International Journal of Commerce and Management Studies (IJCAMS)

Vol.4, Issue 3, Sept 2019

www.ijcams.com

Reliability Centered Maintenance (RCM): Methodology and Benefits

Dr.Tushar Tale
Assistant Professor,
PDIMTR, Dhanwate National College,
Rashtrasant Tukdoji Maharaj Nagpur University Nagpur.

Abstract

RCM is a methodology aimed at mitigating the impact of equipment failures by having an enhanced understanding of how the asset works, what it can and cannot achieve. By knowing the failure mode and root causes, the efforts of maintenance are rightly focused to solve the fundamental problems and thereby enhancing the reliability of equipment or process.

In this paper, the researcher studied the concept of RCM, why we should implement it. A detailed methodology is presented, by following which you can implement RCM in your organization. This paper provides an overview of the reliability-centered maintenance (RCM) along with RCM methodology and benefits of implementing RCM in the organization. The RCM method provides a framework for utilizing operating practice in a more organized way. The necessities for reliability models and data are therefore highlighted. If implemented in the manner suggested in the paper, the organization will be benefited in terms of the improved operating performance of the assets and greater cost effectiveness in maintenance.

1. Introduction

Controlling maintenance costs, together with improving plant reliability and capacity has become an area of escalating attention in the ever increasing need to increase manufacturing competitiveness. A number of new maintenance philosophies have evolved and proven them in assisting maintenance managers in providing better plant utilization at lower cost. Amongst these are preventive maintenance, predictive maintenance, proactive maintenance, condition based maintenance and more recently reliability centered maintenance (RCM). A RCM strategy employs preventive, predictive and proactive maintenance technologies in an integrated manner to increase confidence that a machine will operate dependably over an extended life cycle. The integrated approach of various techniques is required, as no single technique is sufficient to accurately understand the problems of complex equipment. However, in combination, the various technologies provide a powerful set of capabilities of deriving a holistic picture of machine health. The ability to use the various techniques focused around reliability affords an opportunity to move beyond fault detection towards developing a meaningful and valuable tool for a maintenance improvement program. The focus shifts on the elimination of machine failure, rather than the prediction of failures. Along with the preventive, predicted and proactive approaches, the RCM philosophy include knowledge based diagnostics of samples to incorporate a learning component within the program. The element of knowledge is permanently embedded within the working practices so that the organization does not repeat bad practices and make continuous error.

1.1 Historical Perspective of Maintenance Practices

Over the last seven decades, the views about maintenance keep on changing. In the early 1930s and 40s, generally called first generation maintenance practices, the practice was to 'fix it when it broke'; the term used was breakdown maintenance or corrective maintenance. In this period, the industry was not highly mechanized, equipment was simple and generally over-designed. This is tabulated as bellow

Attributes	First Generation	Second Generation	Third Generation
Expectations	Fix it when it broke	✓ Higher plant availability ✓ Longer equipment life ✓ Lower costs	✓ Higher plant availability ✓ Greater safety ✓ Better product quality ✓ No damage to the ✓ Environment ✓ Longer equipment life ✓ Greater effectiveness
Techniques	Fix it when it broke	System for planning and controlling work	✓ Condition monitoring ✓ Design for reliability ✓ Hazards studies ✓ FMEA ✓ FTA ✓ Experts system
Models Maintenance	Corrective	Preventive maintenance	✓ Total Productive ✓ Reliability Centered Maintenance

1.2 Comparison of Maintenance Practices

The next generation called the second-generation spans from the 1950s to mid of 1970s. The period witnessed increased mechanization, complex machines. The major concerns from maintenance were higher plant availability, longer equipment life, and lower costs. The techniques of preventive maintenance were used considering failures follow bathtub curve theory.

In the third generation, with the advent of mechanization and automation, availability and reliability have assumed significant status. Along with this, the quality standards, safety, environment protection, longer equipment life are the other expectations of maintenance. Techniques like condition monitoring, expert system, design for reliability and maintainability, hazard studies, failure mode, and effect analysis, fault tree analysis took their position in the maintenance management.

1.3 Concept of RCM

RCM is a methodology as well as a philosophy, and it is not possible to define it with the help of one definition. The following definitions will help in understanding the concept of RCM. RCM is a systematic approach for quantitatively assessing the need to perform or review preventive maintenance tasks and plans. It provides a methodology targeted on system functions, the failures relating to that function, and in particular to the effects of dominant functional system failures. A decision tree is used within RCM to recognize and categorize critical system components jointly with an appropriate and applicable maintenance policy. The main concept underlying the development of RCM is an attempt to retain the design reliability of equipment, through the analysis of factors which affect its operating reliability, and with a view to optimize preventive maintenance programs via effective maintenance planning.

RCM provides a structured and logical approach to determine the maintenance requirements of any physical asset in its operating context. The methodology helps in identifying what causes the functional failures of equipment and what are the consequences of any failure? RCM concept then recognizes that in the true sense any maintenance is carried out, not so much to prevent the failures but to reduce the consequences of failures. RCM approach takes in consideration that all equipment or components do not follow an age dominated failure mode and, therefore the maintenance requirements of all components cannot be evaluated in a similar manner. Thus RCM is a process used to determine the maintenance requirements of any physical asset in its operating context. A great strength of RCM is the way it provides simple precise and easily understood criteria for deciding which (if any) of the preventive tasks is technically feasible in any context, and if so for deciding how often they should be done and who should do them.

To summarize

- RCM is a process used to decide the maintenance necessities of any physical asset in its operating context.
- RCM is a process used to decide what must be done to ensure that any physical asset continues to fulfill its intended functions in its present operating context.
- RCM is a method for developing and selecting maintenance design alternatives based on safety, operational and economic criteria. It employs a system perspective in its analysis of system functions, failure of functions and prevention of these failures.
- RCM is a system consideration of system functions, the way function can fail and a priority based consideration of safety and economics that identifies applicable and effective PM tasks.

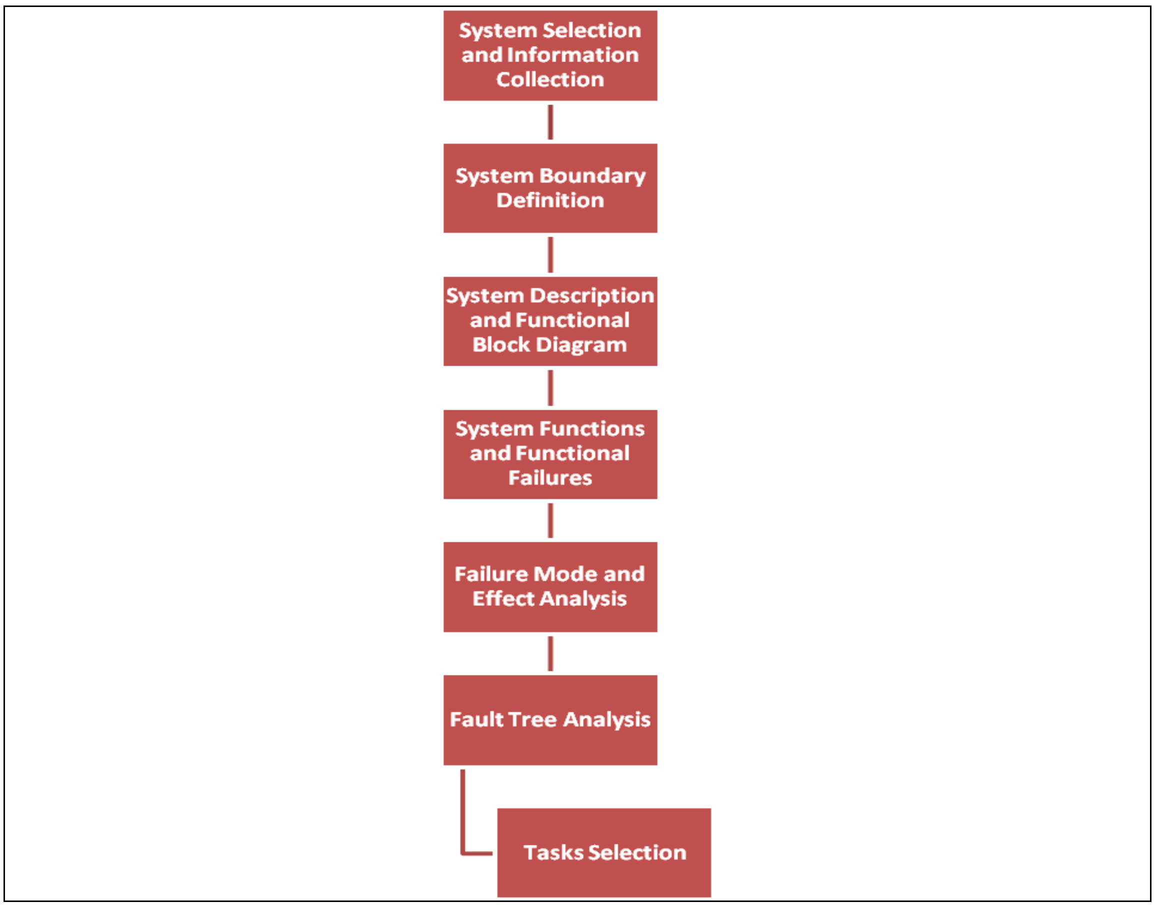
Thus RCM has four unique features:

1. Preserve functions
2. Identify failure modes that can affect functions
3. Prioritize function needs via failure modes

4. Select only applicable and effective tasks

2. RCM METHODOLOGY

The concept of RCM was developed in the early 1970s by the maintenance steering group of commercial airline industry in order to reduce maintenance downtime, maintenance cost and improve flight safety. It has also been successfully employed in grain terminals, coal mining, oil refinery, gas plants and paper industry. The methodology of the RCM is presented in the flow chart as shown bellow



Flow diagram of RCM methodology

The various steps of the methodology are briefly discussed here.

1. System Selection and Information Collection: Various factors like large PM cost and actions, large corrective actions and cost, safety and environmental issues are considered for selection of system. Documents such as system schematics, equipment history files, vendor manuals, system operation manuals are need to be referred for collection of information.

2. System Boundary Definition: Major equipment included in the system are
identified with primary physical boundaries. Defining of boundaries is required to
make sure that the potentially important functions are not neglected and to
establish the IN interfaces, factors coming into the system like power signals, flow
heat etc. and OUT interfaces, factors that leave the system.

3. System Description and Functional Block Diagram: The various type of
information developed in this phase are the following :

i. Description of functions, redundancy and protection features
ii. Hierarchy of functions
iii. IN/OUT interfaces
iv. Equipment list for each functional subsystem
v. Equipment failure history of past 2-3 years.

4. System Function and Function Failure: Function statements are developed for each functional subsystem by capturing every output interface. Functional failure statements focus on loss of function and not on equipment.

5. Failure Mode and Effect Analysis: In this step, the specific component failure modes — how the component must fail in order to produce functional failure — and the root cause for each failure mode are defined. Then the consequences of the failure mode are listed at three levels, locally at the level of component, at the system level and at the plant level.

The primary reasons for conducting FMEA are to assure that the failure mode in question does in fact have a potential relationship to the functional failure being studied and to introduce initial screening of failure modes that are not detrimental.

FMEA technique was developed by the American defence industry in the 1960s to address the problems experienced with complex electronic weapon control systems. Subsequently it was extended for use with other electronic, electrical and mechanical equipment. FMEA can be performed in a variety of different ways depending on the objective of the assessment, the stage of equipment development and the information available on its components at the time of analysis. The FMEA focus may dictate a different worksheet format in each case; nevertheless, there are two basic approaches:

- The Functional FMEA, which recognizes that each item is designed to perform a number of functions which can be classified as outputs. These outputs are identified and loss of essential inputs to the item or internal failures are then evaluated with respect to their effects on system operations.
- The Hardware FMEA, which sequentially lists individual equipment items and analyses the effect of each item failure mode on the operation of the system. In many cases a combination of these two approaches is employed.

The FMEA worksheet is tabular in format to foster a systematic approach to analysis. The various columns of the table are:

• **Item Identity/Description:** A unique identification code and description of each item.

• **Function:** A brief description of the function performed by the item.

• **Failure Mode:** Each item failure mode is listed separately — there may be several for an item.

• **Possible Causes:** The likely causes of each failure mode.

• **Failure Detection Method:** Features of the design through which the failure is recognized.

• **Failure Effect:** The effect of the failure at the local level, system level and plant level.

• **Compensating Provisions:** Any internal compensating provisions which could mitigate the effect of the failure.

6. Fault Tree Analysis/Logic Tree Analysis: There are two approaches that can be used to analyze the causal relationships between component failures and system failure. These are inductive or forward analysis and deductive or backward analysis. FMEA is an example of inductive analysis, it starts with a set of component failure conditions and proceeds forward, identifying the possible consequences. This is a 'what happen if' approach. Fault tree analysis is a deductive 'what can cause this' approach and is used to identify the causal relationship leading to a specific system failure mode– the top level. The fault tree is developed from this top, unwanted event, in branches showing the different event paths. Component failure events represented in the tree are progressively redefined in terms of lower resolution event until the basic events on which a good quality failure data are available are encountered. The events are combined logically by use of gate symbols, which shows the structure of a fault tree.

7. Task Selection: The RCM process requires that each task selected must satisfy the applicable and effective test, which are defined as follows:

Applicable: The task will prevent or mitigate failure, detect the onset of a failure or discover a hidden failure.

Effective: The task is the most cost effective option.

In RCM tasks are designed to prevent three types of failures:

a) Dangerous failures are injurious to the public, employees or to the environment, such as the boiler safety valve, or the rupture of a tank of volatile chemicals. Example of Bhopal gas leak is an example of this type of failure.
b) Expensive failures where the consequences are operational downtime and large breakdowns such as loss of cooling water to a data center or breakage of the chain in an auto assembly line. The breakdown of power transmission is an example of this type of failure.
c) Frequent failures that happen continually and are disruptive to the work environment resulting in high repair cost. Frequent

breakdown of buses of a transport company is an example of this type.

Under RCM, the problem is not a failure at all, it is the consequences of failure.

3. Benefits of Implementing RCM

RCM focus is on system function approach. Complex redundant systems have

reliability directly engineered into their design. The reliability of a system is reduced if maintenance tasks and frequencies are not its integral component. Over maintenance reduces the system reliability on account of maintenance induced failures. For highly reliable system, reliability very often is reduced due to human intervention under the pretext of PM. Therefore, RCM methodology has been successful in building up highly reliable systems. RCM methodology helps in achieving the following:

- High quality, cost effective maintenance plans in less time
- Assurance that all maintenance important parts and their failure mode are
- critically considered in the development of maintenance programs
- Increased probability that the level and content of the maintenance requirement is optimally specified
- Provides the basis for routine, on-line information sharing among engineering,
- operations and maintenance staff
- Longer useful life of expensive assets
- Improved safety of equipment and plant personnel
- Better environment protection
- Improved operating performance in terms of output, quality and customer service.

4. Conclusion:

RCM is a methodology aimed at mitigating the impact of equipment failures by having an enhanced understanding of how the asset works, what it can and cannot achieve. By knowing the failure mode and root causes, the efforts of maintenance are rightly focused to solve the fundamental problems and thereby enhancing the reliability of equipment or process.

In this paper researcher studied the concept of RCM, why we should implement it. A detailed methodology is presented, by following which you can implement RCM in your organization. If implemented in the manner suggested in the study, organization will be benefited in terms of improved operating performance of the assets and greater cost effectiveness in maintenance.

5. References :

1. Agarwal, V.K. and Gandhi, O. P., "*Reliability Centered Maintenance*",
Proceedings of SERC School on RAM, April 14-25, pp145-152, IIT Delhi, 1997,

2. Anderson, R. T. and Lewis, N., "*Reliability Centered Maintenance*
Management and Engineering Methods", McGraw Hill, 1990.

3. Maubray, J., "*Reliability Centered Maintenance*",
Butterworth Heinemann,
Oxford, 1991.

4. Rausand, M., "*Reliability Centered Maintenance*",
Reliability Engineering and
System Safety, Vol. 60, pp121-132, 1998.