Designing of Computerized Maintenance Management Information System and Root Cause Analysis for National Fertilizers Limited, Panipat, India

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The present paper deals with designing of Computerized Maintenance Management Information System (CMMIS) for a fertilizer plant and applied Root Cause Analysis (RCA) with CMMIS. The computer software was developed in Microsoft Visual Studio.NET. The developed computer software is versatile, less complicated, less costly and less time-consuming and consists of a number of modules like equipment detail, critical issues, work order, maintenance schedule, safety records, tools and tackles, employees, literature related to maintenance and reports, etc. Firstly, a list of plant requirements was created, such a system was conceptually designed, and finally an object-oriented model was built based on the conceptual design. RCA makes it more effective to highlight the main or critical root cause of the maintenance problem. The currently developed software 'CPP CMMIS' aims to have an informational tool for maintenance activities; to reduce total downtime, overall annual maintenance cost and frequency of failures of the machines; and to get day-to-day maintenance schedule.

***Keywords*:** Computerized Maintenance Management Information System (CMMIS), Captive Power Plant (CPP), Root Cause Analysis (RCA)

Introduction

Maintenance is one of the most crucial areas governing organizations. This is particularly true of an industry. Yet it is the most neglected aspect. In most industries in India, owing to a number of reasons, the capacity utilization is less than 60%. Maintenance, when neglected, leads to frequent breakdowns, leading to costly repairs and faster deterioration of valuable equipment besides causing incalculable loss of production. Considerable sums of money are wasted in business annually because of ineffective or poorly organized maintenance. However, maintenance is the only

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element, which contributes to effective operation during the life cycle of an equipment. Maintenance has a major role to play, but must be coordinated with other disciplines also. The objective of maintenance is to try to maximize the performance of equipment by ensuring that items of equipment function regularly and efficiently, by attempting to prevent breakdowns or failures and by minimizing the losses incurred by breakdowns or failures. Maintenance is an increasing portion of operational costs, and it is seen as the last opportunity for major operational improvement. Most organizations continually search for any means (program, process, concept or approach) by which to improve their maintenance function. They strive to assure that each maintenance dollar is well-spent (labor productivity) while achieving equipment reliability (asset productivity). Organizations must be successful in this quest, if they are to survive and thrive. Maintenance organizations everywhere have the responsibility to assure optimum use of the capacity of the enterprise. This can be achieved by employing Computerized Maintenance Management Information System (CMMIS) as a fundamental information resource providing the technology management staff with a wealth of support related information as well as assisting management in decision making. The 'I' is inserted into the CMMIS acronym to emphasize that a computerized support system is only an informational tool.

1.1 Basic Approach and Philosophy

All the reasons for components failure or unavailability:

- To find out the causes for multiple failures (as opposed to single, independent failures) when components fail or become unavailable.
- To find out design or operational features which prevent such multiple failure events.
- These questions lead to consideration of the following related concepts:
  - Tool cause: The most basic reason or reasons why a component (or components) failed, any of which would, if corrected, prevent recurrence;
  - Coupling factor: A characteristic of a group of components or piece parts that identifies them as susceptible to the same mechanisms of failure;
  - Defence: The design and operational features that protect against causes of equipment failure (or unavailability).

2. Literature Review

Corder (1976) defined the scope of modern maintenance management thus: "Maintenance management is very wide indeed, since almost all current engineering, management and accounting practices have some relevance to the subject." Chapman (1993) stated that CMMS software was seen first around 1976. Today, it is widely used in the manufacturing plants all over the world. Maintenance optimization is greatly facilitated when companies adopt a World-Class Manufacturing/Maintenance (WCM) philosophy or management strategy in conjunction with CMMS implementation. There are many factors which influence management on installing CMMS software and using it within their plants. Trunk (1997) puts forward the following reasons for adopting CMMS software:

- Customers demand compliance with ISO 9000.
- FDA requires maintenance management systems for plants that handle pharmaceuticals.
- Insurance companies demand to know the cost and condition of material handling assets.

Chapman stated, "The tracking and control of plant maintenance and outage activities involves objectives and requirements which are different from the control of normal engineering and construction work. The integration of these requirements into a computerized management information and control system challenges the system designed. Maintenance and outage work is estimated, scheduled and controlled at a much greater level of detail than normally required on a typical engineering and construction project." Lamendola (1998) emphasized the need to eliminate nonvalue added activities especially with respect to documentation of work within the maintenance. He stated that "this philosophy has long been the essence of CMMS". Travis and Casinger (1997) outlined other difficulties associated with modern maintenance management. In their paper, they prioritized the top five problems encountered by maintenance managers and suggest that CMMS is the solution to these problems. The problems are outlined as follows:

- Little or no support from management to implement world-class maintenance practices; CMMS reports can highlight the levels of downtime and reduce costs.
- Inventory problems, the need to reduce spares and still have parts on hand. Control of spare modules is part of most of the modern CMMS packages.

- The problems associated with maintenance personnel excelling at some jobs and lacking skills in other craft areas. CMMS allows managers to review this information: what work has been done and by who over a period and assign work appropriately in a variety of craft areas in the future.
- Not enough maintenance personnel to handle the workload. CMMS can generate reports on labor requirements for each work order totalling the information by craft and week, showing imbalances and requirements for additional personnel.
- Machine breakdown just before preventative maintenance is due—CMMS can provide reports for each item of equipment, which can help pinpoint problem parts or requirements to reduce the preventative maintenance interval.

Wireman (1994) concluded that if CMMS are to be properly examined, it is important to have an understanding of the primary maintenance functions incorporating: maintenance inspections and service, equipment installation, maintenance storekeeping, and craft administration. He outlined the objectives of CMMS covering: improved maintenance costs, reduced equipment downtime as a result of scheduled preventative maintenance, increased equipment life, ability to store historical records to assist in the planning and budgeting of maintenance, and ability to generate maintenance reports. Most of the CMMS systems have four modules or components catering for:

a. Work order planning and scheduling;

b. Maintenance stores controls;

c. Preventative/predictive maintenance; and

d. Maintenance reporting.

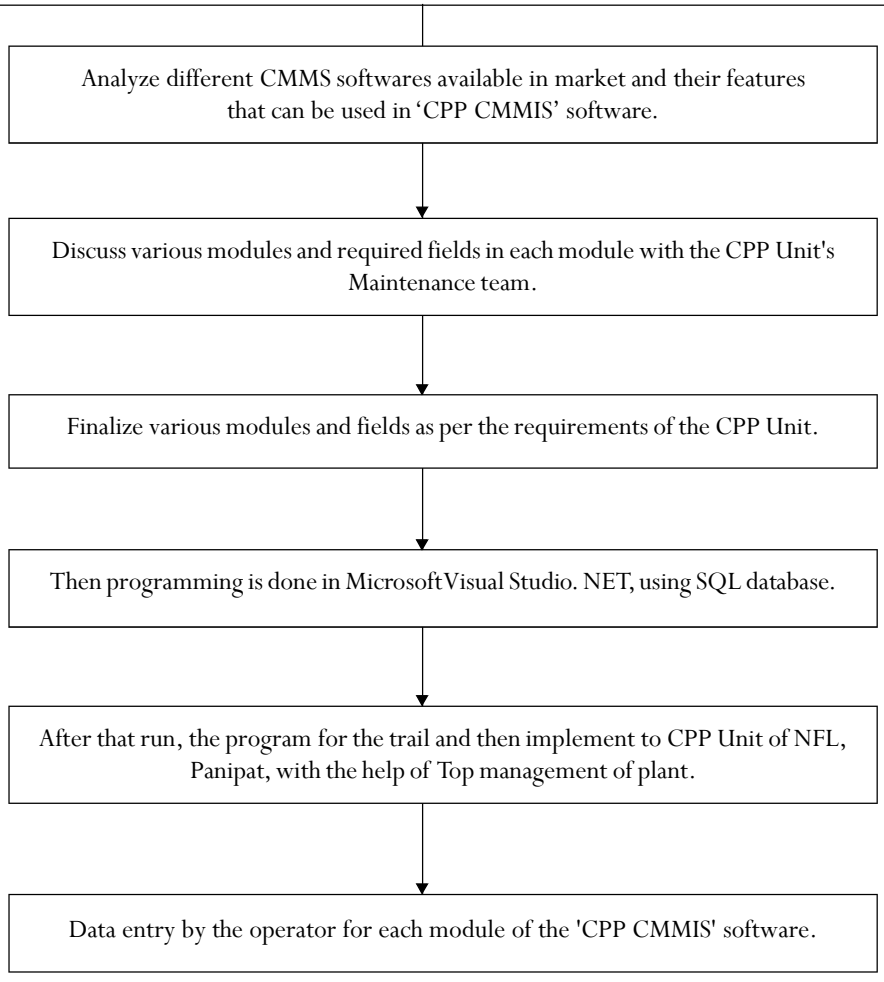
Rajiv *et al*. (2011) for the first time, developed RCA and maintenance schedule in the process industry. RCA is an interesting topic to research as it has been introduced first time in healthcare. Rogers *et al*. (2005) investigated and analyzed critical incidents and adverse events in healthcare. The objective was to carry out a review of published and unpublished work on the analysis on methods of accident investigation in high-risk industries and of critical incidents in healthcare.

3. Designing of CMMIS

The maintenance function of the manufacturing company for which the CMMIS was developed was totally responsive and breakdowns were dealt with as they occurred. Maintenance history of machines is kept in manual files and not computerized, which

leads to poor record keeping. So, efficient maintenance planning for the machine cannot be done with these types of records. History of each machine—i.e., when it was repaired last time, who repaired it, what were the spare parts used and when is the next due date of maintenance—was never available when required. As a response, a CMMIS was designed using Microsoft Visual Studio.NET for the Captive Power Plant (CPP) unit of the NFL, Panipat (India) and named 'CPP CMMIS', and also customized to the needs of the plant (Figure 1).

Figure 1: Flowchart for the CMMIS Designing for NFL, Panipat



The designing of 'CPP CMMS' software consists of the following steps:

However, more features were added to the structure of the computer system, making it more robust and versatile.

The following are the modules details of the designed 'CPP CMMIS' software:

Module 1

Equipment: This module contains information like warranty, supplier's details, manufacturer's details, image of the equipment and issue history about equipments/ machines in the plant whose maintenance is to be done.

Module 2

Critical Issues: This module gives the full description about any critical problem/ issue, e.g., repeated emergency breakdown, any mishaps in the plant, etc.

Module 3

Task: This module shows the details related to various maintenance tasks.

Module 4

Maintenance Schedule: This module contains the complete details of the different maintenance tasks and the schedules. Maintenance manager will get the ALERT message on the maintenance date of an equipment.

Module 5

Staff: This module gives the records details of staff members in the plant.

Module 6

Work Order: This is very important module. After getting the information about equipment, task and maintenance schedule, the work order is prepared. As soon as the work order is saved, an email is sent to the assignee's email-id with the work order details.

Module 7

Inspection: Non-Destructive Testing (NDT) team does the daily inspection for various critical equipments of the plant and send its report to the maintenance team on papers. This module is made for NDT team. They can update their findings in this module.

Module 8

Tools and Tackles: This module gives the useful information about all the tools and tackles used in the plant.

Module 9

Spare Parts: This module contains information related to the spare parts used in the maintenance activities and their availability.

Module 10

Downtime: This module stores information about different downtime that occurred for various critical equipments and their causes.

Module 11

Safety Record: This module stores information about accidents that happened in the plant and the causes.

Module 12

History: This module shows the history of equipments and critical issues for a specified range of dates given by the user.

Module 13

Literature: This module acts as maintenance manual available on the computer and useful for every staff-member. Any other maintenance-related practice can be shared on this module.

Module 14

Reports: This module shows the records for all important modules in the tabular form. The modules for which report can be generated are: equipment, critical issues, task, maintenance schedule, staff, work order, inspection, tools and tackles, spare parts and safety records.

4. CMMS Implementation

Many industries implement CMMS or CMMIS, but only some of these are successful in achieving its benefits. One of the most important issues is the quality of the implementation process of the CMMIS. It has the main effect on the efficient collection, maintenance and reporting from a historical database. Implementation must be quick and efficient. Technical support for implementation must be available and personnel should be on hand on an ongoing basis for any future challenges that may arise.

The steps in implementing CMMIS are as follows:

- The first and most important step in the implementation process is for plant management to decide the procedure and policies of maintenance department.
- The next step is to gain plant commitment to the process. Without this commitment, the system will never be fully functional.

- After determining the maintenance function and gaining total plant commitment, a company needs to select and purchase a CMMIS that meets its needs. Consideration must be given to data collection and data entry.
- The next step should be developing an implementation schedule. This schedule will let plant management know where they are in the implementation process.

5. Root Cause Analysis (RCA) and Maintenance Schedule

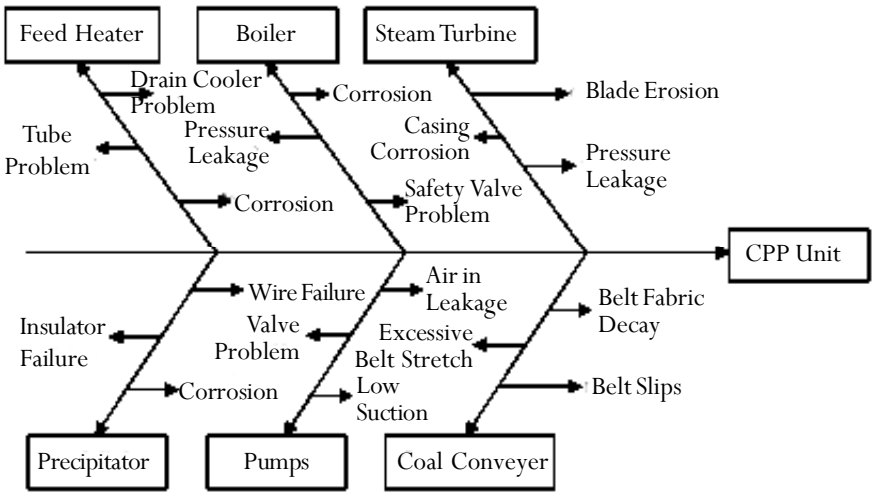
RCA is a class of problem solving methods aimed at identifying the root causes of problems or events. The practice of RCA is predicated on the belief that problems are best solved by attempting to address, correct or eliminate root causes, as opposed to merely addressing the immediately obvious symptoms. By directing corrective measures at root causes, it is more probable that problem recurrence will be prevented. However, it is recognized that complete prevention of recurrence by one corrective action is not always possible. Conversely, there may be several effective measures that address the root cause of a problem. Thus, RCA is often considered to be an iterative process, and is frequently viewed as a tool of continuous improvement.

The purpose of RCA is 'to uncover the underlying reasons (root causes) as to why an event (not just equipment but any type of event) is occurring so that the necessary steps can be taken to eliminate the event in its entirety.' RCA uses a fishbone diagram (Figure 2) that stresses verification at every level. The advantage is that the actual root causes that are uncovered are facts that have been derived from the verification process. RCA is driven by maintenance prevention strategies and maintenance schedule. Effective maintenance scheduling and maintenance work management are critical if control is to be gained over maintenance activities. Yet implementing effective planning and scheduling processes is not an easy task, particularly if you are already operating in a reactive operational environment.

The following are the main points for making maintenance schedule more effective:

- Providing training at all levels of your organization to ensure that everyone understands not only the details of the work management processes, but why they need to be followed;
- Working with your production and operations managers and supervisors to ensure that they are equally committed to making the maintenance scheduling and work management processes effective; and
- Assisting you in refining and improving the processes, and overcoming objections to their implementation at different level.

Figure 2: Root Cause Analysis for Captive Power Plant (CPP) Unit of NFL



Conclusion

The software contains powerful features for accumulation of historical data about maintenance-related activities. The software can meet the objectives of CMMIS. It is an effective tool to facilitate, simplify and rationalize administration of information and data about equipment and maintenance. The new modules added to the software are 'Literature Module', 'Spare Parts Module', 'Safety Record Module' and a separate 'History Module'. Effective communication and updates on maintenance activities can be achieved by 'ALERTS' and 'EMAIL' facilities provided in the software. It is to help maintenance activities to be more efficient, to ensure better use of maintenance personnel, to manage spare parts and tools, to estimate maintenance cost, to improve cost control in maintenance and to communicate with the top management with proper facts. Also, in the present research work, RCA is applied with CMMIS in fertilizer plant on CPP unit. This analysis gives the list of all root causes for the failure of CPP Unit. A fault tree (Figure 2) was also constructed starting with the final failure and progressively tracing each cause that led to the previous cause.

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