UNIT 8 INFORMATION TECHNOLOGY (IT) ENABLED MAINTENANCE MANAGEMENT

Objectives

After going through this unit the students shall be able:

- to understand the benefits of using IT applications for maintenance management,
- to explain the basic principles of application for IT enabled maintenance management,
- to elaborate on the input, processes and output features of 'Maintenance Management softwares,
- to help decide on the selection of suitable maintenance management software,
- to help in stepwise implementation of computerized maintenance management softwares.

Structure

8.1 AN OVERVIEW

Maintenance management and engineering function has to position it to achieve the corporate objectives and strategies in general and the operational strategies in particular. In the process, it needs to interface with different functions, within and external to the enterprise. Figure 8.1 illustrates the relation of maintenance function with the various other functions in achievement of its strategies.

Information generation, processing and usage are major requirements for the maintenance function to efficiently manage its resources. Many of the earlier maintenance systems suffered from crude and conventional methods of data processing and information exchange. The result of this had been that many a times decisions were made purely based on intuitions and guess works. The efficacy and efficiency of such decisions were obviously questionable and led to loss of productivity.

Information technology (IT), the new buzzword for the use of electronic, communication and convergence technologies has made tremendous difference to our way of functioning in all walks of life. IT has made deep inroads into possibly every facet of economical functioning of organizations. Terminologies like e-business, e-commerce, enterprise resource planning (ERP), Customer Relations Management (CRM) etc. have become common parlance in the management circles. Though the use of IT has been adopted quite lately for maintenance functions compared to other functions like finance, personnel,

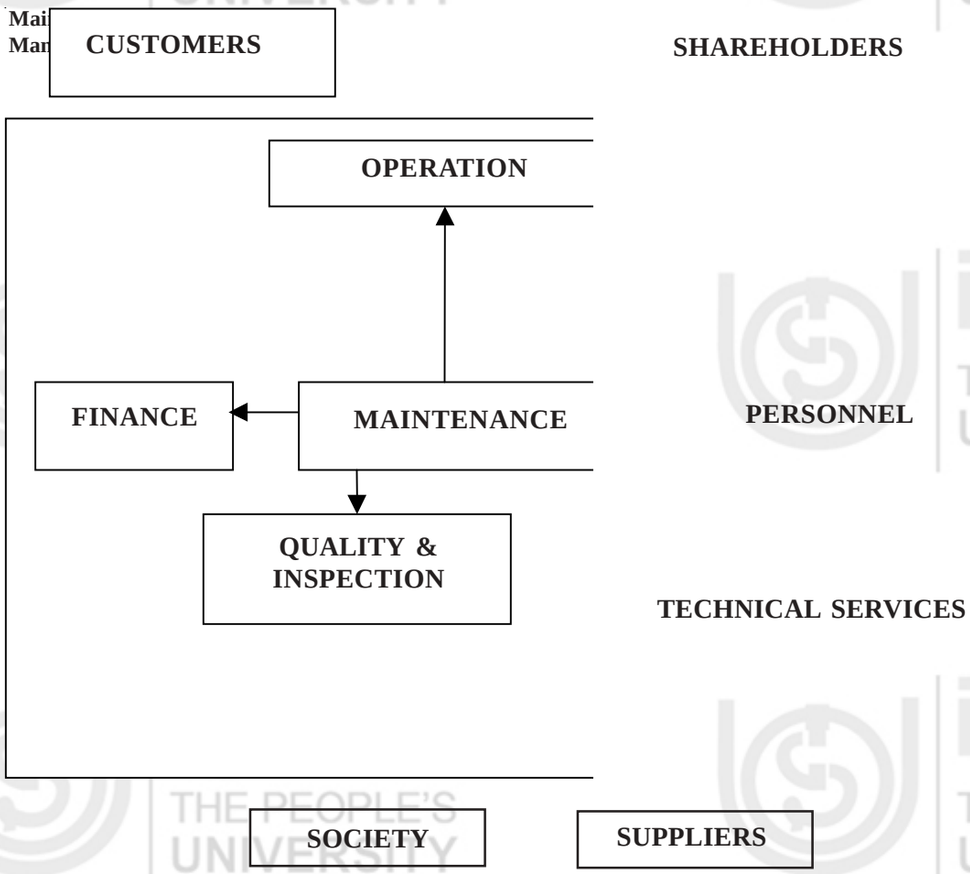

Figure 8.1 : Maintenance Systems

materials etc., tremendous progress has been achieved in the use of IT in both the maintenance management and engineering functions. We would have a brief coverage on this in the following paragraphs.

8.2 BENEFITS OF IT ENABLED MAINTENANCE

Use of IT in many organizations has resulted in many benefits over the conventional manual systems. Some of these benefits have been indicated below:

- Reduction in downtime costs
- Reduction in maintenance costs
- Reduction in materials costs
- Reduction in life cycle costs of machinery
- Increased availability of plant and equipment
- Reduction in the breakdowns
- Increased and extended usage life of plant and equipment
- Improved diagnosis of machine problems
- Availability of machine, operation and maintenance information in right time and in right perspective
- Proper planning, scheduling and control of preventive, predictive and corrective maintenance
- Efficient control of backlogs
- Better utilization of maintenance resources, men, materials and logistics
- Availability of History of machines to enable decision making
- Ensure efficacy and efficiency of reporting systems

- Better interface amongst maintenance and other functions like operation, materials, quality, safety etc.
- Reduction in unnecessary paper works, in essence, improvement in the overall PRODUCTIVITY AND PROFITABILITY of the organisation.

8.3 CONCEPTUAL MODEL OF THE MAINTENANCE FUNCTION

Though, many benefits of use of IT in maintenance has been delineated in the previous section, it should be recognized that computers are basically tools in the hands of managers to achieve their objectives. As the famous saying regarding computers 'Garbage in, Garbage out' signifies, sufficient amount of preparatory and systematic analysis would be required, if computerization efforts are to succeed. Indeed, there have also been number of cases where improper use of computers have added to the misery of maintenance managers. Some of the benefits mentioned above have not accrued but exactly the opposite has happened in those companies. Hence the necessity to completely visualize the maintenance function in a systematic fashion and then go for use of computers to achieve the pre conceived benefits.

The *Figure 8.2* explains the conceptual model through which the maintenance function can achieve its objectives on a sustained basis.

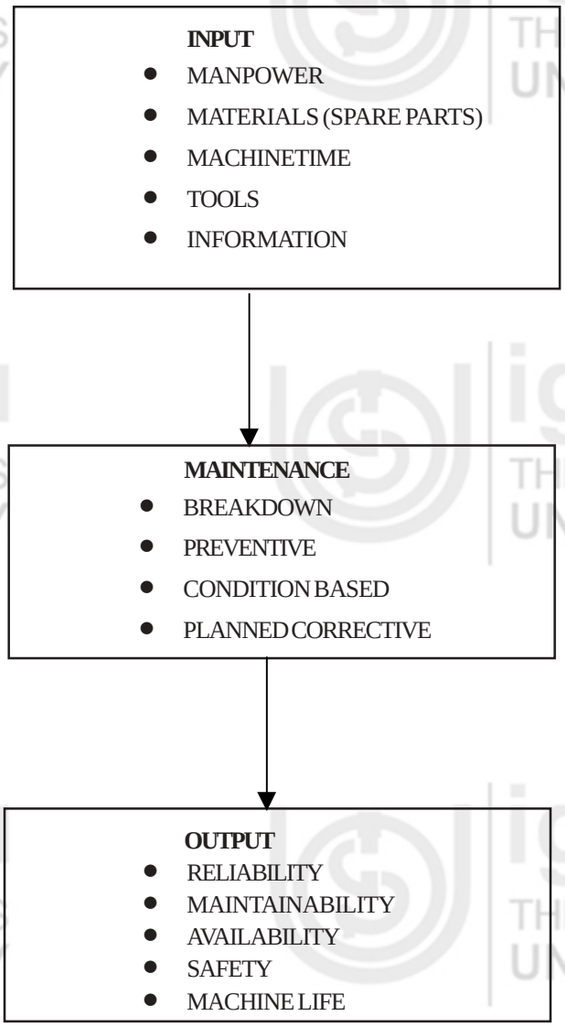

Figure 8.2 : Inputs Maintenance Output Model

Maintenance Objectives: The objectives of maintenance have to be aligned to that of the operation's objectives, which in turn is connected to the corporate objectives. In general sense, it would be to ensure the optimum availability of plant and equipment as demanded by the production plans. This is planned to be achieved at the lowest maintenance costs without compromising on the long-term effect on the life of the equipment.

Types of Maintenance Activities: The maintenance activities in a plant can be classified into five parts, namely, emergency corrective (breakdown), planned corrective, preventive, predictive maintenance and other related functions (like utilities' operation, workshop management, modifications etc.)

Execution of Maintenance Function: Any of the above maintenance activities follows an execution cycle beginning from the need for the maintenance activity and goes through the sequence of work request, authorization, planning, scheduling, execution, feedback information, analysis and reporting. The reporting step further leads to review of the need for the maintenance activity thus completing the cycle. The following *Table 8.1* identifies these factors for different types of maintenance activities.

Table 8.1 : Factors for Different Types of Maintenance Activities

Type of Maintenance	Emergency Corrective	Planned Corrective	Preventive	Predictive	Other
Need	▪ Breakdowns ▪ Other Loss of Critical functions	Identified Equipment Problems	▪ Reduction of Wear and Tear ▪ Prevent Breakdowns ▪ Monitoring	▪ Monitoring Machine Conditions ▪ Diagnosis	Ensure Logistics
Requesting Agency	Production Dept	▪ Production Dept ▪ Maint. Plng. ▪ Feed back from PM	▪ Maintenance Planning ▪ Feedback from Pred. Maint.	▪ Maintenance Planning ▪ Feedback from other types of Maint.	Plant Management
Authorisation	As per Standard Procedures		Production / Safety / Planning if shutdown required	Generally not required	Generally not required
Planning	Work Orders	Work Orders	Check Lists / Work Orders	Check Lists / Computer-ized Route Plans	Operation / Maint. Plans
Scheduling	▪ High Priority ▪ Opportunity Windows	▪ Medium to Low Priority ▪ Opportunity Windows	▪ Based on Calendar time, running hours, pred. Maint feedback ▪ PERT/CPM for overhauls	On Line or based on calendar time, running hours etc.	Similar Methods depending upon type of operation / maintenance
Execution	Maintenance Personnel	Maintenance Personnel	Maintenance / Operation Personnel	Maintenance / Operation Personnel	Maintenance Personnel
Feedback	▪ Downtime ▪ Resources Utilised ▪ Reason for failure	▪ Downtime ▪ Resources Utilised ▪ Reason for failure	▪ Downtime ▪ Resources Utilised ▪ Requirement of Corrective Maint.	▪ Resources Utilised ▪ Requirement of PM / Corrective Maint.	Similar Feedback depending upon type of operation / maintenance
Reports	History, Downtime, Failures, Costs, Equipment,, Manpower & Material Efficiency, Backlogs etc.				

IT can help in all the above-identified activities and sub functions except the actual execution of the various types of maintenance, which of course have to be performed by the maintenance personnel. They would be aided by the IT enabled information processing and results so that they can execute the maintenance activities in the most efficient fashion.

8.4 MAINTENANCE DATABASES

In order to enable information technology processing to help the maintenance function, input data has to be collected and entered in the master databases. In this section, we would see the types of master databases that are required to be maintained.

Equipment Master: The equipment master would have all the static information about all the equipment in the plant. Some of the illustrative information are the equipment code, equipment description, manufacturer/supplier details, purchase data, warranty/insurance information, drawings, major specifications, details and specifications of sub-assemblies, details of spare parts etc. This master information can be maintained in the data base in different forms.

Corrective Maintenance Master: This master database maintains the information regarding the standard corrective maintenance activities to be performed on the equipment. Some examples of corrective maintenance activities are balancing a fan rotor, replacement of pump impeller, relining a cement kiln refractory wall etc. For each of these activities information like activity code, description of the activity, normal frequency of execution, resource requirements like manpower, materials, tools, standard downtime, activity restriction like safety permits etc. are stored in the database. It could be visualized that some corrective maintenance activities would be standard activities applicable to a large number of equipment, whereas some of them would be equipment specific. The master database can also keep this information as to whether a particular activity is standard or equipment specific.

Preventive Maintenance Master: Similar to corrective maintenance master, information about the preventive maintenance activities are separately maintained in the preventive maintenance master data base. Some examples of preventive maintenance activities are regular lubrication (both topping up and change of oil), scheduled replacement of consumables like bearings, v-belts, oil seals etc., overhaul of gear boxes, engines etc. The data base would contain details like activity code, description of the activity, normal frequency of execution, resource requirements like manpower, materials, tools, standard downtime, activity restriction like safety permits etc. The frequency of execution of preventive maintenance activities can be based on different logics. For example, the v-belt of a fan can be changed on the basis of elapse of calendar time since last replacement, completion of pre determined number of running hours, indication of an abnormal symptom of condition monitoring parameter measured through predictive maintenance etc. The database can contain a logic indicator as to which particular or a combination of these triggers has to be employed to schedule a particular preventive maintenance activity. Like in the case of corrective maintenance, preventive maintenance activities can also be standard activities or equipment specific.

Predictive Maintenance Master: The predictive maintenance master database would contain information regarding the predictive maintenance activities, which are mostly standard activities. Some of these activities are measurement of vibration levels or spectrum, oil contamination levels, temperature, pressure and other monitoring parameters. Nowadays the predictive maintenance instrument suppliers combine their measurement equipment with computerized portable data collector and analysis software. In such cases, the predictive maintenance master database resides within the respective hardware/software. The results of the predictive maintenance have always to trigger one or more of the other types of maintenance, namely, corrective, preventive or emergency maintenance. Hence the logic for the same also needs to be maintained in the master database. One

example of steel linkage is the requirement of greasing of an anti friction bearing in case the high frequency vibration levels increases more than alarm levels on the bearing casings.

Spare Parts/Materials Master: The information regarding the maintenance materials is normally maintained in this master database. Ideally, this information would also be required for materials management function and hence would be part of that system. The type of information that would be maintained are item code, item description, specifications, cost, lead time, vendor details, ordering quantity, classification etc. The database may also keep this information regarding other types of maintenance resources like tools, sub assemblies, rotable spares etc.

Latest maintenance management softwares have capability to store both the text characters as well as images. Thus the above master data bases can also retain information like equipment figures and drawings, lubrication diagrams, instructions for preventive maintenance etc. in the computer medium.

8.5 PLANNING AND SCHEDULING SYSTEM

We would now see the use of the master data base information in planning and scheduling the various types of maintenance activities. Planning of the activities needs to be carried out for time periods of a longer duration whereas scheduling would be the execution pattern for the current and relatively shorter periods. Let us now see how this can be achieved by the computerized processing.

Preventive Maintenance Planning and Scheduling: The PM activities might have already been identified through the master database. The plan for these activities normally emanates from the manufacturer's suggestions as to the activities to be carried out from time to time, the experience of the shop personnel from their observations during corrective and preventive maintenance activities and the indication of machine condition through condition monitoring activities. The plan for the activities would need to be scheduled based on the long term and short-term availability of various resources like machine time availability for maintenance, manpower, materials, tools and other utilities. Normally the planning horizon is one year in which the conception regarding these factors would be firmed up by the management. For example, it might be decided that the PM activities as suggested by the manufacturers need to be completed during the warranty period without fail. Similarly, the material required for statutory inspections need to be provided for and completed at high priority. Once these management decisions are quantified, the master schedule for the year can be drawn up by the computer software. Normally, the schedules are made on a weekly basis to facilitate easy execution and follow up. Thus the schedules may indicate for every week, the activities that are planned to be executed. These schedules, however, can be output in different formats. The simplest of these formats would be to get them printed out in the form of standard work orders or check lists. In an on line system, these can also be made available as a display on the computer screens. The schedules can also be classified in terms of priorities, that requiring machine shutdowns, department or section wise, trade wise, machine wise and so on. The schedules can also contain additional information like manpower required, down time and materials required, safety permits, activity instructions etc.

The maintenance manager/supervisors has the flexibility to schedule these activities through various mechanisms to be executed during the week. A simple method would be to post these schedules/check sheets in the work allocation board for the various trade/group personnel and follow up the progress every day.

The other detailed method would be to issue job orders which would connect each work order to a particular person and the hours clocked by the person continuously monitored. What ever the method of scheduling and follow up, the basic purpose of it would be to give feedback to the scheduling system, so that, constant update and continuous corrections can be effected in the subsequent schedules.

Corrective Maintenance Planning and Scheduling: Corrective maintenance is normally to be classified in two parts, planned corrective maintenance and emergency / unplanned corrective maintenance also known as break down maintenance. The planning and scheduling of planned corrective maintenance is similar to preventive maintenance with the only difference that it has no fixed repeating frequency. It mainly emanates from the feedback received from the execution of preventive or predictive maintenance activities. Thus the scheduling of planned corrective maintenance would depend upon the recommendation of the maintenance manager / supervisor. Normally, the planning horizon for the planned corrective maintenance is in the range of a month or so.

The break down maintenance is normally to be scheduled on the occurrence of the failure which is intimated by the production / operation personnel. A work request is filled up by the operation personnel, which identifies the equipment, problems faced and priority for the job. The maintenance planner / manager on receipt of the request schedules the job with estimates of various resources like man power, materials etc. once the job is complete the feed back is provided as to the reasons for the failure, future corrective actions required, resources utilized etc. In case of extremely emergent failures, the maintenance activities are performed immediately and the required information is fed back at a later point of time to the system.

Predictive Maintenance: This is the process of acquisition of machinery health information through periodic monitoring of machinery characteristics. Some of these characteristics are vibration, temperature, pressure, thickness, oil condition etc. There are many specialized instruments for the purpose of predictive maintenance. The most critical of the predictive maintenance applications would be using continuously monitoring sensors installed on the machines, which are connected to dedicated systems. The lesser and more common types of applications use portable instrumentations, which would be used on a predetermined frequency to collect the data from the machinery. Based on the trend and other nature of the information obtained, diagnostics of the machinery problems are made and corrective actions if required are prescribed. Some of the corrective actions are varying the frequency of the monitoring, initiating PM or planned corrective maintenance etc. As most of the predictive maintenance activities are carried out without requiring any shut down of the machines, the scheduling of the activities can be carried out with lots of flexibility as to the time at which it can be carried out. The recent trends are towards use of dedicated hard ware and soft ware systems for the specific condition monitoring technique, like vibration analysis, and use the resultant information to interface with the regular maintenance system.

8.6 CMMS MODULES

Having studied the basic features of the planning and scheduling of the various types of maintenance activities, we shall now study the common modules present in the computerized maintenance management system (CMMS) software.

Machinery Information and Preventive Maintenance Module:
This module normally contains the following facilities:

- Enable querying and printing static equipment information
- PM work order scheduling by calendar or metered usage & printing of PM work orders
- Scheduling of multi crafts for performing the PM
- Scheduling PM based on prior completion of PM, request of Maintenance Planning, predictive maintenance results etc.
- Balance PM work load over the scheduling period
- Forward planning to inform production function in advance in case PM requires equipment shutdown.

The preventive maintenance work orders would basically track maintenance labour and materials utilized so that these costs can be calculated and monitored. In addition, the downtime due to preventive maintenance and the corrective maintenance requirement also collected for compilation and analysis.

Normally the PM software module has the ability to print the work orders in a specific sorted order, the key for which could be the craft, department, priority, etc independently or in combination. The module also produces various types of reports and queries, some of which are, past due work orders, back log of non-completed work orders, equipment history, equipment wise down time, cost of preventive maintenance, type and number of defects observed and corrected etc.

EQUIPMENT DATA

Equipment Number	
Equipment Name	
Department	
Location	
Size/Capacity/Rating	
Weight	
Cost	
Installation Date	
Manufacturer	
Model/Type	
Sl. No	
Drawing / Manual Location	
Motor Model	
Volts	
Kw/Hp	
Rpm	
Preventive Maintenance Data	
Pm Job Code	
Priority	
Category	
Frequency	
Downtime	
Labour Time & Craft	
Tools & Instruments	
Permit Code	

Figure 8.3 : Preventive Maintenance and Equipment Master Data Base

Pre-requisites and Operation of the PM Software Module:

The initial step would be to compile a list of equipment to be covered under the computerized system and collect both basic data as well as PM requirements of each of this equipment. This information would be available from manufacturer's manuals for operation and maintenance, which may need suitable modification based on the operating experience of the plant personnel. An example of the type of data that would be keyed in the equipment and PM master database are given the Figure 8.3. Based on the estimations made about the down time and labour time required for completion of the identified preventive maintenance activities and material availability, the computer program schedules the preventive maintenance activities, normally every week and prints out the corresponding work orders.

Activity A

Discuss with the Chief of Maintenance function of a company, which has recently introduced CMMS about the advantages, and concerns of its use.

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Corrective Maintenance and Work Order Module: The execution of corrective maintenance activities through a well-structured work order system helps a maintenance department with higher availability and reduced costs. Ideally, the work order system should produce enough information to enable the maintenance manager take proper decision regarding allocation of the resources to achieve overall improvement in the productivity. Normally the corrective maintenance and work order module has the following features:

- Track labour and material utilization and costs thereof
- Assign different crafts for different works
- Identify work orders separately for equipment under warranty
- Track contracted out maintenance separately
- Facilitate use of special tools and materials
- Enable obtaining special permits like safety / electrical lock out etc.
- Enable scheduling based on various logics like priority of equipment, priority of jobs, material availability, craft etc.
- Permit input of information related emergency maintenance, which are not scheduled, after they are completed

Just like the PM module, the corrective maintenance module is also capable of producing various types of reports, the most important of which are:

- Active and Pending work orders report
- History of equipment
- Downtime of equipment
- Cost of Corrective Maintenance

Pre-requisites and Operation of the CM Software Module:

The CM module basically operates through the central point of recognition of work order numbers. There should be a unique and specific maintenance work

order number for each of the corrective maintenance carried out. The work order numbers can be manually entered into the module, or it can also be automatically generated by a programmed logic. The CM master database would have information about CM activities, which are amenable for planning in advance, and the increased use of planning, helps the corrective maintenance to achieve improved performance in terms of reduced downtime, lesser consumption of materials and effective utilization of maintenance manpower. On the other hand, increased dependence on emergency and unplanned maintenance increases the workload and results in higher costs and lower morale.

Use of a priority rating system helps in scheduling CM activities in a systematic manner. Before a CM work order is authorized and planned, the priority rating may be assessed as per guidelines, either manually or computerized logic. There are published priority rating guidelines like the RIME – Relative Importance of maintenance expenditure, NUCREC – Need urgency, customer rating and equipment criticality and Eli Lilly system which uses various criteria and methodologies to arrive at the priority of a particular corrective maintenance work. The other information required for scheduling work orders are similar to PM system, namely, shut down possibility, craft hours availability, materials and special tools availability etc. The module follows the same procedure as PM to schedule and print the work orders on weekly basis or as demanded. The basic information present and requested by a work order is illustrated in the *Figure 8.4*

W.O.No.	**PRIORITY**			**CATEGORY**
Issue Date:				Requested By:
Date Required:				Approved By:
Cost Centre No.				Equipment No.
Eqpt Name:				Dept.
Location:				Failure Code:
Labour	Craft	Regular Hrs	Overtime Hrs	Supervisor
WORK DESCRIPTION				
SPARE PARTS DETAILS				
Part No.	Description	Location	Quantity	Value
Date / Time Completed		Outside Costs		Checked By
OBSERVATIONS AND INSTRUCTIONS				

Figure 8.4 : Work Order Format

The various reports that can emanate from a CM module are as follows:

- Maintenance History Report
- Maintenance Costs Report
- Work Order Backlog Report
- Material Consumption Report
- Downtime Report

Spare Parts Control Module: This module is very similar to a materials management module, which helps in classifying maintenance materials, purchase, inward goods inspection, issue and receipt. It also tracks consumption and controls inventory. The main difference between a materials management computerized software and a spare parts control module would be that of difference in numbers and types and the logics and models used for inventory controls. There could also be renewable spares (also called rotable spares) whose position need to be tracked separately in the spare parts control module. Some of the features of a computerized spare parts module are given below:

- Predictable materials are included in the work orders and their need communicated to stores
- Matching of parts required to availability automatically
- Automatic reordering based on inventory control/ purchase logic
- Accumulation of material costs in the history of equipment
- Linking of equipment data to spare parts data
- Performance reporting on consumption, inventory, stock outs etc.

Condition Monitoring Module: The modern day computerized software systems for maintenance have a condition monitoring module which can receive equipment performance characteristics like vibration signals, temperature, pressure, lubrication oil condition etc directly from the sensors mounted on the critical equipment. These information would be suitably trended and various corrective action like issue of alarms, tripping of the equipment, carrying out diagnostics to suggest preventive / corrective maintenance etc can be performed by the software. Since this type of on-line condition monitoring would be quite expensive and may not be feasible for all types of equipment, there are also alternative portable data collector and analyzer systems which can be used independently to manually collect the condition monitoring data and analyze through a dedicated software.

Activity B

Visit a Small Industry that has still not adopted IT enabled maintenance systems and discuss the problems faced by them in getting adequate information for making maintenance and operation decisions. Perform a cost benefit analysis for this company towards implementation of CMMS.

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8.7 SOFTWARE SELECTION

Broadly there are two alternatives to a maintenance department, either internal development of the software or purchase of a standard software.

The merits and demerits of internally developed software are:

- Flexibility in developing the software
- Can be designed to exactly suit the internal requirements
- Greater acceptability
- Long development time and special skills requirements
- Higher cost of development and maintenance

Alternatively ready-made software has the following features:

- Relatively lower cost
- Less preparatory time
- Can get the latest technology software
- Integrated systems like ERP (Enterprise Resource Planning) software, which has maintenance as one of the modules thus enabling interlinking with other functions of the organization.
- Sometimes may not meet all special requirements of the plant
- Difficulty in maintenance and up gradation.

While selecting particular software, the following factors need to be considered so that maximum use can be made by the company:

- **Ease of Use:** The software should preferably have in-built features like help menus, tool tips etc for making the user comfortable with the operation of the software. In case of sophisticated softwares, detailed user training would be essential by the software vendor and during the training; the actual data pertaining to the company can be used to understand the process better.
- **Ease of Implementation:** Depending upon the sophistication in the software, installation, testing and commissioning of the software is performed either by the user himself or the vendor or a third party implementer. As far as possible, the users are to be associated with these processes. This would help in identifying any possibly bugs at this stage itself, which can be corrected before going for full-fledged implementation.
- **System Support:** The software should be aptly supported with technical and system supports for provision of upgrades, fixing errors and integration of both hardware and software with the factory network systems, intranet and Internet.
- **Hardware and Software System Requirements:** The requirements in terms of hardware features in terms of processor speed, memory and hard disk capacity, applicable drive systems etc are to be understood before selection of the software. Similarly the software system requirements like operation system, RDBMS environment are also important.
- **Documentation:** The extent of documentation provided by the vendor is to be critically analyzed, as this is an important requirement for continuous reference whenever problems are encountered in operation. It should also ensure whether details of source code etc would be available or accessible in case of future requirements.

Some of the commercially available CMMS softwares in maintenance management are listed in the table at the *Appendix 8.1*.

Activity C

Receive a demo of one of the CMMS software and evaluate it regarding the databases and features and capabilities for carrying out different types of maintenance activities.

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8.8 COMPUTERISED MAINTENANCE SYSTEM IMPLEMENTATION

Most of the enterprises have priority for computerization for functions other than maintenance, like finance, personnel, operation etc. Even today, many companies operate their maintenance function through manual systems and procedures. Hence the implementation of computerized maintenance system, many a times, has to start with an effort to justify the investment in a CMMS software. This needs to be done by identifying the benefits of computerized maintenance systems over a period of time and the cost trade offs such a system implementation would provide to the company. As in preventive maintenance, the results of the implementation take a considerable period to show in the improvement of the bottom lines. Hence the justification has to be worked out as rate of return on investment over a sufficiently longer period of time.

Once the CMMS software is acquired, the implementation efforts have to be carried out through the following steps:

1) Motivation of all level of personnel to obtain support for implementation
2) Installation of the computer hardware /software
3) Training of the personnel
4) Creation of the Master Data bases
5) Creating Security system for the files/transactions
6) Phase wise/Department wise adaptation
7) Follow Up/Back up of Files

Activity D

Nowadays maintenance computerization forms one of the modules of an integrated ERP (Enterprise Resource Planning) software system for large organizations. Discuss with the supplier of a well-known ERP system the advantages of having such a provision.

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8.9 SUMMARY

We have explained the various features of an IT enabled maintenance management system in the previous paragraphs. Needless to mention, the success of the usage of the IT software depends on the ability of the people who use these tools to properly plan, execute and control. Before introduction of an IT based system, the management should be clear about the objectives, strengths and limitations and the time span in which the results are to be expected.

The IT enabled maintenance information is a powerful tool in the hands of the maintenance manager, but he needs to properly understand the same and take proper decisions based on them. No amount of sophisticated computer outputs would be useful, if these are not acted upon with the ultimate objective in mind. It is not enough to just obtain the charts and drawings, but the people concerned should be trained to properly understand their real meaning and purpose.

However, we are observing the increasingly effective use the IT enablers are performing in the various economic sectors and for the maintenance function. It is expected that the utilization of IT for the betterment of maintenance and related functions would go a long way in the coming times. It can be said with confidence that in the coming three to five years time, the IT enabled maintenance systems would be in use in almost 90% of the companies in India. If you are not one of them, you can be sure that you are left out in the last in the productivity race.

8.10 SELF-ASSESSMENT QUESTIONS

Overview

1. How is the maintenance function related to other functions of an enterprise?
2. 'Timely and Relevant information is a main requirement of productivity' – State reasons.
3. In your opinion, what is the cause of late adoption of Information Technology (IT) for maintenance compared to other functions?

Benefit of it Enabled Maintenance

4. What cost improvements are possible in maintenance with IT applications?
5. 'IT application is not panacea for all the ills of the maintenance function' – Justify this statement.
6. What intangible benefits can be expected from IT enabled maintenance operations?

Conceptual Model of the Maintenance Function

7. Why should one understand the total concept of the maintenance system's functioning before attempting to use IT enablers?
8. What are the major objectives of maintenance function?
9. Explain the steps involved in the execution cycle of any maintenance activity.
10. 'IT can be used only for pre-planning oriented maintenance activities like preventive and predictive maintenance' – True or False? Give Reasons.

Maintenance Databases

11. What are the various databases used in IT enabled maintenance softwares?
12. Give the details of contents of any two maintenance databases.
13. What are the sources of the data for Equipment and Preventive Maintenance Masters?

14. What concerns from the point of views of maintenance manager and information system manager are important regarding creation, maintenance and use of maintenance master databases?

Planning and Scheduling System

15. What is the difference between planning and scheduling activities?
16. How does a computerized maintenance software enables planning and scheduling of preventive maintenance?
17. 'Breakdown maintenance due to its nature of sudden occurrence is difficult to plan hence not covered by computerized maintenance planning system' – True or False? State Reasons.
18. Discuss the relative merits and demerits of using exclusive softwares for predictive maintenance activities.

CMMS Modules

19. Name the various modules normally present in CMMS and their functions.
20. What outputs are expected from machinery information and preventive maintenance module?
21. Work Order is the basic medium of data collection in CMMS – Explain.
22. Name some of the priority rating systems in Corrective Maintenance module.

Software Selection

22. What are the merits and demerits of internally developed and ready made softwares?
23. What factors would you consider while selecting a CMMS software?

Computerised Maintenance System Implementation

24. What cost factors are considered to justify use of CMMS?
25. Why motivation of personnel is important in CMMS implementation?
26. What ways the personnel can be trained towards CMMS implementation?

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Appendix 8.1 : Commercially Available CMMS Software

Supplier	Product(s)
ABB Service	SCOOPE a tool for on-line performance and OEE measurement.
AllMax Professional Solutions, Inc.	Allmax Task Manager (ATM)Operator 10® Software
Advanced Maintenance Solutions	COGZ EZ for DOS, COGZ for DOS
Advanced Software Designs	Maint Scape
American Quality Systems	ProView for DOS
Anderson and Associates	Process Management and Asset Control
Angus Systems Group	Angus Maintenance Management System
Argos Productivity Solutions	Argos 2000
AssetWorks	Asset Works
Avair, Inc.	Ounce of Prevention System
BCN Informática	G-Mant
BCS Group Ltd	ToMM
BDR Systems, Inc.	MPRO 2000
BIC Systems Ireland	Archibus/FM
BQR Reliability Engineering Ltd.	C.A.R.E.
BarControl	Maintenance Mate 1, Maintenance Mate 2
Benchmate Systems	Benchmate for Windows
Bender Engineering	Maintstar
Berland Technologies	MIRO 2.0
CAMP Systems Sdn Bhd	Maint Pro
Cendec	Cendec Materials, Procurement, Fixed Asset and Maintenance Software
CHAMPS Software	CHAMPS CMMS, CHAMPS ISM
Caver-Morehead Systems	FM1
Cayenta	MAINSAVER
Chase Software Systems	Cmms Systems - Small Business Edition, the Professional Edition and the Enterprise Edition
Chips Informatica Ltda.	Engeman
CK Systems, Inc	MaintiMizer
COGZ Systems	COGZ Maintenance Software for Windows
Comac Systems Limited	Delta, Ease and Comac Mk10
Compliance Technologies	Process Safety Management Assistant™ SMA), Mechanic's Mate™, Action Items Tracker™, What If…?™
Computron Software	Yorvik
Contine Systems, Inc.	GURU
Cybercode	Maintenance Complete 2000
CyberMetrics	Facili Works Maintenance Manager
Cygnus Management Systems	Workepic
DFM Systems	MAPCON
DP Solutions	PMC2000, FLEETMAINT2000, iMaint EAM.
Datastream Systems	MP5i, MP2i, MP2 Enterprise, MP2 Professional, Procure

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Supplier	Product(s)
Data-Trak	Atlas 2000 Client/Server (Oracle8) Atlas 2000 File Server (Paradox) Atlas Professional Atlas Classic
DCE Software Solutions	MaintSmart
DECISION Systems, Inc.	REASON Root Cause Analysis
DesCry LLC	Asset Handler
Design Maintenance Systems	MAINTelligence Software Package
EBS	iWO
EMS-Solutions	EMS-WASP
E-MAX	Facilatizer
Eden Technology	AMPS, Span-FM, FMMS, PA
Edulog	Facility Management System
Electronic Data Systems	EMPRV
Entek IRD International	EMONITOR® Odyssey™
EPAC Software Technologies	**ePAC**
Express Maintenance	ExpressMaintenance, Safe-Labels
FBO Systems	Maintenance Logic System
Fielden Management Services	Trident Software
Fluor Daniel	CMMS Plus, TabWare
Four Rivers Software Systems	Total Maintenance System (TMS)
Frank M. Murray	PMSystem Maintenance Management Software
Frontec Maintenance Systems	Idhammar & APIPRO
fsc limited	4Site for Windows
GP Solutions	GP MaTe, PEM
Galiot	Galiot Software
Gastops, Inc.	MetalSCAN, ECMS, MAINSTAY, Lube Analyst
Geelong Timesharing Centre	MainTrak
Glide Main	Mcmain for Windows, Istod Lite
GlobeRanger	FleetRanger
HCI Systems	Building Blocks
HSB Reliability Technologies	RM-30
IB Informatica	INFO-PMS
ID Group	Lock'it
IFCS Inc.	Senergy, Segma
Indus International	Enterprise MPAC, Passport
Industrial Project Assistance	Scoope
Information Science Consultants Ltd.	RCM, RCS, NES45, MMS
Interplan Systems	ATC™ "Around-The-Clock™" Shutdown / Turnaround Management System
KDR Creative Software, Inc.	X-SITE Software
KWN Coolware	Preventive Maintenance & Equipment Locator
Kakari Systems	IGOR
Karta Technologies	Boiler Maintenance Workstation

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Supplier	Product(s)
M-Tech	Espresso
Madison Systems	Avantis, MapicsXA, Prism
Maintenance Experts	MEX
Maintenance Management Solutions	TDBU
Management Technologies	ProMaint
Meridium, Inc.	Enterprise Reliability Management System
MicroMain	MS2000, msWEB, msMOBILE, msREQUEST, msITRAK, msKTRAK, msSERVICE, msEXEC
MicroWest Software Systems	Advanced Maintenance Management System
Modern Management, Inc.	MODCAM
MRO Software, Inc.	MAXIMO Enterprise, MAXIMO for Facilities and MAXIMO for Industry
NTech Incorporated	eMAINT
North40 Software	KeepItUp! - Maintenance Tracking System
Norwich Technologies	Maintenance Master for Windows V6.0
Oliver Group	EXAKT
Opms.net	Online Preventative Maintenance System
Optimization Resources, Inc.	Data Splice^{TM} Enterprise Integration Suite
OpWare, LLC	ProTek Plus
Orion Group Software Engineers	Xsite:FMMS - Facility Maintenance Management System
Paradigm Business Systems North America	Paradigm Business System (PBS) software for all aspects of fleet, quartermasters and facilities asset management, maintenance and cost control.
PMI Software Ltd	PEMAC Maintenance Management Software
PMSystem	Maintenance Management Software
PMS Systems	SMART/MMS
PMXpert Software	PMXpert 6.5
PSi	PerFORMance
Peregrine Systems SPAN-FM Product Center	FacilityCenter, SPAN-FM WorkGroup for CMMS
Phoenix Data Systems Inc.	AIMS-CMMS
Pinnacle Decision Systems	FAME
Plann Canada	Plann Expert
PPS Systems, Inc.	OPRA
Pragma	On Key
Presence Systems Ltd	Modus7 - Performance measurement (OEE) and Downtime & Spoilage analysis Database system
Prime Systems	Prime Time-PM
Prism Computer Corporation	FAMIS Maintenance Management
ProfitKey International	Rapid Response Manufacturing Client/Server

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Q2 Solutions	M1 - Maintenance One
Supplier	**Product(s)**
QBIC III Systems, Inc.	QBICFlex
RJN Group	CASS WORKS
Ramco Systems	ERP, EAM, HR, E-COMMERCE
Relex Software Corporation	Relex for Windows/NT
Revere - Walker Interactive	IMMPOWER, MASC/Immpower-SP
SAP	mySAP PLM Asset Life-Cycle Management
Servidyne Systems. Inc.	SCORE®, WinSCORE®, Guest Services®, CheckMate™
Siveco Group	COSWIN helps companies to improve their equipment reliability, reduce maintenance costs and optimise their profitability.
SOMAX	SOMAX/Windows
SQL Systems	R5
St. Croix Systems, Inc.	WOSYST Equipment Management Software
Shire Systems	FrontLine Maintenance Management
Silverlake Associates, LLC	SMMS (Silverlake Maintenance Management System)
Software Solutions Limited	IMPACTxp
Software Solutions Unlimited, Inc.	Ultramain
Sofwave	MAINCOR Maintenance & Calibration Software
Source International, Ltd.	Ladder Logic, Automation Studio for Hydraulics, Automation Studio for Pneumatics, MainBoss Maintenance Management Software
Specific Designs, Inc.	EM/dBS Version 5.04, BCODE/dBS, LINK/dBS, LOG/dBS, PORT/dBS
Summit Software Systems	Maintenance Productivity Enhancement Tool (M-PET)
Symbiotic Systems	Maintenance Manager
System Software Associates	BPCS Maintenance Management
TMA Systems	TMA
TODAY Systems	Operating Control System