UNIT 18 TOTAL PRODUCTIVE MAINTENANCE (TPM)

Objectives

After going through this unit, you will be able to:

- know the origin of Total Productive Maintenance (TPM),
- get into the characteristics of TPM and getting motivated towards the TPM,
- eliminate variety of losses of an organization and thereby aiming at maximizing the equipment utilization,
- identify chronic and sporadic defects associated with equipment,
- sharpen the understanding of autonomous maintenance and its relevance in operational context,
- acquire the concept of TPM promotion and its structure.

Structure

18.1 INTRODUCTION: ORIGIN OF TPM

The origin of TPM can be traced back to 1951 when preventive maintenance was first introduced in Japan. The Japanese took the concepts and techniques of preventive maintenance from the U.S.A. The induction of preventive maintenance from the U.S.A. heralded the modernization of plant maintenance in Japan. Nippondenso Company Limited first introduced plant-wide preventive maintenance in 1960. This was the usual form of preventive maintenance, wherein operators devoted themselves only to production jobs and the maintenance personnel were responsible for the maintenance of plant and equipment. In the mid 1960's, Nippondenso undertook the automation of its production with the result that the manufacturing and assembly operations became largely automated. This brought in a new problem — one of maintenance of automated equipment. It was found that the maintenance crew, only by itself, could not effectively maintain the greatly increased number of automated equipment. Accordingly, the management of the company decided to change the allotment of duties of the operators of automated equipment in as much as each operator was made responsible for routine maintenance of his equipment. This was the origin of one of the important features of TPM, which is autonomous maintenance by production operators.

Thus, Nippondenso had already recognized the importance of preventive maintenance in improving equipment availability and had also by then introduced autonomous maintenance by production operators, as noted above, thereby freeing the maintenance personnel from the routine maintenance tasks and making it possible for the maintenance department to take up the essential tasks of maintenance planning based on equipment performance, plant and equipment modification for improved reliability and maintainability, development of reliability and maintainability specifications for new equipment and designing-out-of-maintenance. These tasks are aimed at maintenance prevention (MP). Thus preventive maintenance together with MP and maintainability improvement (MI) activities gave birth to productive maintenance (PM). The aim of productive maintenance is, therefore, the maximization of plant and equipment effectiveness in the pursuit of economic effectiveness and achievement of optimum life cycle cost of production equipment. This was the origin of the second important feature of TPM, which involves activities to maximize equipment effectiveness. Moreover, Nippondenso, by then, had already developed quality circle activity with all the employees participating in it. It recognized the use of small group voluntary activity for promoting the adsorption of PM and getting the total involvement of plant personnel in productive maintenance of plant and equipment. Based on this, Nippondenso decided to evolve PM with all employees participating in it; use of total participation through small group voluntary activity for TPM promotion. This essentially was the origin of the third important feature of TPM, which is the use of company-led small group activity.

Based on the above development, Nippondenso evolved TPM between 1969 and 1971, and it was awarded the 1971 Distinguished Plant Prize (PM Prize) for the development and effective implementation of TPM by the Japanese Institute of Plant Engineers (JIPE). Thereafter, the formal definition of TPM was enunciated by JIPE in 1971.

18.2 MOTIVATIONS AND IDENTIFYING CHARACTERISTIC OF TPM

Having discussed in chronological sequence the origins of the three important features of TPM, we can now take up in sequence the basic motivations, and identifying characteristics of TPM. Takahashi has identified three specific motives for the advocation and subsequent adoption of TPM in Japan [9]. These three motives are as follows:

1. Adoption of the life cycle approach for improving the overall performance of production equipment.
2. Improving productivity through a highly motivated workforce, which can be achieved through job enlargement in which all workers are given a range of challenging jobs in order to develop their skills at different crafts.
3. The use of voluntary small group activity for identifying the likely cause and frequency of failure of critical equipment, possible plant and equipment modifications, which will result in significant savings, and efforts to fully utilize existing equipment through improved availability.

The formal definition of TPM was also enunciated along the same lines. Two specific parts of the first motive are as follows:

i) Pursuit of economic life cycle cost of physical assets, which must include building in of reliability and maintainability features and the extension of the useful life of the assets, and since TPM deals primarily with production equipment and is used in manufacturing industries, such assets are plant and machinery, and

ii) Improving the overall performance of plant and machinery, which should also take into account the effective use of such production equipment through the minimization of losses not only due to breakdowns, but also due to poor quality and losses due to set-up, adjustment, idling and minor stoppages of the equipment and equipment operating at reduced speeds.

Although the contribution of the last four causes, namely set-up, adjustments, idling and minor stoppages, and operation at reduced speeds, may seem small as compared to breakdowns and defective products, in actual practice, these four losses add up to a significant amount. This recognition differentiates productive maintenance (PM) from preventive maintenance. Whereas the practical application of preventive maintenance now-a-days* covers much more than just ‘routine’, or periodic preventive maintenance, and includes condition-based maintenance, or predictive preventive maintenance, plant modifications and designing-out-of-maintenance, activities aimed at the minimization of quality losses and set-up, adjustment, idling and minor stoppages, and speed losses do not come under the purview of preventive maintenance.

To be able to stay in business, the manufacturing organizations have to ensure much higher levels of equipment availability. Such high levels of equipment availability cannot be achieved with the ‘I operate - you fix’ altitude wherein the production operators only run the machines and the maintenance department attends to all maintenance activities, including routine activities which are carried out to keep the machines in good running order, such as cleaning of the machines, periodic lubrication, periodic checks and inspections and minor adjustments and repair. The maintenance departments are finding it difficult to attend to such routine tasks. Moreover, attending to such routine tasks is resulting in a situation wherein the necessary preventive maintenance activities, such as preventive replacement of critical components, equipment overhauls and necessary plant modifications, are getting backlogged for lack of available manpower, and this, in turn, is resulting in greater incidence of failures and loss of equipment availability.

As against this backdrop, let us consider a situation wherein the production operators perform basic maintenance activities on their own machines. They not only maintain their own machines in good running order but also are capable of detecting potential problems before a major breakdown occurs (at which time, the maintenance department is called in to take the necessary preventive action to avoid a long shutdown). This will not only leave the maintenance department free to attend to more pressing tasks which require higher levels of skills, but also bring back in the production operators the pride of craftsmanship. The production operators will then cherish their machines and tools, preserve them and use them with care, and this, in turn, will inculcate in them a sense of belonging to the organization. Thus, the integration of simpler and routine maintenance tasks with the production work not only enlarges the production job and makes it more interesting but also fosters in the production operators a commitment to the plant [3]. Moreover, with this the maintenance tradesmen are also able to carry out their tasks properly and under a more congenial atmosphere and this brings with it a feeling of job satisfaction in them. This, as we had noted earlier, is what is meant by autonomous maintenance and a key ingredient of TPM is that the production operators perform basic maintenance tasks on their own equipment.

The objectives of maximization of equipment availability, minimization of quality loss, and minimization of set-up, adjustment, idling and minor stoppages and speed losses are major challenges to any manufacturing organization and these challenges call for reforms and improvements in standards, processes, methods and procedures. Such reforms and/or improvements cannot be carried out by a few technical people working in production and maintenance departments; these challenges require the active participation and involvement of all employees in the organization.

* Nakajima[4] has taken preventive maintenance to include routine maintenance and periodic inspections, whereas productive maintenance (PM) must include not only routine or periodic preventive maintenance activities but also the concept of maintenance prevention (MP) and designing-out-of-maintenance. This view of preventive maintenance is outdated.

In the preceding paragraphs we have discussed the need for having a highly motivated workforce, that is, the need for a high level of motivation in the persons who carry out the essential tasks, or activities, whether they are production operators, maintenance tradesmen, or quality control inspectors. After all, in the final analysis, these persons perform the important tasks, which directly affect equipment availability, product quality and productivity. These persons must not only do their allotted task to the best of their capability, but they should also forever attempt to reach higher levels of performance. Higher levels of performance require commitment to the job, motivation and a sense of belonging to the organization. This sense of belonging to the organization also inculcates in the employee a sense of belonging to the larger group, wherein the maintenance fitter not only identifies with the plant/equipment, he also identifies with the production operators and the quality control inspectors, who are also a part of the same group. Thus innovative ideas and suggestions for reforms and improvements must be preceded by an attitudinal change in the workmen leading to involvement, which, in turn, comes from a conscious effort through a synchronization of hand, head and heart and from creative work which is beneficial to the larger group. One of the practical and time-tested ways of inducing involvement and a sense of belonging in the workman is through active participation, wherein he voluntarily joins a group of people who meet to discuss their problems and suggest better ways of doing what they are doing; a voluntary small group of people who meet to discuss problems with housekeeping, quality, equipment availability and productivity, and to suggest reforms and improvements. This is active participation and quality circles and ZD groups are its different forms. In the context of TPM, we call these PM circles (and PM sub-circles).

Involvement of the workmen on the shop floor is not enough since, as discussed earlier, the objectives of maximization of equipment availability, minimization of quality loss and the minimization of four other types of losses cannot be achieved without the involvement and active participation of all employees in the organization. To be able to effectively deal with these challenges, the organization has to ensure the involvement of all functions in the organization, namely marketing/sales, design/ engineering, materials management/purchasing, production, maintenance and quality control. Thus the promotion and adsorption of TPM requires the development of the TPM Promotion System which links the various PM sub-circles and PM circles to the Departmental PM Committees and the Departmental PM Committees, in turn, are linked upward to the Corporate PM Committee. The Corporate PM Committee establishes the company PM policies and objectives and overseas the activities of the various Divisional/Departmental PM Committees. Similarly, Divisional/Departmental PM Committees establish the PM policies and objectives for the division/department and oversee the activities of the PM circles, which come under them. There is an overlap and the shop manager/foreman who is a member of the Divisional/ Departmental PM Committee is the PM circle leader. The PM sub-circles come under the overall direction and guidance of a PM circle and consist of volunteers who may be operators, maintenance tradesman etc and is headed by a leader, who is typically also a volunteer.

Activity A

Distinguish productive maintenance from preventive maintenance.

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Activity B

Visit a manufacturing unit or think of your company's maintenance department. Which one is in practice: preventive maintenance or productive maintenance?

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18.3 ELIMINATING SIX BIG LOSSES

We had noted that the first of the three motives for the advocation and subsequent adoption of TPM, as identified by Takahashi, was the 'adoption of the life cycle approach for improving the overall performance of production equipment'. Efforts at improving the overall performance of plant and machinery must not only be directed at losses due to ineffective maintenance, but also towards the other losses which limit the effectiveness of production equipment. After all, the formal definition of TPM clearly states that the aim of TPM is the maximization of equipment effectiveness and as a further clarification, it is also noted that this implies efforts directed at the improvement of the overall effectiveness of production equipment. Wireman, in his book on TPM, explains the first two clauses of the formal definition of TPM, namely maximizing equipment effectiveness and establishment of a total system of PM covering the whole life of equipment, as ensuring equipment capacity and implementing a programme of maintenance for the entire life of the equipment [10]. He goes on to state that ensuring equipment capacity implies efforts directed at ensuring that the equipment performs to its specifications — 'operates at its design speed, produces at the design rate and results in quality product at these speeds and rates'. This implies efforts aimed at the maximization of equipment utilization (and not just the maximization of equipment availability), and there are six significant causes of reduction of equipment utilization. These are as follows:

1. Losses due to ineffective maintenance, and these, in TPM terminology, are called breakdown losses.
2. Setup and adjustment losses.
3. Loses due to idling and minor stoppages of equipment.
4. Loss due to operation at reduced speed, or at less than full (design) load — this Wireman calls 'reduced capacity loss' [10].
5. Losses due to poor product quality — due to defects in process and production of defective items.
6. Loss due to reduced yield from the startup of the equipment to the point of stable production — and this Wireman calls 'startup/restart loss' [10].

These are the six major equipment losses and the stress it places on the elimination of these major losses is one of the three identifying characteristics of TPM (*Figure 18.1*).

The reduction of equipment utilization has three constituents, which have to do with the availability of the equipment, the rate at which the equipment is performing, and the product quality performance of the production equipment (this, in TPM literature, is called the 'quality rate', in keeping with the performance rate). Thus the overall equipment effectiveness has three constituents, namely, availability, performance rate, and quality rate and overall equipment effectiveness

= availability × performance rate × quality rate.

Note: These three constituents are also measures of equipment effectiveness.

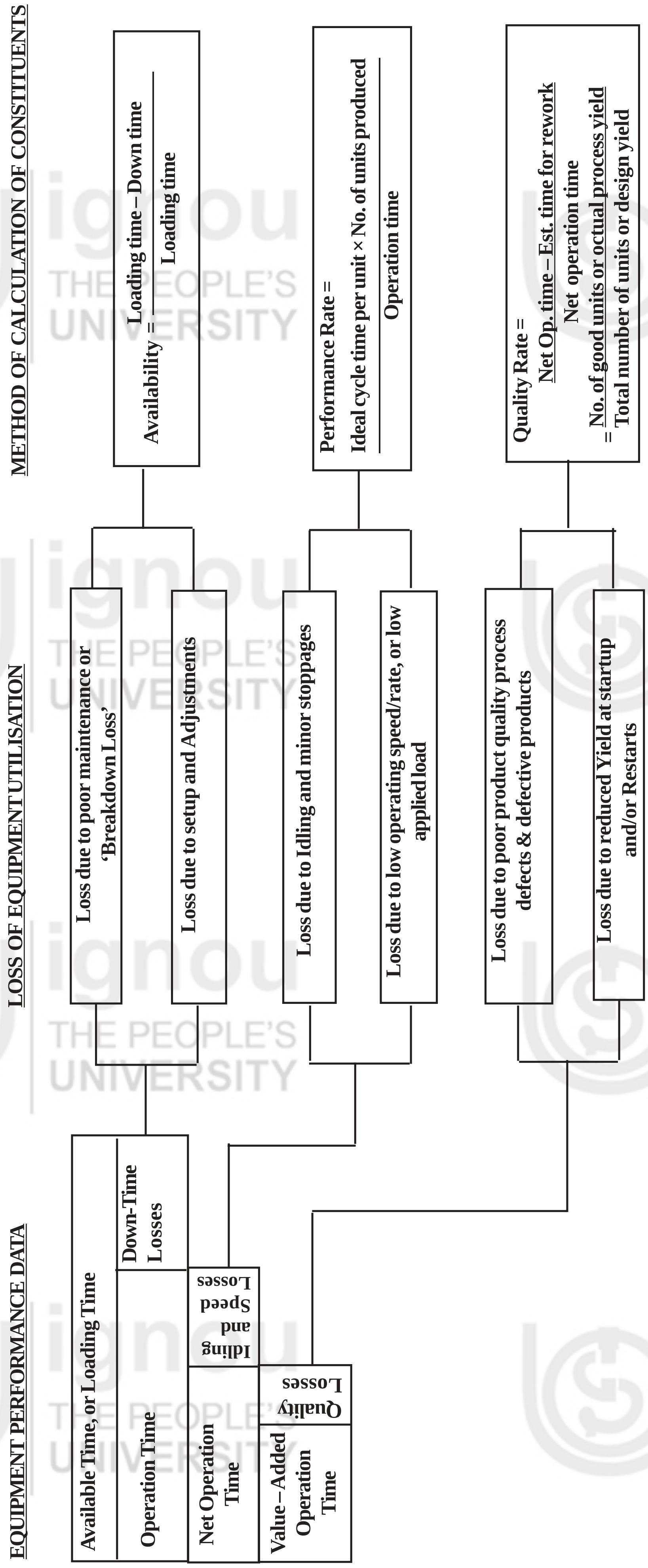

Figure 18.1 : Calculating availability, performance rate and quality rate

These three constituents, the six big losses and the method of calculating these three constituents from the shop, or equipment performance, data are given in Figure 18.1. The terms used in the figure are as explained below:

i) Loading time is the available time on the equipment for production/productive work. This is the total time available minus the necessary time for planned or essential activities, such as time lost due to meetings, scheduled tea/coffee breaks or precautionary rest periods, and also breaks in production schedule or planned production stoppages for planned/preventive maintenance work, and, on rare occasions, scheduled production stoppages for non-maintenance reasons.

ii) Operation time is loading time minus the downtime, or the time the machine is down for reasons other than given above under (i). Such downtime includes time lost due to equipment breakdowns, setup of equipment, tools, dies and accessories, and adjustments to the equipment. These adjustments are generally carried out by operators, and take less than 10 minutes.

iii) Net operation time is the time the equipment or the machine is operated at its design speed, at the design rate of production, or at the design load. The time lost due to idling and minor stoppages of the machine, and operating it at a reduced speed or at a reduced rate of production is subtracted from the operation time to get the net operation time. The term design load has also been included to take account of process plant equipment, which are either derated and/or operated at low loads for various reasons. An example of this would be a 210 MW thermal power unit being operated at 150 MW because two out of six pulverizers are down. In thermal power plant terminology, such outages are called partial outages.

iv) Value-added operation time is the net operating time during which actual value addition is carried out. This is obtained by subtracting the total estimated time for rework of defective/nonconforming products from the net operation time. Thus the time required to make up for the quality losses is subtracted from the net operation time to get the value-added operation time.

Activity C

With respect of your organization, carry out an analysis of machine utilization. Find out the significant causes of reduction of equipment utilization.

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18.4 CHRONIC AND SPORADIC LOSSES

What we will discuss in this section relates to all the six major losses. The effect of chronic losses is most acutely felt in the cases of equipment breakdowns and product quality problems. Chronic is used to refer to an undesirable condition, or phenomenon, which is either deep seated and continued over a long time, or occurs repeatedly over a long period of time. As opposed to this, a sudden, or an unexpected, occurrence, which occurs rarely, is referred to as sporadic. The difference between chronic and sporadic losses is illustrated in *Figure 18.2*.

Figure 18.2 : Difference between chronic and sporadic losses

Chronic breakdowns, or chronic defects, occur repeatedly over a long period of time and keep on occurring till something radical, or different, is done to get rid of the cause, or causes, of such breakdowns, or defects. Chronic losses are caused by conditions, which, over a period of time, get to be perceived as normal, and such losses only become obvious, or come to be recognized, when they are compared with the optimum conditions. The figure illustrates a case wherein after the chronic loss had been recognized; necessary efforts had been made to bring the level of loss down to the desired optimum level. Sporadic breakdowns, or sporadic defects, on the other hand, are sudden and unexpected occurrences and these occur only occasionally. The cause for a sporadic problem can be easily found out. Sporadic breakdowns, or sporadic defects, are usually due to a single cause (recall control charts and the existence of an 'assignable cause'). Sporadic losses can thus be removed by restoration — a repair or corrective action that restores the equipment, or the process, to its original, satisfactory condition. On the other hand, simple restoration actions are usually ineffective when it comes to chronic problems. This is primarily because chronic problems are usually due to multiple causes and these causes are usually difficult to find since they are hidden in the structure of the equipment and also the operational and maintenance practices. Thus chronic losses call for innovation, as opposed to restoration [2].

There are many other differences between chronic and sporadic losses. The differences have been summarized in the form of a table and this is given as *Table 18.1*.

Table 18.1: Differences between chronic and sporadic losses

Aspect	**Characteristics of** **Sporadic Problems**	**Chronic Problems**
Visibility	Conspicuous — conditions created considerably different from routine operating conditions	Hidden — tend to be over-looked since losses hard to measure
Frequency of occurrence	Low — only occasionally	High — occur frequently
Method of Detection	No special method necessary since visibility is high	Can only be detected by comparing the actual condition with the theoretical (design) standard/specifi-cation, or optimum condition/ level
Economic impact/loss	A single problem very costly but cumulative effect and cost minor	A single occurrence has small impact, or loss, but cumulative effect, or loss, considerable
Resulting impact on supervision and management	Substantial — sudden nature of problem attracts immediate attention and action.	Small and due to the repetitive/continuing nature of problem accepted as unavoidable/inevitable
Causation	Cause-and-effect relationship simple to trace. Generally due to a single cause	A single cause is rare; usually multiple causes or worse still, a complex combination of causes.
Type of solution required	'Restore the status quo'	'Change the *status quo*'
Type of analysis required	Usually simple — 'ask why five times'	Intricate and complex cause-and-effect analysis, corre-lation analysis and design of experiments and analysis of variance.
Corrective action to be taken by	Usually the line personnel in production, or design, can attend to it	Will need specialists in process engineering mainte-nance, and/or quality assurance.

Table 18.2 : Characteristics of equipment losses

Sl. No.	**Type of Loss**	**Conspicuous, or clearly evident**	**Hidden**
1.	Breakdown loss a. sporadic breakdowns b. chronic breakdowns	 √ 	 √
2.	Setup and Adjustment loss	√	√
3.	Idling and Minor stoppage loss		√
4.	Speed loss		√
5.	Quality loss a. sporadic defects b. chronic defects	 √ 	 √

From the table, we find that one may summarize by noting that sporadic problems, or conditions, are conspicuous, have easily identifiable causes and therefore call for simple and easily designed corrective actions which can be implemented by line personnel. As opposed to this, chronic problems are hidden and are usually due to a complex combination of causes. Coming to the type of analysis required, for sporadic problems, since the cause-and-effect relationship is rather simple to trace and such losses are generally due to a single cause, the type of analysis required is simple and straightforward. Usually logical step-by-step deduction would be adequate, and in most cases, the true cause can be detected by 'asking why five times', in keeping with the teachings of Taiichi Ohno of Toyota [8]. As opposed to this, the type of analysis required for chronic problems is usually intricate and complex. It also calls for detailed knowledge of the system/process and the equipment. This, together with the need for the application of sophisticated techniques, such as correlation analysis, design of experiments and analysis of variance etc., calls for the involvement of specialists in identifying, planning and implementation of corrective actions(s).

The characteristics of different types of equipment losses are given in Table 18.2. A closer look at the table would show the reader that five out of six big losses have been included in the table and the only loss which has not been explicitly included in the startup loss* . We have noted earlier that the difference between sporadic and chronic losses is clearly felt (or seen) in cases of equipment breakdowns and product quality inadequacies. However, the table shows us that, in addition to chronic breakdowns and chronic defects, idling and minor stoppage and speed losses are also hidden. Moreover, there are some setup and adjustment losses, which are hidden (whereas the others are quite obvious). As a matter of fact, idling and minor stoppages and reduced speed operations are also overlooked and considered normal exactly in the same way as chronic breakdowns and chronic defects. Two examples of chronic losses have been cited by Shirose [7]. He gives the example of a punch press, which has been operating at 200 strokes per minute.

In this case, the speed loss of 50 strokes per minute will remain hidden till such time that the operating (or actual) speed is compared with the design speed, or design capacity of the press. The second example is one of setup loss. Shirose cites the case in which setup currently takes 1 hour. He states that if the setup time can be brought down to 30 minutes by improvement in the technical and operating procedures and methods, then only will be hidden loss of 30 minutes become evident. The above discussion clearly brings out the importance of chronic problems/conditions. We must, therefore, briefly examine how such chronic losses occur, why these losses are neglected and also some of the actions, which can be taken to reduce, and if possible, eliminate, these chronic losses.

Activity D

Visit your maintenance management department and list out the equipment with sporadic defect and chronic defect.

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* Implicitly, the startup loss is also included since yield loss is also a form of quality loss.

18.5 AUTONOMOUS MAINTENANCE

The Japanese refer to autonomous maintenance as self-initiated maintenance. The term self-initiated maintenance also highlights the fundamental change of attitude, which is a prerequisite of TPM — moving away from the 'I operate, you fix' syndrome. However, this change of attitude implies cooperation and the recognition of the fact that operations and maintenance are inseparable when it comes to the job of looking after the maintenance of production equipment and machines. The fact that these two functions have to work together for the maximization of equipment effectiveness has been brought out quite clearly in the preceding chapter. Wireman uses the term team-based maintenance and this term is probably more appropriate since it brings out the need for the operator and the maintenance technician to work as a team. It also highlights the fact that the operation function does not replace the maintenance function and the operators take away only a part of the workload from the maintenance technicians* . We will use the term autonomous maintenance in this book primarily because this is the term that is used in the TPM literature now a days and is also understood quite well by the practitioners.

Autonomous maintenance has become synonymous with productive maintenance and TPM, and whenever one hears of TPM, the picture that emerges in one's mind is that of maintenance being performed by equipment operators. This thinking is so strong that if the more knowledgeable practitioners and maintenance professionals in India are asked to define TPM, the most likely answer will turn out to be as follows:

'a model wherein the routine preventive maintenance tasks are taken care of by the equipment operators leaving the maintenance department enough time to attend to other essential and pressing maintenance functions'.

What exactly is autonomous maintenance? Autonomous maintenance is maintenance performed by production operators [1] and the maintenance tasks, which are generally performed by them under TPM, include the following:

1. Cleaning, lubrication and bolting
2. Daily and periodic inspections
3. Minor repairs/adjustments and servicing

Let us briefly look at the need for autonomous maintenance. Why do we need autonomous maintenance and can we really have TPM without autonomous maintenance? Let us consider the actual state of affairs in our industrial organizations. The main reason for the poor availability of equipment, plants and production facilities is that the basic equipment conditions are not maintained. The periodic preventive maintenance tasks of cleaning, lubrication, tightening of bolts and fasteners, periodic replacement of wearing parts, equipment inspections and servicing are not performed. The maintenance department, in most cases, does not get the time to attend to these tasks and is too busy taking care of equipment breakdowns. Because these essential tasks are not performed, the condition of the equipment worsens and this, in turn, gives rise to a larger number of breakdowns. This makes the matter worse and the maintenance departments find it all the more difficult to carry out the preventive maintenance tasks and ensures that the basic equipment conditions are maintained. Add to this the fact that the equipment operating conditions are, in most cases, poor, operating procedures are not strictly adhered to and the operating standards are not maintained by the production operators. This also has a negative effect on the condition of production equipment and, therefore, on equipment breakdowns. Increasing number of breakdowns also results in inadequate restoration

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* As per Wireman, operators perform about twenty percent of the work that is performed by the maintenance technicians prior to the implementation of TPM.

activity and use of patchup repairs. The relationship between the operations and maintenance departments is adversarial. The two departments do not get along well; let alone the question of working together as a team. One blames the other for the poor condition of production equipment. As a result of this, the production equipment suffers. Because of this, the availability of our equipment, plants and production facilities is poor and things are getting worse every day. Consider also the globalization and opening up of our economy will bring with it competition and this, in turn, will call for use of sophisticated and automated equipment and plants. Maximization of equipment availability and extension of the useful life of production equipment have become essential and these objective cannot be achieved with the ‘I operate, you fix’ attitude of the past. Autonomous maintenance can help us to attain these objectives.

The thing to remember is that autonomous maintenance is carried out to prevent accelerated deterioration of equipment and also to slow down the process of natural deterioration. The very basis of autonomous maintenance is the prevention of deterioration and this has been neglected in our factories, production facilities and process plant for far too long. Autonomous maintenance will enable the maintenance of basic equipment conditions and with it also bring back into the production operators the pride of craftsmanship. The operators will learn to take care of their equipment and machines and use them properly. This will also ensure the use of improved operating procedures and maintenance of operating standards. The accelerated deterioration brought on by excessive loading, maloperation and operating errors will also be prevented. The incidence of equipment breakdowns will also be much lower. The maintenance department will find time for important tasks, such as, predictive maintenance, analysis of past failures, strengthening of weak points and reliability and maintainability improvement activities. Thus autonomous maintenance will not only take away a part of the workload of the maintenance department, but also bring into the organization sanity, cooperation and a sense of belonging to the organization. Thus we may conclude that autonomous maintenance is necessary for our factories and process plants. Moreover, autonomous maintenance is essential for reduction of the six big losses and accordingly, we cannot have TPM without autonomous maintenance.

18.5.1 Prerequisites for Autonomous Maintenance

Autonomous maintenance requires a change of attitude in the employees. Under autonomous maintenance, the operators of production equipment are required to attend to routine preventive maintenance tasks in addition to their allotted jobs of operating the production equipment. This implies that the operators are not only required to cooperate with the maintenance department and help in the task of maintenance of production equipment, but also to take on added responsibilities. Taking on added responsibility also implies acquiring a new skill. Similarly under autonomous maintenance, maintenance technicians are also required to change their attitude. Many eyebrows will be raised on reading this statement; but for a moment, consider the fact that the maintenance personnel, in most of our factories and process plants, have been busy carrying out routine tasks and patchup repairs, and have not taken on condition-based maintenance jobs which require the ability to analyze condition monitoring data and based on this, to decide the best course of action, and also analysis of past failure data and failure modes to identify equipment weaknesses and then plan reliability and maintainability improvement activities. These jobs require updating of skills, acquisition of new knowledge and, in many cases, even learning of new skills. In addition to this, the maintenance technicians will also have to learn to cooperate with the production operators and not treat them as enemies. Thus a most basic change of attitude is required from the production operators and the maintenance technicians.

The implementation of autonomous maintenance calls for an attitude of understanding and cooperation on the part of the employees. This, in turn, is derived from the employees sense of belonging to the organization and the trust the employees have in the management of the organization. In India, in most industrial organizations, the industrial relations situation is not entirely conducive for the implementation of TPM. There is a lack of trust between the employees and the management and to this, in many cases, is added a lurking suspicion of the intentions of the management in the minds of the employees. This lack of trust has to be removed and this can be done by a clear demonstration of management's faith in TPM and its dedication to improvement and growth. The management has to take the necessary actions to bring about certain changes in the operation of the company. These changes are the prerequisites for the implementation of autonomous maintenance.

The prerequisites for the implementation of autonomous maintenance include the following changes/activities:

i) recognition of the need for planning in maintenance and implementation of planned maintenance,

ii) installation of history cards on all critical equipment and machines,

iii) use of preventive maintenance and proper scheduling and control for all periodic preventive maintenance tasks including cleaning, lubrication, periodic inspections, periodic replacements, overhauls and servicing,

iv) use of predictive, or condition-based, maintenance for critical equipment (particularly on rotating machines, like pumps and turbines—use of vibration and noise monitoring, and on gearboxes—use of wear-debris monitoring/ ferrography),

v) use of a maintenance planning and control system based on a work order, or job order, system (it can either be a manual system or a computerized system depending on the size and complexity of operations but as the size of operations increases, steps should be taken to computerize the manual system),

vi) systematic collection of failure data and collection of costs of both breakdown and preventive maintenance jobs and feeding these back to the maintenance department via the data processing/management services department,

vii) analysis of maintenance costs to identify areas/systems requiring special attention in the form of strengthening of components and subsystems and reliability and maintainability improvement efforts,

viii) analysis of failure data and analysis of failure modes to identify the reliability and maintainability improvement needed, and

ix) restructuring of the maintenance organization to give it the required importance and power and also to ensure prevention of failures and an attitude of proaction as opposed to reaction and fire-fighting. The new structure must be capable of ensuring that all the preventive and corrective maintenance actions, detailed above, are properly planned and executed (for this, in larger process plants and manufacturing facilities, it may be necessary in create a maintenance planning bureau/cell/department).

These changes will demonstrate to the employees that the management wants to bring about major changes in the way the plant is being operated. The dedication of the top management to the effort will be brought home by the expenditure of resources required for some of these activities. Once these activities and systems are installed and progressing satisfactorily, then the management can go to the employees and seek their cooperation in the task of implementation of autonomous maintenance.

Activity E

Autonomous maintenance requires a change of attitude in the employees. Comment in regards to your own organization.

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Activity F

Think of manufacturing unit of your company and prepare a report on autonomous maintenance. How is it different from that of productive maintenance?

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18.6 TPM PROMOTION

We had noted that T in TPM stands essentially for total involvement, or involvement of all employees at all levels, and also that for this purpose, right at the beginning of its development at the Nippondenso Company, taking a cue from quality circle (or QC circle) activities, TPM was evolved as 'PM with all employees participating (in it) through small group activities' [5]. We will discuss the basic characteristics of PM groups and circles* before we discuss TPM promotion.

18.6.1 Characteristics of PM Groups and Circles

PM groups and circles are set up with the twin objectives of (i) tapping the knowledge and abilities/skill of the employees for solving work-related problems and for generating improvement ideas and suggestions, and (ii) developing a motivated workforce and improving communication between the employees and management through employee participation. PM groups are also small groups and similar in size as quality circles. But beyond this there are a few similarities. The two characteristic features of PM groups and circles are the two basic roles of small groups in TPM, which, in turn, are as follows:

1. Harmonizing group goals with the company, or corporate, goals,
2. Implementation of the five S's and autonomous maintenance.

18.6.2 Concept of TPM Promotion

In TPM, harmonizing the goals and themes of the small groups with the company, or corporate, goals is very important. The company, or corporate, goals are set by the top and senior management personnel. They set the organizational goals and they also determine the company wide PM policies*. These goals and policies have then to be transmitted down the organizational structure, through departments and departmental managers, to the shops and sections, and these goals and policies form the basis for

* A small group in TMP can either be called a group or PM circle depending on its size and its position in the TPM promotion structure (please see Fig. 14.4). Usually group lower down in the organizational structure are often called circles, as for example, machine shop medium section, first shift cicrle and the higher PM group may be called machine shop medium section cicles leader group, or committee.

the determination of the departmental PM goals and policies. The departmental PM goals are, in turn, used for setting of goals for the PM groups and circles in the shops and sections and further down, the PM sub-circles, if necessary. This is the first ingredient of the concept of TPM promotion, namely 'top down' goal setting and direction of activities, as shown in *Figure 18.3*.

The goals of the PM groups and circles, so set, have, in turn, to be achieved by the respective PM groups and circles. For the achievement of the goals, the improvement ideas and suggestions have to be implemented. The implementation of improvement ideas and suggestions requires the involvement, active support and assistance of higher-level groups right through departmental PM committee, upto the company wide, or central, TPM promotion committee. Implementation of ideas and suggestions of the groups is essential for the sustenance and growth of motivation in the members. This brings us to the second ingredient of the concept of TPM promotion, namely, 'bottom up' (or bottom-to-top) small group activities and implementation of improvement ideas and suggestions of the groups, as shown in *Figure 18.3*.

Figure 18.3 : Concept of TPM promotion — 'Top Down' goal setting & direction and 'Bottom up' improvement activities.

These two ingredients of the concept of TPM promotion, namely 'top down' goal setting and 'bottom up' improvement activities, ensure that the activities of the PM groups and circles, at every level of the organizational structure, complement and enhance the organizational activities [18]. This way they help in the achievement of the organization goals. For this, it is necessary that the PM groups should be integrated into the corporate, or company, organizational structure [18], and this, in turn, calls for a formal structure for TPM promotion.

18.6.3 TPM Promotional Structure

The effective administration of the scheme of small group autonomous activity, thus, requires a formal structure, that is, TPM promotion requires an organizational structure. TPM promotional structure of overlapping small groups is shown in Figure 18.4. This organizational structure ensures that the activities of the small groups in the various functions, like production, design and development, purchasing etc., and at the various levels in the organization are properly directed, coordinated and linked. TPM promotional structure enables cross-functional integration.

An example of the TPM police is given on page 14, as Fig.1.5, of Nakajima's book entitled 'TPM Development Programme:Implementry Total Productive maintenance At the company or top management, level thse policies are in the form of mission statements.

The TPM promotional structure is based on the following three important principles:

1. Use of overlapping small groups
2. Use of committee and subcommittees
3. Fanning out from the production/operations department to the entire company

The small groups function at every level of the company, starting from the top and senior management levels to the production shops and production lines. The two ingredients of the concept of TPM promotion call for proper linking of the small groups at the different hierarchical levels, and this is done through the use of overlapping small groups. The leaders of the PM circles at the lowest, or the first, level are members of the small group at the next higher, or the second, level, and so on right upto the top. This ensures linking of different groups, and enhances vertical (both top to bottom and bottom to top) and horizontal (between shops, departments and functions) communication. This is illustrated in Figure 18.4* . Notice that the promotional structure, shown in the figure, has a TPM promotion committee, four subcommittees (they can as well be called committees), and a TPM promotion office for overall administration of the scheme of small group autonomous activity. The TPM Promotion Committee is the apex body under the chairmanship of the Managing Director, or the Chief Executive Officer of the organization. It is responsible for directing the TPM activity of the entire company. It sets the TPM policy for the company and it also sets the TPM goals and activities for the company as a whole. It coordinates the TPM efforts of the various functions, or divisions and departments, to enable the achievement of the corporate goals. Under the TPM Promotion Committee, there a number of committees/subcommittees, with each committee/subcommittee being responsible for a particular topic, such as education and training, implementation of five S's standards, and MI and MP. The number of committees/subcommittees will differ from one organization to another.

Although TPM efforts are essentially directed at line activities, and the equipment operators, maintenance tradesmen, and the quality control inspectors and technicians are still the leading players [6], the TPM effort should spread to the other departments and functions of the company. Only when this happens, will the total involvement, as enunciated in the definition of TPM, be achieved. In this regard, one alternative is to take up the job of TPM promotion in two phases, with phase I concentrating on the production shops and departments, and in phase II, fanning out to the other departments such as design/engineering, sales and service, purchasing and general administration. In this context, Suzaki states that although, in most organizations, PM groups are still concentrated in the production shops/departments, TPM has recently begun to spread out to other departments [8].

Activity G

With respect to globalization and national policy measures, what is your top management's recommendation on PTM promotion?

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In Fig. 18.4, the tree uses production department, machine shop, medium machine section and the first shift for the purpose of illustration. The reader will appreciate that the same kind of overlapping structure will be incorporated for the other two shifts, for the other sections of the machine shop, and for the other shops.

Figure 18.4 : TPM promotional structure — Overlapping small groups

18.7 SUMMARY

TPM is neither an enigma nor an utopia. TPM is implementable; it is a practical and down-to-earth technique developed specifically for manufacturing organizations. However, the implementation of TPM requires will and determination, a clear statement of goals, attitudinal change and dedicated efforts by people in various departments and at different levels in an organization. Let us consider the objectives of zero breakdowns and zero defects. Although approaching zero is difficult, believing that zero defects and zero breakdowns can be achieved is, by itself, an important prerequisite for the success of TPM. One has to begin by changing the way employees look at breakdowns and defects. Instead of believing that (i) it is not the operator's responsibility to perform routine maintenance activities and periodic equipment inspections, (ii) all equipment eventually break down, and (iii) all equipment breakdowns can be fixed, production operators and maintenance tradesmen must believe that equipment should never breakdown and they can be maintained so that the loss due to break downs can be minimized, if not totally eliminated. The implementation of TPM requires a motivated and disciplined workforce and coordinated action by different departments and different levels directed at the same set of goals. Accordingly, TPM promotion has to be an organized group effort and for this purpose, it needs a formal TPM promotion system.

18.8 SELF ASSESSMENT QUESTIONS

1. What are the objectives of Total Productive Maintenance? How does it differ from Total Preventive Maintenance?
2. What is a bath-tub curve? How can it be used in practice?
3. Discuss preventive maintenance. In what ways is preventive maintenance absolutely necessary in JIT/ Kanban /pull manufacturing as opposed to push manufacturing.
4. Discuss the significance of Age-specific failure rate.
5. Every day the chief of maintenance needs concise information concerning the maintenance function. What information does he require?
6. When are the following policies useful?
   i) condition monitoring
   ii) preventive replacement
   iii) replacement on failure
7. Are the jobs in maintenance department popular with the young engineering graduates? What would you suggest to make the maintenance function more attractive?
8. What are the big six losses? What is the importance of these loses?
9. Calculate the availability, performance rate and quality rate from equipment performance data.
10. If the trend of computerization process continues to grow, what would be its impact on the maintenance function?

18.9 FURTHER READINGS

1. Goto, F., "Autonomous Maintenance", Chapter 4 in Nakajima, S. (Editor), *TPM Development Program: Implementing Total Productive Maintenance,* Productivity Press, Cambridge, Massachusetts, U.S.A., 1989, pp. 165-217.

2. Juran, J.M. and Gryna, F.M. Jr., *Quality Planning and Analysis: From Product Development Through Usage*, McGraw-Hill Book Company, New York, 1970, p 9.

3. Kelly, A., "Topics in Terotechnology: An Instructional Series - 10. Motivation of Maintenance Tradeforce", *Maintenance Management International*, Vol. 4, No. 2, January 1984, pp. 71-81.

4. Nakajima, S., "The Organization of Maintenance in Japanese Industry", *Maintenance Management International*, Vol. 3, No. 2, August 1982, pp. 83-88.

5. Nakajima, S., "TPM - Challenge to the Improvement of Productivity by Small Group Activities", *Maintenance Management International*, Vol. 6, 1986, pp. 73-83.

6. Nakajima, S., "TPM Small Group Activities", Chapter 8 of *TPM Development Program: Implementing Total Productive Maintenance* (Nakajima, S., Editor), Productivity Press, Cambridge, Massachusetts, U.S.A., 1989, pp. 349-363.

7. Shirose, K., "Equipment Effectiveness, Chronic Losses and Other TPM Improvement Concepts", Chapter 2 of *TPM Development Program: Implementing Total Productive Maintenance* (Nakajima, S., Editor), Productivity Press, Cambridge, Massachusetts, U.S.A., 1989, pp. 27-84.

8. Suzaki, K., *The New Manufacturing Challenge: Techniques for Continuous Improvement*, The Free Press (A division of Macmillan, Inc.), New York, 1987, pp. 31-41 and 113-123.

9. Takahashi, Y., "Maintenance — Oriented Management Via Total Participation: Total Productive Maintenance, A New Task for Plant Managers in Japan", *Terotechnica*, Vol. 2, No. 2, May 1981, pp. 79-88.

10. Wireman, T., *Total Productive Maintenance: An American Approach, Industrial* Press Inc, New York, 1991, pp. 4, 21, 22, 35 and 61.

Suggested Text Book

Bikash Bhadury, *Total Productive Maintenance*, Allied Publishers Limited, New Delhi, 1998 [ISBN 81-7023-805-6]