that provide necessary fulfilment and follow up on the programme

Preventive maintenance could be minor or major. In minor preventive maintenance, there should be necessary lubrications, as well as preventive maintenance inspection, adjustments and repairs limited to a maximum time per machine of say ten minutes. Anything over this time should be covered by a separate job order. Major preventive maintenance is mainly performed on critical equipment.

There are many returns to users of preventive maintenance programme, namely: grated safety of works, improved equipment reliability, reduced production deferment (or production loss cost), reduced equipment downtime and outages, fewer large scale and repetitive repairs, less cost for simple repairs made before break down, less stand-by or back up equipment required, better equipment or spare parts control, etc.

2.2 Inspection Decisions

Equipment is inspected to determine whether further maintenance attention is required. Once the depth and type of inspection have been decided upon the best frequency must be determined.

For equipment in continuous operation not only is there a loss of production when equipment fails but also when it is inspected. If it is assumed that downtime due to inspection is proportional to inspection frequency, and downtime due to breakdown is inversely proportional to inspection frequency, and downtime due to breakdown is inversely proportional to inspection frequency, the total downtime in unit time D_T is given by

$$DT = D_1 N + D_B \frac{k}{N} \quad (1)$$

where D_1 = Downtime per inspection.
N = Number of inspections per unit time.
D_B = Downtime per breakdown and
k = A constant for a particular piece of equipment based on operating experience.

The optimal inspection frequency can be obtained by differentiating the expression for total downtime with respect to the number of inspections in unit time and equating to zero.

$$\frac{d(D_t)}{dN} = D_1 - D_B \frac{k}{N^2}$$

Assuming D_B and D_1 are constants. Hence

$$N_{opt} = \sqrt{\left(D_B \times \frac{k}{D_1}\right)} \quad (2)$$

In this maintenance type the operating parameter to be monitored should be indicative of the machine's condition such as: temperature, pressure, vibration etc. The method uses the old law of maintenance attributed to Confucius which states that "if it works don't mess with it" by recording or monitoring the operating parameter, you can actually see the parameter approaching the tolerable (or severity) limit, thus giving you advance warning of when you will have to shut down the machine for repairs even before major damages occur. In this manner, you have better spare parts/material control, anxiety is reduced to the barest minimum, repair windows could be arranged to coincide with public holidays, a work-free or break periods, etc since failure times and incipient faults could be predicted to a very high accuracy before damages are done to the production process line. The use of baseline signatures, trends and severity (tolerable) limits its peculiar with this maintenance type.