

Maintenance Management —A Conceptual Framework

PREAMBLE

This chapter focuses on the basic concepts of Maintenance and Plant Engineering. The objectives of maintenance department and the functions that are carried out by maintenance department of an organisation are thoroughly discussed. The inter-relationships and possible interactions of plant engineering with various departments of a given organisation are portrayed. Various management functions such as planning, coordinating, directing applying to plant engineering are depicted. Some light is thrown on emerging issues in maintenance/plant engineering area, such as tero-technology or total productivity maintenance (TPM), etc.

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1.1 INTRODUCTION

The concept of maintenance is as old as Stone Age. When man learnt to manufacture tools for hunting and fighting, he also learnt how to preserve, sharpen and keep them ready to use at any moment he wanted. He understood the need for upkeeping (maintenance) of his tools and assets, and found ways and means to safeguard and enhance their life. This function has been slowly gaining importance from Stone Age to Modern Age. Yet, in many industries today, maintenance function is given a low priority. Perhaps this is because it was considered to be a third rate job till the Middle Age, a rather unfortunate perception which continues to this age. Maintenance, being an absolute necessity, has not been given due importance over centuries and not much thought has been given to its significance. There are studies to support this. The results of the studies revealed that the equipment utilisation is found to be as low as 30% in few cases while 50%–60% in many cases. However, in the present-day environment, particularly when limited capital is available to spend for capital equipment, the best method to increase the productivity is by enhancing the useful life of the assets and their maximum utilisation. Therefore, maintenance function has become a challenging job. In India, organisations like National Productivity Council (NPC), in addition to a few universities, e.g., Indira Gandhi National Open University (IGNOU), are playing a vital role in disseminating the knowledge about the importance and significance of maintenance management in an organisation.

1.1.1 Maintenance Management

Maintenance management, in a broader sense, is termed as Plant Engineering and Management (PEM). This is because its activities are related to engineering and management. Generally, maintenance is regarded as a repair function. However, in reality it is a combination of four basic activities, retain, preserve, prolong, restore (known as 2Ps and 2Rs of maintenance) carried out to prolong the acceptable condition of a machine or equipment. However, a much broader concept has been assigned to PEM by adding the activities like enhancing reliability, availability, and maintainability (R-A-M) of machine, equipment, assets, or tools. And these functions have taken broader shapes in the modern world with names like “Physical Assets Management”, “Tero-technology”, and “Total Productive Maintenance”.

1.2 AWARENESS ON MAINTENANCE AND PLANT ENGINEERING AND MANAGEMENT

Plant Engineering and Management can be compared with a doctor’s job if we assume our body as a machine. When a refrigerator or a television in our house fails to work, we immediately call a repairman to get it rectified. This activity of the repairman in an organisation will be equal to that of maintenance or plant engineering.

Generally, in small organisations, plant engineering activities are carried out by production personnel (self-maintenance). In a few firms, this is carried out by an external agency or any appropriate outside parties on call as and when required (contractual maintenance). However, medium to larger industries usually go for in-house maintenance with a separate department for the following reasons:

- Maintenance and repair of equipment is not so easy and specialised personnel are required to handle the situation.
- It is not economical to call or contract the services of outside parties.

- Breakdown maintenance becomes too difficult sometimes due to non-availability of repairmen in the needed time.
- When maintenance is given to outside parties, it leads to too much dependability which is not desirable.
- Loss of production due to lack of maintenance cannot be compensated by contractual maintenance because outsider may not stand responsible.
- Shifting, day-to-day preventive maintenance activities, and other practical difficulties cannot be entrusted to outside parties.

The function of maintenance is not just repairing the equipment when it fails, but it is more concerned in preventing it from failing. Further, the maintenance has to find ways and means to enhance the useful and productive life of the equipment. However, outside parties may not do any justice to these two activities. Therefore, most firms often maintain a separate department of maintenance or plant engineering to look after the act of enhancing the life or effective and efficient usage of machinery and equipment.

Let us now define maintenance* or plant engineering.

A plant, in industrial jargon, is a place where men, materials, machinery and equipment, etc., are brought together to convert the inputs to desired outputs through well-defined process or method. Plant engineering is a study that looks after the smooth operation of a function without any interruption by keeping the machinery available to the maximum extent possible. *Therefore, the maintenance or plant engineering is the activity mix of erecting and installing the machinery, maintaining the good condition, enhancing the useful life, preventing the failures, and restoring the condition of the machinery/equipment in case of any failures.*

Thus, the plant maintenance consists of the following three major types of activities:

- **One-time Activities:** Erection, installation, and commissioning of equipment or machinery.
- **Ongoing or Continuous Activities:** Preventing the failures of the equipment, maintaining good condition of machine, and enhancing the machine life.
- **Intermittent or Limited Activities:** Restoring the condition of the equipment in case of failure or replacing the failed or poorly performing parts.

The technical activities mentioned above also include some analytical and managerial aspects such as planning, scheduling the preventive maintenance, analysing the failures, and spare parts management.

In fact, every machine is thoroughly inspected or tested by the seller before it is sold and by the buyer before it is put into use. Though the user operates the machine as per the specifications and directions by the original equipment manufacturer (OEM), even in the idealistic conditions also, there is no 100% guarantee that the machine will never fail. No machine is immune to failures. Moreover, as the machine is put into use, the wear and tear develops on running. These worn-out parts lead to the failure or breakdown of the machine and hence to stoppage or shutdown for repair or replacement of parts. At certain times, any delay in taking action as required may prove very costly or crucial. The role of Plant Engineering and Management comes into play at this moment to restore the condition or to control the machine from further deterioration or failure. As a matter of fact, the PEM enters the picture much before the failure occurs, i.e., to prevent the failure.

*Strictly speaking, Plant Engineering and Management is the broader concept of maintenance. But in this book, both these terms are more or less synonymously used.

Strictly speaking, the function of maintenance or PEM begins much before the activity of preventive maintenance. The activity starts with the erection and installation of machinery. In some industries, the unloading of machinery when they are procured is detached from purchase or stores management and is assigned to the PEM owing to the reason that the maintenance personnel are well-versed with the knowledge of machine care and method of unloading, etc. In the case of sophisticated machinery, proper handling and unloading becomes utmost necessity.

1.3 OBJECTIVES OF MAINTENANCE AND PLANT ENGINEERING

1.3.1 Need for an Objective

The maintenance manager needs an objective for interpreting the goals of the organisation into terms of departmental aims both in the long-term (policy/strategy) and short-term (task) bases. To achieve the design life of the equipment, safety of the operators, assets and the production output of the plant, a suitable policy is required to be framed. Thus, the maintenance objective should be in accordance and compatible with the objective of the organisation. At the same time, the use of energy and consumption of certain consumables and spare parts is to be optimised. For this the maintenance manager must fully understand his resources and requirements of his department as well as that of the organisation. These are exhibited in Figure 1.1.

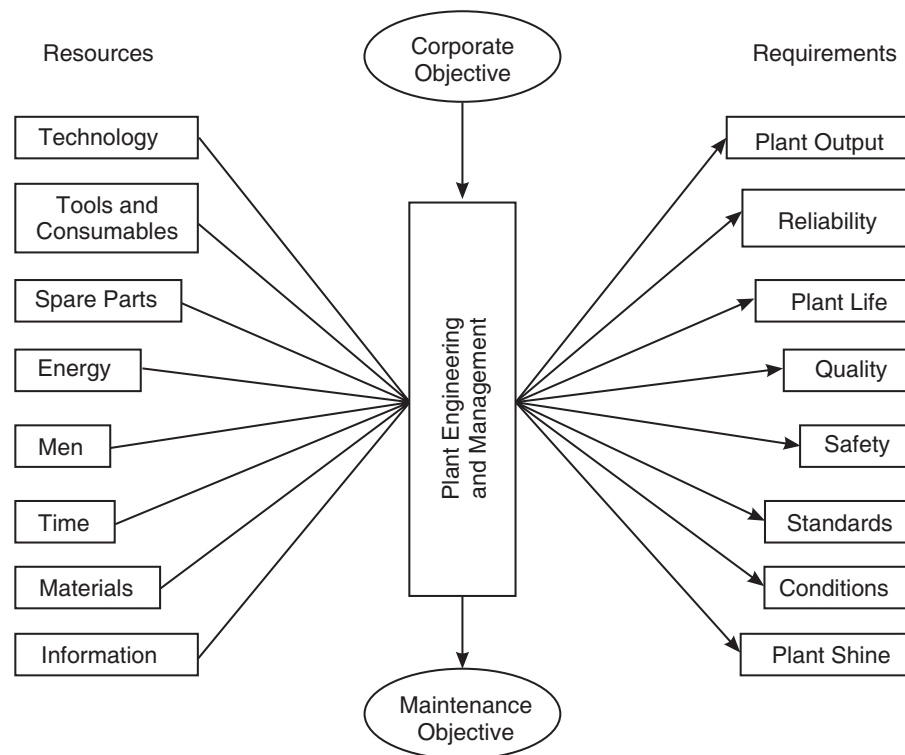


Figure 1.1. Resources and requirements for reflecting the corporate objectives into maintenance objectives

1.3.2 Objectives of Maintenance and Plant Engineering

From the above discussion, we get a clear picture about plant engineering and its need for objectives and goals. Now let us discuss the commonly adopted objectives of Plant Engineering and Management (PEM) in an organisation.

- To maximise the uninterrupted available time of the assets or machinery or equipment or services so that they can be used for the intended purpose they were procured.
- To preserve the value of assets by reducing the rate of deterioration by maintaining them to work in good condition. For example, lubricating, removing rust, dust, and dirt periodically and applying grease, etc.
- To facilitate maximisation of output of production by maintaining utilisation of machinery without affecting its deterioration.
- To perform the maintenance activities in the most economical way, such as restoring the condition of machine at the earliest possible time when it fails or is about to fail, planning and scheduling preventive maintenance without interrupting the production schedules.
- To update the machine and/or reconditioning with the latest technological or engineering features and/or management philosophies/styles.

In a nutshell, the objective of plant engineering is to concern itself with the provision of uninterrupted production process at minimum cost and maximum reliability and availability.

BUSTLE - 1.1

List a few organisations in your vicinity or those you are familiar with in which there is

- (i) a separate plant engineering department in the factory itself.*
- (ii) contract of the services from outside agencies.*
- (iii) system of hiring the services of the outside parties as and when needed.*

Interview them about the problems that they are facing due to the prevailing system. Analyse their merits and demerits. Suggest some remedies for the problems.

Test Your Understanding 1.1

1. Why do large industries prefer to establish their own in-house maintenance department? Give examples of the existence of plant engineering department in large scale industries. Justify their existence.
2. What are the expected problems when large industries undertake contractual maintenance? Explain with one or two illustrative examples.

1.4 STATE OF PLANT

Often people speak and take an account of the terms such as off time and on time or productive hours and non-productive hours depending on the running of the plant. With reference to the Plant Engineering and Management and Maintenance functions, the plant is usually found in one or more of the following states.

1.4.1 On Production

In this state, the production continues and there is no loss of output. This is the most ideal state that any production engineer or manager always desires to have. To retain the same state, the responsibility is on the maintenance engineer to maintain the equipment or machinery in perfect working condition or operable state. The maintenance engineer or the plant manager will monitor the equipment without disturbing the production. This is done online, i.e., while the machine is running and hence called online monitoring. Some small activities exist, such as lubricating, cleaning, inspection, and setting at contacting parts, etc., that will prevent the probability of failure of a machine and enhance the life. Generally, these activities can be performed while the machine is running by monitoring at suitable intervals. Such activities take less time rather few minutes (five to ten) only and hence will not interrupt the production.

In some occasions, production state is further classified into two sub-states:

- (a) **Production State with On-line Maintenance:** A little disturbance in the production occurs rather than any loss of production.
- (b) **Production State with Off-line Maintenance:** No maintenance activities are involved while production is going on, i.e., maintenance is carried out when production is not planned or engaged (such as lunch time or small gaps whenever the machine is free or not engaged).

1.4.2 Dead State

Dead state is a state of plant when the machine is not required for production for a given period of time. In other words, since the machine is not taken up for production, this time is usually said to be dead time. This is the most suitable time for Plant Engineering and Management to take up maintenance such as preventive maintenance or scheduled maintenance. Commonly, the night, Sundays or holidays or play days, etc., are considered to be the dead time of the machines as they are not operated during these times. The maintenance manager can plan and schedule the preventive maintenance during this time without any production loss. However, planning and performing should not exceed the dead time otherwise it may disturb the production.

1.4.3 Production Outage

This state of a plant arises due to shortage of stocks or product changeover or shift changeover or machine changeover, etc. In such state, the production is not extracted from the machine and remains idle for shorter duration. This shorter duration also can be made use of by the Plant Engineering and Management for effective maintenance.

1.4.4 Down State or Under Shutdown

This is a state of a plant, which comes into existence when the production is stopped and the equipment is shut down for maintenance by pre-planned agreement. The moment the machine is shut down, it will be handed over to the department of Plant Engineering and Management. Unlike the above two states (dead state and outage), this state is the stoppage of machine intentionally and purposefully for maintenance and a considerable loss of production may take place and attributed to maintenance

Summarily, a plant or machine can be stated to be in one of the two states, namely, up state or down state. The up state includes the states when the machine is available for production, i.e., on production state, production outage while all the other above-mentioned states are down states during which the machine is not available for production.

BUSTLE - 1.2

Consider the equipment such as a car or bike, household refrigerator, personal computer or laptop, television, washing machine, tape recorder, or CD/DVD player, etc., and identify the states they encounter in one month and put the duration of these states in the above model. Based on your findings comment on the condition and functioning of the equipment.

Test Your Understanding 1.2

1. Explain various possible states of a machine, which it may experience in its life. Support with suitable examples.
2. What do you understand by the dead state of a machine? What are the adverse effects of this status? How can a plant engineer exploit this state to contribute to the productivity?

1.5. FUNCTIONS AND RESPONSIBILITIES OF PLANT ENGINEERING

Generally, in small to medium scale industries, a separate plant engineering department does not exist. In most cases, the production manager looks after the functions of plant engineering or adopts contractual maintenance. However, if a separate department of plant engineering and maintenance exists (generally in a large scale industry), it holds responsibility for the following functions:

1.5.1. Installation, Erection, and Commissioning

The function of installing, erection, and commissioning is one-time activity of plant engineering department (PED), i.e., at the beginning of the establishment of the organisation or whenever a new machine is procured. However, it revokes when the management takes a decision to shift a machine from one place to the other within the organisation or when the total firm is shifted to any other place or in the case of expansion, etc.

1.5.2. Preventive Function

Preventive function is the major responsibility of plant engineering department. The Maintenance or PE department prepares short-term as well as long-term schedules to check each and every machine at regular intervals throughout the year. The PE crews will carry out the inspections, overhauls, and activities like lubrication along with checking of the operating parameters. The worn out parts (if any) will be replaced if required, so as to prevent further deterioration and not to lead to major failures or

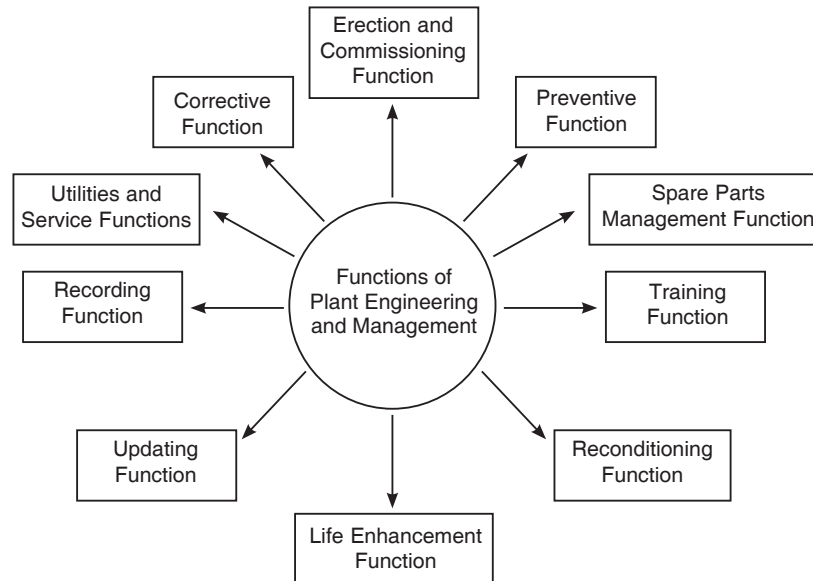


Figure 1.3 Functions of Plant Engineering and Management

catastrophes. The basic objective of this function is to forestall or try to prevent the occurrence of a failure. There are various strategies and approaches to accomplish this objective such as planned maintenance, shutdown maintenance, productive maintenance, predictive maintenance, preventive maintenance, maintenance prevention, which will be explained in detail in Chapter 3.

■ 1.5.3. Corrective Function

Corrective function is one of the basic functions of plant engineering. When a machine fails to perform the intended work in a production department, the production department will immediately inform the PED through a maintenance service requisition. The maintenance crew, notified for the purpose, will then be assigned to repair the machine/equipment and restore its condition. The order of priority or sequence of the jobs of the maintenance will be decided by the head or officer in-charge or foreman of the Maintenance/PED. The priority of taking up the jobs is usually decided on the basis of First Come First Serve (FCFS), Earliest Due Date (EDD), Service In Random Order (SIRO), Any Pre-emptive or Non-pre-emptive preferences or Johnson's and Jackson's rules of sequencing or using other operations research techniques such as assignment problem, etc.

Depending on the nature of the organisation, type of production, and other prevailing conditions or situations, this function is observed in different forms such as breakdown maintenance (BDM), corrective maintenance (CM), operate to failure and corrective maintenance (OFCM), emergency maintenance (EM), etc. These functions will be discussed in Chapter 3 in detail.

■ 1.5.4. Updating Function

Though the existing machines run at full efficiency, the latest technological developments can influence the productivity. Often, these new technological developments are introduced to enhance productivity in the form of ease of operation, increased output, wastage reduction, less time consumption, etc.

Owing to these reasons, the top management will insist the plant engineering department to update the technological features of the machinery. This function is often referred to as design out maintenance, which not only improves the productivity but also keeps the organisation alive or enhances its life. Further, if this function is ignored or neglected, the equipment becomes obsolete early and hence its resale value diminishes.

For example, you have purchased a personal computer with say, 40 GB Hard Disk Drive, which is the highest configuration during the time of your purchase. Suppose two or three years hence, a new configuration, 80 GB Hard Disk Drive, is prevalent in the market. It is considered to be the latest configuration that is in use. In such case, it can be suggested that 40 GB drive be replaced by 80 GB immediately, otherwise it will become completely outdated after a couple of years. It cannot even be sold in the second sale and just have to be discarded. Thus, updating the configurations or specifications with reference to the changing technology is very essential to prevent declination which may result in the collapse of the equipment, its products and even the organisation in the course of time.

1.5.5 Recording Function

“Men may come, men may go; But I go forever”, Robert Frost, the famous poet describes the nature of a river. These words hold true for the maintenance department. It continues as some people may join or leave the organisation. The new entrants, particularly, if they are inexperienced or fresh to the field of engineering/technology/management, to facilitate them, the department has to maintain the operating and maintenance manuals, machine specification and details of its procurement/installation/commissioning, instructions of safety, repair history, preventive maintenance history, etc. The time and cost details of day-to-day repairs and preventive maintenance (PM) activities will be recorded in their logbooks or registers. Based on this information in the logbooks, a weekly/monthly report will be generated and subsequently the reliability, availability, maintainability calculations can be performed. The maintenance department will also maintain a record of the procurement of spares and inventory stock registers of inward/outward movements, etc.

The manager’s function is not all-embracing unless there is a proper feedback system. Many experts on management speak about authorities and responsibilities of a manager and the proportion in which they should be delegated. But they speak least about accountability. Every manager has to be accountable for every job he/she does. In fact, this function is more significant in maintenance department. The plant manager also has to take accountability for his/her success as well as failure. This can be possible only if there is a good reporting system.

However, a good reporting system can be established in an enterprise with

- simplified organisation and organisational structure
- well-defined programmes and policies without any ambiguity
- well-designed methods of communication
- smooth relations among the managers horizontally and vertically
- good record-keeping
- faith in one another

Good recording system provides better control over the PE activities and events. Records give scope for introspection to the managers and the management by which a quality in work culture can be inculcated. A good recording system will bring healthy atmosphere, unambiguous communications, smooth run of programmes, cordial relationships, and accurate information system.

The record of maintenance jobs are usually figured by keeping track of the materials used and the labour hours expended on any one job. Most generally, the following types of records are found in plant engineering.

- (a) **Material Costs Record:** Material costs are recorded by the use of storeroom requisitions. A mechanic needing a new bearing to repair a machine takes the bearing from the storeroom with a material requisition. All such materials used are accumulated in the storeroom and a record of its use is maintained. Finally, based on this record, total material costs are calculated.
- (b) **Labour Costs Record:** Labour hours spent on any one job can be recorded in various ways. The simplest way is to maintain a work report of each mechanic in a special card submitted at the end of each day indicating how much time was spent on each job assigned to him/her. The mechanic's time spent on a maintenance job is translated into money as the actual rupees paid to that mechanic. Further, this data can be used to estimate the average wage of the department. However, the average wage includes the overheads also, such as storeroom upkeep, power used in the shop, utility charges (compressed air, gases, etc.), safety equipment, etc.
- (c) **Equipment Records:** Records of equipment are a necessary part of every good maintenance programme. Such records include all the pertinent data concerning the equipment itself, such as serial number, supplier and initial cost. Such information is also necessary while ordering parts or seeking information about such equipment from the supplier. A history card also contains a record of repair work performed, the schedule for inspections, and the costs of inspection and repair. Repair cost information is especially valuable, as it can determine the replacement age, i.e., the age when running costs are higher than normal preventive maintenance cost.

Some companies are now making excellent use of data processing equipment and digital computers to assist in maintaining maintenance records. One aircraft company utilises punched cards to feed data into the system and can get almost immediate answers to any of the following queries:

- Who received the service?
- When and where did they receive the service?
- What kind of service was performed?
- How much time did the maintenance man spend?
- What was accomplished?
- How much did it cost?
- Where were the excessive maintenance costs being incurred?

Also, this recording system is of tremendous assistance in making decisions on what to do when, to forecast equipment-replacement schedules and so forth.

1.5.6 Training Function

The department has its responsibility to update the technology, knowledge, skill, efficiency, and effectiveness of its crew as well as the machine operators. It also conducts a time to time expert lectures or workshops to make the machine operators aware about the cleaning and upkeeping of their machines in addition to upgrading themselves with the latest technical knowledge.

The main objectives of training function with reference to plant engineering are

- updating the technology
- optimisation techniques for effective utilisation of resources
- grievance handling with reference to the work difficulties
- interactive sessions with the employees about their experiences while working
- waste reduction, cost reduction, innovations, etc., in the field
- feedback about the troubles faced by the PE personnels.

The training programmes in maintenance provide the following advantages:

- The training programmes help in sharing the views of the problems of the workers with others that bring forth a common solution to the similar problems in their areas.
- Though the crew is thorough and skilled, the training programmes will further help in upgrading them with the technological information for troubleshooting.
- The human behavioural sciences indicate that the joy doubles while troubles are halved if shared with others.
- They pave an easy way for performance appraising particularly, during promotions and awarding merit increments, etc.
- Records of these discussions will be helpful in the future.
- The training programmes help develop a proper work culture in people and produce effective output.
- The training programmes create enthusiasm and reduce fatigue.

■ 1.5.7 Spare Part Management Function

In most of the industries, the inventory of maintenance and repair such as oils, lubricants, grease, machine spares (bearings, bushes, belts, chains, electrical equipment, etc.) are taken care of by the PED and a separate store is maintained in coordination with the production planning and control (PPC), materials planning and control (MPC), and purchase department.

The management of spares has many dimensions such as the availability of spares in the market, the type of market (such as government market, open market, foreign market, etc.) in which they are available, time or season of availability, size, standards, quality aspect, traceability, replaceability, compatibility, etc.

■ 1.5.8 Utilities and Service Function

Utilities mean those aspects which supplement the production. The utilities include telephones, fax machines, compressed air, water circulation, electric power and/or generator, air conditioners, lighting (both regular and emergency), fire extinguishers, and other safety measures (in many cases, fuels such as petrol, diesel, liquefied gases of gaseous fuels, etc., are also included). These utilities will be under the maintenance department which is expected to provide service in all these aspects along with the machine servicing.

■ 1.5.9 Machine Life Enhancement Function

The main motto of PED is to increase the length of the service life of the machinery and equipment. In the interest of this, the department will coordinate with the production departments to upkeep the machinery. The maintenance crew will also perform the activities like removal of rust, cleaning, lubricating, applying grease, etc., to prolong the useful life of the machinery.

For example, a CNC machine will be maintained under specified atmospheric conditions by providing air conditioning. Thus, maintaining correct conditions such as pressure, humidity, noise level, dust level, vibration level, and temperature will enhance the machine life as well as human lives.

■ 1.5.10 Reconditioning Function

As the machines grow old, they tend to create lot of problems due to wear and tear. In such cases, the companies will be under dilemma to replace the equipment owing to their huge costs. Moreover, the decision making to discard the old machines which incurred huge investments is very difficult in many cases. Hence, the maintenance managers will think of renovating or reconditioning the old machine. In this function, the old machine and its base or basic parts will remain the same but some parts may be changed. Thus, the condition of the machine will be restored generally by replacing the worn-out parts and accessories, and, in rare cases, a few of the basic parts may be replaced.

For example, a scooter after using it for about 10 to 15 years, keeping all other parts unaltered, the cylinder can be re-bored to next size and a suitable piston can be replaced to use for another three to five years.

■ 1.5.11 Maintenance Planning Function

In fact, maintenance planning is the most important function that sequences, schedules, and coordinates all the above functions. This function starts with forecasting and procurement of the material requirement, prediction of the failures, monitoring machine health, and assigning time and men to perform the planned activities. Owing to its significance, an elaborate discussion about this function is made in Chapter 3.

BUSTLE - 1.3

Visit an organisation in your vicinity (or the one in which you are working). Observe the functions of plant engineering department being executed in the organisation. Rate how effectively these functions are carried out or the percentage of time spent on each function per month.

Test Your Understanding 1.3

- List the functions of PEM? Briefly explain each of them.
- What are the one-time (non-repetitive) functions of plant engineering? Explain their importance. Give illustrative examples.
- Explain the following functions of maintenance.

(a) Preventive function	(b) Corrective function
(c) Reconditioning function	(d) Installation and commissioning
(e) Training function	(f) Spare parts management
- Describe the role of maintenance department in improving the machine life.

1.6 PHYSICAL ASSETS MANAGEMENT OR TOTAL PRODUCTIVE MAINTENANCE OR TERO-TECHNOLOGY

The term *physical assets management* (PAM) is synonymous to total *productive maintenance* (TPM) and *tero-technology*. It takes into account all aspects of plant machinery from design to discard, viz., design, manufacture, installation, commissioning, maintenance, replacement, and removal of the plant/equipment as well as the feedback of performance for the equipment manufacturer. Tero-technology envisages application of the combination of managerial, financial, engineering, and other practices applied to physical assets in pursuit of economic life cycle costs (LCC). It is concerned with the specification and design for reliability and maintainability of plant, machinery, equipment, buildings, and structures. This total LCC concept enables proper equipment evaluation and selection so as to give an overall low LCC. This gives rise to huge potential for savings in terms of cost effectiveness of replacements on considerations of whole life cycle. 'Design audit' consists of crucial scrutiny of the designs by the operating and maintenance engineers independent of the design process in order to ensure reliability and maintainability of plant and machinery and to identify weaknesses in designs requiring modifications. The word 'tero-technology' stems from the Greek root 'terein' which means 'to look after', 'to guard over', or 'to take care of'. The principles of tero-technology as discussed above can be applied, to a greater or lesser extent, to any physical asset in any organisation, no matter what the size of degree or complexity of either asset or organisation is.

1.7 CONCLUSION

Plant Engineering and Management will undoubtedly increase the productivity of an organisation if managed properly. However, any mismanagement or unorganised way of working will result in huge losses. There are quite a few evidences where many organisations blame Plant Engineering and Management in most of the situations for the loss of production. The middle-level production managers feel that their machines are not updated, not made available for longer time due to shutdowns, improper maintenance, waiting for spares, absenteeism of maintenance crew, etc. Therefore, Plant Engineering and Management is usually held responsible for loss of production. This atmosphere frequently leads the managers to look for the excuses to escape at times. In trying to save his/her stake, the managers end up in bitter relations with each other. However, the employees of the organisation should realise that they are working for the growth and prosperity of the organisation. In connection to this, it is everybody's responsibility to upkeep the machinery and equipment and keep them neat and tidy for enabling to preserve, prolong the life, retain and restore the condition of the equipment.

1.8 RECAP

In a nutshell, the Plant Engineering and Management exists in the organisation to preserve assets, prolong the life of the assets, retain their good condition, and restore the acceptable condition of the machinery or equipment or asset if they fail. The plant engineering and maintenance department is often entrusted to execute the functions like corrective (breakdown), preventive, productive maintenance, spare parts management, etc. It also looks after the erection, installation, commissioning of the new equipment, shifting of the machinery, provides utilities like water, compressed air, inter communication services, etc. The maintenance even undertakes the activities like updating the

technology and reconditioning of the machinery, etc. It interacts with various internal departments such as production to perform the aforesaid functions, finance in budgetary decisions, accounts in cost analysis, personnel in training and compensation against accidents, PPC in preparing PM schedules. Apart from these, PEM interacts with the outside parties also such as material suppliers, OEMs, vendors, sub-contractors, electricity, telecom, waterworks, fire stations, etc. This planning function is elaborated in Chapter 3 due to its high importance in the present scenario. In present days, the maintenance or plant engineering has taken a new shape and dimension in the form of physical assets management (PAM) or tero-technology (TT) or total productive maintenance (TPM). These concepts are also discussed in Chapter 3.

1.9 KEY CONCEPTS

1. **Plant:** A place where men, material, and machines are brought together to convert the inputs into the desired outputs in a well-defined method.
2. **PEM:** Plant Engineering and Management is that part of organisation that helps to preserve the assets, prolong the life, retain the condition of the equipment/assets, and restore the condition when it fails.
3. **OEM:** Original equipment manufacturer is a person or a group or an organisation that manufactures a machine or equipment or an asset.
4. **Reconditioning:** The activity of regaining the condition of a machine or equipment when its efficiency or performance comes down or deteriorates to nearly its scrap value level.
5. **Erection:** The act of arranging or keeping the machine or equipment in its position as per the layout.
6. **Installation:** The act of arranging the machine in position and keeping it in usable condition.
7. **Commissioning:** The function of keeping the machine in working condition to its full efficiency.
8. **Breakdown:** Failure resulting in non-availability of an item.
9. **Down time:** The period of time during which an item is not in a condition to perform its intended function.
10. **Overhaul:** A comprehensive examination and restoration of an item or major part thereof to an acceptable condition.

REVIEW QUESTIONS

1. Define and explain the term maintenance or plant engineering. What are the activities of this department in a large scale organisation? How do they differ as compared to small scale industry?
2. Explain the objectives of Plant Engineering and Management?
3. What are the possible states a machine can experience in its life? Which state do you think is more disadvantageous or detrimental? Illustrate with examples.
4. What do you understand by the shutdown state of a machine? What are the adverse effects of this status?
5. List the functions of maintenance department. Briefly explain each of them.
6. Explain the role of plant engineering in enhancing the machine life.