Maintenance Planning Activity using Intelligent Support System

Rakesh Sharma[1] & N. Govindaraju[2]

[1]*Department of Mechanical Engineering, Al-musanna College of Technology, Sultanate of Oman*
[2]*Department of Mechanical Engineering, Principal, GSS Institute of Technology, Bangalore*

ABSTRACT: Maintenance management is one of the main focuses in industrial sector. Many maintenance functions with varieties optimization models have been proposed to aid maintenance management. However, there are limited models have been implemented in industries. The data problems and the gap between theory and practice have always become a reason. In this paper, computer maintenance system (CMMS) and the different maintenance optimization model has been discussed for carrying out the computations for calculating frequency of failures and downtime as the maintenance data problems using decision making with logic in maintenance decision support system (DSS). Organizations that clearly understand that "Maintenance is forever "and the key to balance a will all resources towards the optimum total operation success will succeed in 21st century. At the end of the paper a case study based on fuzzy control model has been discussed to understand the implementation processes. By the case study we come to a conclusion that by the implantation of CMMS we can increase the productivity and quality, also reduces the material and MRO costs.
Keywords: Maintenance, Planning, CMMS.

1. INTRODUCTION

The importance of maintenance functions for maintenance management in commonly industries has growing rapidly. A lot of researches and publications in the field maintenance decision models have been published to improve the effectiveness of maintenance process. As a part of research project for maintenance decision support system in small and medium industries, we have collected the related publications in those areas. The trends shown there are limited models have been implemented in industrial maintenance process. Although the improvement of IT (both software and hardware) can support to easy develop of the system with lower cost and systematic modules, it is limited work has directed toward developing into operational applications such as computerized maintenance management system (CMMS) or DSS. It can be said that the impact of decision making within a maintenance organization has so far been limited. The data problems and the gap between theories and practice have always become the reason.

In order to increase the effectiveness of the units, DSS is needed to simplify the analyzing process and to reduce the time needed for make a maintenance decision. The aim of this paper is to propose a new optimization technique for maintenance decision support system for analysis CMMS data to support industry maintenance decision process.

Choosing and optimizing maintenance strategies is of for most importance in maintenance management.

In this paper it is discussed that the application of CMMS in maintenance planning activity.

2. A COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEM (CMMS)

A computerized maintenance management system (CMMS) is a type of management software that performs functions in support of management and tracking of O&M activities.

CMMS Capabilities:[1]

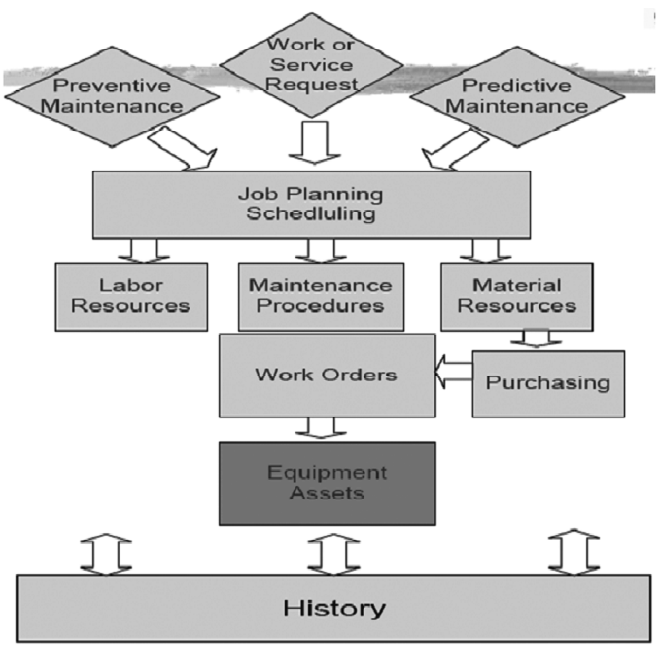
CMMS systems automate most of the logistical functions performed by maintenance staff and management. CMMS systems come with many options and have many advantages over manual maintenance tracking systems. Depending on the complexity of the system chosen, typical CMMS functions may include the following:

- Work order generation, prioritization, and tracking by equipment/component.
- Historical tracking of all work orders generated which become sortable by equipment, date, person responding, etc.
- Tracking of scheduled and unscheduled maintenance activities.
- Storing of maintenance procedures as well as all warranty information by component.
- Storing of all technical documentation or procedures by component.

- Real-time reports of ongoing work activity.
- Calendar- or run-time-based preventive maintenance work order generation.
- Capital and labor cost tracking by component as well as shortest, median, and longest times to close a work order by component.
- Complete parts and materials inventory control with automated reorder capability.
- PDA interface to streamline input and work order generation.
- Outside service call/dispatch capabilities.

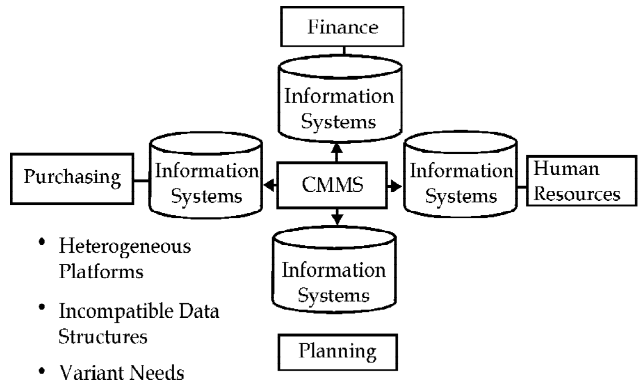
Many CMMS programs can now interface with existing energy management and control systems (EMCS) as well as property management systems. Coupling these capabilities allows for condition based monitoring and component energy use profiles.

CMMS Working



The information regarding preventive maintenance, work service request from customer and predictive maintenance is gathered by planner and the planner will put into schedule after clearly determined labor resources, related maintenance procedures and material resources. Then, work orders are generated. Based on work orders, maintenance crafts will carry out the task maintenance the equipment & assets. After the task is completed, necessary information will be keyed in into CMSS to be saved. The information becomes the equipment & assets history.

Shared CMMS Data



Reasons for CMMS not been previously implemented on the Shop Floor:

- Terminals are expensive;
- CMMS license fees are expensive;
- Information is entered days after the fact;
- Shop Floor requires real-time up to the minute information;
- Most CMMS focus on modules;
- Shop Floor require equipment focus.

CMMS Keep maintenance Simple and Fast Level because it limit the interfaces to Work Orders and Work Requests, in Real-time operations add dates and time automatically, also CMMS put all fields in a single web page. The major advantage of CMMS is it guides user interface logic and uses a hierarchical structure to form choices at each level.

3. RELATED WORK [2]

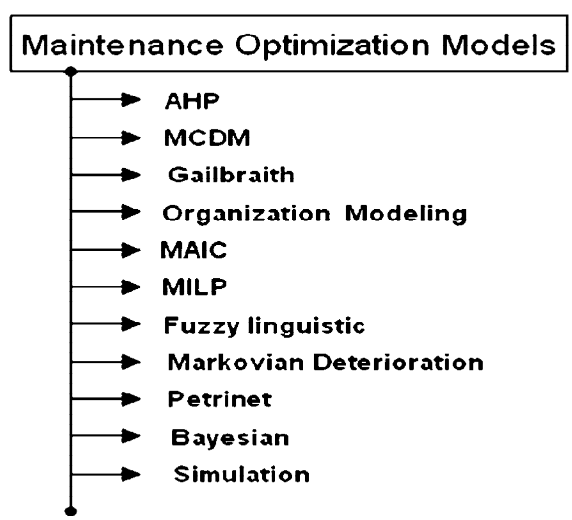


Figure 3: Classification of Maintanance Optimization

Maintenance optimization is the process to attempt the balance of maintenance requirement such as legislative, economic, technical or others. The goals is to select the appropriate maintenance technique for each piece of equipment in the system and identifying the periodicity that the maintenance technique should be conducted to achieve the best requirement, maintenance target concerning safety, equipment reliability, and system availability/costs. Reference [4] has presented various resources in the field of maintenance optimization models as shown in figure 3.

Each classification and available literature of maintenance optimization models has been described as follow:

1. *Analytical Hierarchy Process (AHP):* It was developed by [5] as mathematical decision making model to solve complex decision making problems when there are multiple objectives or criteria considered. It's requires the decision makers to provide judgments about the relative importance criterion for each decision alternative ([6], [7]).

   AHP can be using to model a hierarchy of levels related to objective, criteria, failure category, failure details and failed components as described in figure 3.

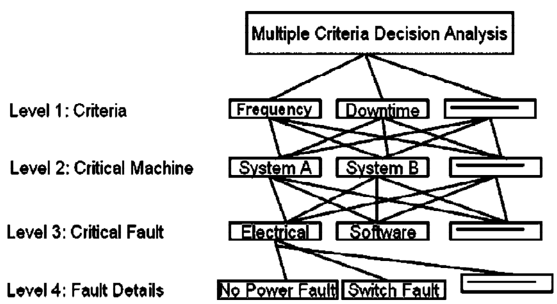


Figure 4: AHP Decision Support

   AHP divided the priorities related to every element priorities in the same level. With AHP, every decision variety can be compared according in manner adaptive to shop floor realities. Fig. 4 AHP decision support.

2. *Multiple Criteria Decision Making (MCDM)*: Ranking and selecting between alternates is a relatively common, yet often difficult task. MCDM refers to the solving of decision and planning problems involving multiple and generally collecting requirements. The decision makers (DM) one reasonable alternative from among a set of available ones ([8], [9]).

3. *Gailbraith:* The theory believes that "the greater uncertainty of the task, the greater amount of information that must be processed between decision makers during the execution of the task to get a given level of performance". Industries can reduce uncertainty through better planning and coordination, often by rules, hierarchy, or goals [10].

4. *Organization Modeling:* Reference [11] reviews maintenance organization models, e.g. advanced terotechnological model (ATM), Eindhoven University of Technology model (EUT), total quality management (TQM), total productive maintenance (TPM), reliability centered maintenance (RCM) model etc., and suggest maintenance can be contributor to profits by use of information technology (IT) and showed that integrated IT permits co-planning of production with maintenance.

5. *Materially per Apparencchiature de Impiariti Chemiei (MAIC):* Reference [12] has presented a knowledge-based decision support system, MAIC for maintenance of a chemical plant.

6. *Mixed Integer Linear Programming (MILP):* It is very general framework for capturing problems with both discrete decisions and continuous variable. This includes assignment problems, control of hybrids system, piecewise-affine (PWA) system (including approximation of nonlinear system), and problems with non-convex constrains [13].

7. *Fuzzy Linguistic:* Fuzzy logic was introduced by [14] as a superset of conventional or Boolean logic that has been extended to handle the concepts of partial truth – truth values between "completely true" and "completely false". It was described as a means to model the uncertainty of natural language. Zadeh stated that rather than regarding fuzzy theory as a single theory, we should regard the process of "fuzzyfication" as a methodology to generalize any specific theory from crisp or discrete to a continuous or fuzzy form. By the term "fuzziness" Zadeh meant classes in which there is no sharp transition from membership. For example, the class of tall men is fuzzy set. In general, fuzzy logic is a form of AI that can deal with non-quantifiable concepts. It enables software developers to program easily computer that can simulate the vagueness and uncertainty of term like "old" and "smart" – terms inherent in human reasoning and thought-processes ([15], [16], [17], [18]). In fuzzy logic, unlike standard conditional logic, the truth of any statement is a matter of degree. For example, for the rule if (weather is cold) then (heat is on), both variables, cold and on, map to ranges of values. Fuzzy systems rely on membership function to explain to the computer how to calculate the correct value between zero and one. The degree to which any fuzzy statement is true is denoted by a value between zero and one. A typical fuzzy

system consists of a rule base, membership function and an inference procedure, as presented in figure 5.

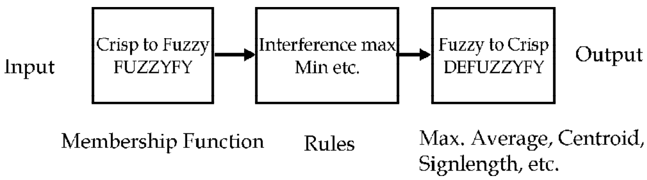


Figure 5: A Typically Fuzzy System

8. *Markovian Deterioration:* Markovian deterioration is a mathematical model for the random evolution of a memoryless system. Often the property of being 'memoryless' is expressed such that conditional on the present state of the system, it's future and past are independent ([19], [20], [21], [22]).

9. *Petri Net:* It is one of several mathematical modeling languages for the description of discrete distributed system. A petri net is a directed bipartite graph, in which the nodes represent transitions (i.e. discrete events that may occur), places (i.e. conditions), and directed arch (that describe which places are pre – and/or post conditions for which transitions) [23].

10. *Bayesian:* Bayesian statistic is based on Bayes' rule or conditional probability. It is well known that probability of events A and B both occurring can be written as the probability of A occurring multiplied by probability of B occurring given that A has occurred ([24], [25]). This is written as,

    $P(A \text{ and } B) = P(A)\, P(B \mid A)$

11. *Simulation:* Reference [26] and [27] use the modeling on continuously monitored systems. Reference [28] has used simulation model to reduce maintenance and inventory cost for a Manufacturing system with stochastic item failure, replacement and order lead times. Reference [29] demonstrates application of simulation models to evaluate maintenance policies for an automated production line in a steel rolling mill.

4. CMMS BENEFITS

One of the greatest benefits of the CMMS is the elimination of paperwork and manual tracking activities, thus enabling the building staff to become more productive. It should be noted that the functionality of a CMMS lies in its ability to collect and store information in an easily retrievable format. A CMMS does not make decisions, rather it provides the O&M manager with the best information to affect the *operational efficiency* of a facility.

Benefits to implement a CMMS include the following:

- Detection of impending problems before a failure occurs resulting in fewer failures and customer complaints.
- Achieving a higher level of planned maintenance activities that enables a more efficient use of staff resources.
- Affecting inventory control enabling better spare parts forecasting to eliminate shortages and minimize existing inventory.
- Maintaining optimal equipment performance that reduces downtime and results in longer equipment life.

5. A CASE STUDY

TEM-D Mechanical Components Manufacturing Company: The above named firm is an hypothetical organization that specializes in manufacturing of mechanical components like bolts, nuts, screws and the likes. The major manufacturing machine is lathe machine amongst others. A study was carried out in 2002 concerning the costs of operating and maintaining the lathe machine in relation to the total production cost of components produced by the machine over a period of two years. It was found that one thousand pieces each of both bolts and nuts were produced over a period of one month at the production cost of N200 per piece. This production cost estimate per piece when calculated over a month amounted to N200,000 for each components, giving total production cost of N400,000. It was also discovered that some costs were incurred in maintaining the machine prior to production and also during production. These costs are termed maintenance and operating costs respectively. To maximize profit – TEM-D intends to sell the products at the price double the total cost of production which implies that any extra costs (maintenance and operating costs) on total production cost must be less than the total production cost for TEM-D to make profit. This objective necessitates the use of a control model like fuzzy-logic control model.

Application of fuzzy-logic control model: The major parameters in the Gantt Charting Multiple Machines' Preventive Maintenance Activities as identified in the case study of TEM-D manufacturing company are: Maintenance Cost, Operating Cost and Total Production Cost. Defining these parameters in terms of fuzzy logic model, we have:

(i) Input Parameters: (a) Maintenance Cost (X)
(b) Operating Cost (Y)
(c) Total Production Cost (N400,000)

(ii) Linguistic Variables (ΣXY – N400,000)

(iii) Output Parameters

Errors
- (a) ($\sum XY$ – N400,000) = Positive = (Pessimistic) (Pe)
- (b) ($\sum XY$ – N400,000) = Zero = (Most Likely) (ML)
- (c) ($\sum XY$ – N400,000) = Negative = (Optimistic) (Op)

Errors dot
- (d) d/($\sum XY$ – N400,000)/dt = Positive = (P e)
- (e) d/($\sum XY$ – N400,000)/dt = Zero = (M_L)
- (f) d/($\sum XY$ – N400,000)/dt = Negative = (O_P)

Note: Errors are output parameters within a month. Error-dot is output parameters over the period of 2 years during which the research was completed.

A rule-matrix is thus generated from the output parameters in order to formulate a rule structure for the fuzzy logic model given as follows:

Rule Matrix
(Error)

(Errors –dot)	P	Z	N
	1 P_e	2 M_L	3 O_P

Now formulating rule structure we have:

IF (ΣXY – N400,000) = P, AND d(ΣXY – N400,000)/dt = P, THEN output = P_e

IF (ΣXY – N400,000) = Z, AND d(ΣXY – N400,000)/dt = Z, THEN output = M_L

IF (ΣXY – N400,000) = Z, AND d(ΣXY – N400,000)/dt =N, THEN output = Op

Note: The main objective of TEM-D manufacturing company is to reach out for the condition of optimistic (Op) where (ΣXY – N400, 000) = Negative. A situation where the sum of the costs of maintenance and operation are lesser than the total production cost (N400,000).

From the rule-structure, system operating rules for the sake of computation are generated as follows:

System Operating Rules

INPUT # 1: (“Error,” Positive (P), Zero (Z), Negative (N))

INPUT # 2: (Error-dot,” Positive (P), Zero (Z), Negative (N))

CONCLUSION: (“Output”, Optimistic (Op), Pessimistic (Pe), Most Likely (ML))

INPUT #1: System Status

Error = (ΣXY – N400,000)

P = Pessimistic, N = Optimistic, Z = Most Likely

Error-dot = d(ΣXY – N400,000)/dt

P= Getting Pessimistic, N = Getting Optimistic, Z = Getting Most Likely

OUTPUT Conclusion & System Response

Output Op = Optimistic, Pe = Pessimistic, M_L = Most Likely

As reported in A.T. Kearney’s and Industry Week’s survey of 558 companies that are currently using a computerized maintenance management system (DPSI 1994), companies reported an average of:[3]

28.3% increase in maintenance productivity

20.1% reduction in equipment downtime

19.4% savings in lower material costs

17.8% reduction in MRO inventory

14.5 months average payback time..

6. CONCLUSION

In this paper we have made an attempt to briefly review the recent developments in the area of CMMS in maintenance engineering and management (MAM). It is hope by authors that this sort of consolidated information on CMMS is useful for research workers, academicians and practicing engineers in the area of maintenance management.

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