International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 9, September- 2014

A Decision Model of Effective/Efficient for Living Reliability Centered Maintenance (LRCM) Program with Weibull Distribution Analysis

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***Abstract*— This paper will examine the generic process of living reliability centered maintenance (LRCM) through a decision model with Weibull distribution. This analysis provides one source of innovation in maintenance management policies and improves reliability in a wide variety of applications through a methodical approach that ensures an organization's maintenance management plan is efficient and effective. This paper is arranged in the following manner a decision model for living reliability centered maintenance and Weibull distribution for finding failure rate and the conclusions are given in the last sections.**

Keywords—LRCM; PM; RCM

I. INTRODUCTION

Living reliability centered maintenance (LRCM) is a logical process by which to expose, track, and extract bottom line benefits from each maintenance initiative over the years. As our operating experience grows, we collect operating and maintenance data which expands our ability to analyze and understand the equipment behavior. This expanded knowledge of the plant behavior may tell us that the RCM program requires some adjustments.LRCM binds RCM analysis to the work order system i.e. contributes a usable data point to the analysis of reliability. LRCM applies fundamental RCM to each challenge by combining technology solutions that encourage vital human participation and control over the entire process. LRCM finds the gap by empowering maintenance staff to surmount four challenges that obstruct the achievement of reliability from data –

1. Data extraction and transformation.
2. Management of the relationship between the work order system and the RCM knowledge base.
3. Sample generation.
4. Reliability analysis.

II. RCM DEFINED

RCM is a processused to determine what must be done to ensure that any physical asset continues to do what its users want it to do in its present operating context [1]. It is generally used to achieve improvements in fields such as the establishment of safe minimum levels of maintenance, changes to operating procedures and strategies and the establishment of capital maintenance regimes and plans.

Successful implementation of RCM will lead to increase in cost effectiveness, machine uptime, and a greater understanding of the level of risk that the organization is managing.

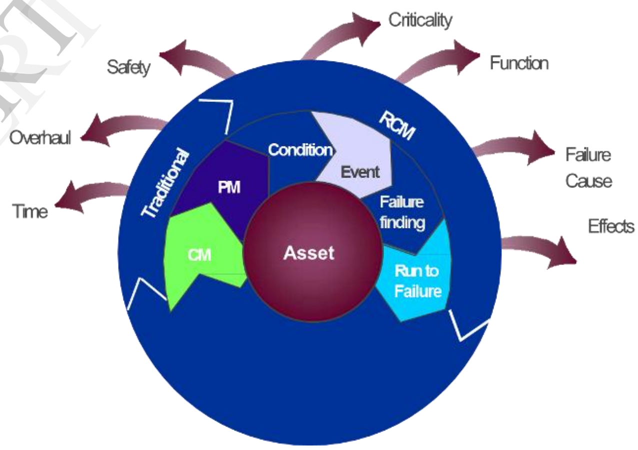


Fig.1. Maintenance evolution – RCM

III. RCM FUNDAMENTAL

As mentioned, the Society of Automotive Engineers published the all industry commercial standard for RCM SAE JA 1011 states that in order to be called a RCM Process. It obtains satisfactory answers to these seven questions, which must be asked in this order:

1- What are the functions and associated desired standards of performance of performance of asset in its present operating context (functions)?
2- In what ways can it fail to fulfil its functions (functional failures)?
3- What causes each functional failure (failure mode)?
4- What happens when each failure occurs (failure effects)?

5- In what way does each failure matter (failure consequences)?
6- What should be done to predict or prevent each failure (proactive tasks and task intervals)?
7- What should be done if a suitable proactive task cannot be found (default actions)? [2]

IV. LIVING RCM PROGRAM

Living RCM program is defined as that maintenance program in which continues to grow, evolve, change, and adjust occur during the operating condition of machine according their proper functionality as per given their prospects.

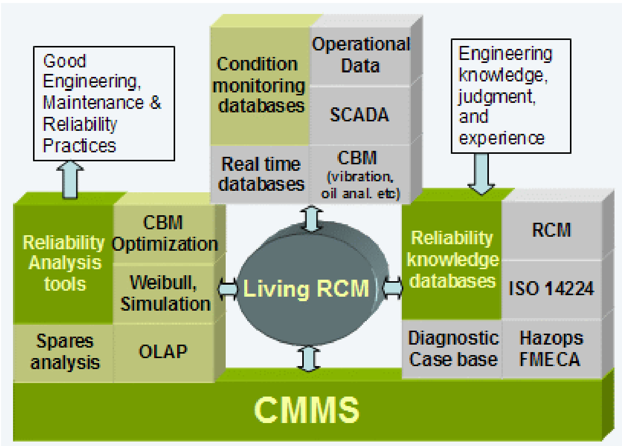


Fig.2. Living RCM program

V. A DECISION MODEL WITH WEIBULL DISTRIBUTION TECHNIQUE FOR LRCM

This decision model explains the methods which keep our RCM program accurate and it provide an automatic tune-up and self-adjusting based on the evaluation of completed PM tasks. In this decision model, I take weibull distribution analysis forminimize and predict failure rate of a running system.

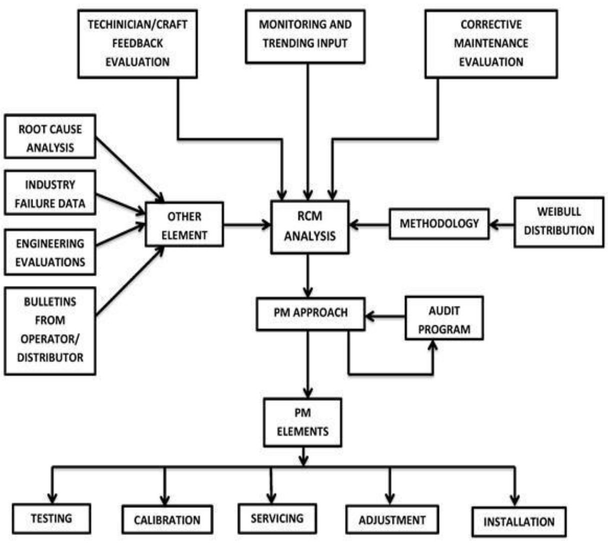


Fig.3. A decision model diagram for LRCM with weibull distribution

I have also included corrective maintenance (CM) as an element of the process and feedback from a monitoring and trending program. It is essential for a living program to have a logic embedded in this process; otherwise, PM program will oscillate. Therefore, we have inserted some "intelligence" into the decision processes to avert the possibility of overshooting.

A) TECHNICIAN/ CRAFT FEEDBACK EVALUATION ELEMENT

Craft personnel are the matter of inheriting pride of ownership in the program and an extremelyvaluable source of information, and we shall find them ready allies if we bring them into the process. The craft feedback grading categories are designed to utilize the professional opinion of the crafts to validate the existing PM for accuracy and appropriateness of the periodicity, or to justify other changes to the PM as applicable.[3]

Category Grade	Results	Function of the component
5	Good	Like new
4	Above average	Minor degradation
3	Average	Degradation is normal as expected
2	Below average	More degradation than expected
1	Poor	Significantly deteriorated

B) CORRECTIVE MAINTENANCE EVALUATION

Corrective maintenance evaluation can provide an increase in safety, quality and availability in industrial plants. However, the setting up of a corrective maintenance evaluation Program is a strategic decision that an evaluation system is proposed that carries out the decision making in relation to the feasibility of the setting up, management and control. [4]

C) MONITORING AND TRENDING INPUT

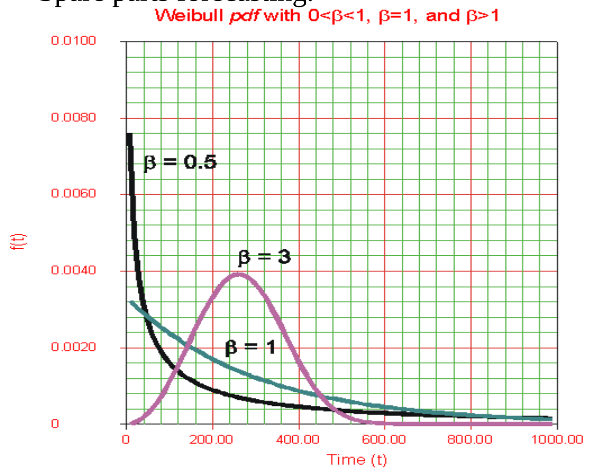
- Monitoring and trending is performed to detect incipient failures and degradation rates for a component before total failure of the component occurs.
- It includes performing condition-monitoring PdM activities, analyzing the results of those activities, and comparing them to previous readings to detect trends and rates of equipment degradation. Monitoring facilities, responding to alarms, and controlling field devices in all or part of the system.[5]
- Initiating sequenced control, or commanding individual field devices, including set points.

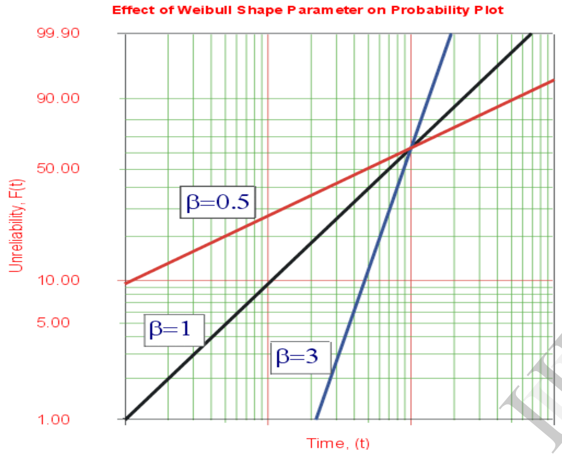
VI. WEIBULL DISTRIBUTION TECHNIQUE

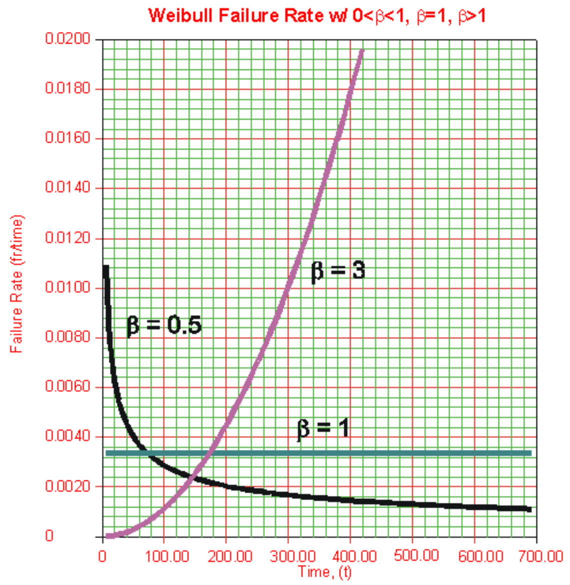
Weibull analysis is also known as "Life Data Analysis". The weibull distribution is used to estimate life characteristics of the product such as reliability or probability of failure at a specific time, the mean life and the failure rate.
Weibull analysis includes following features:

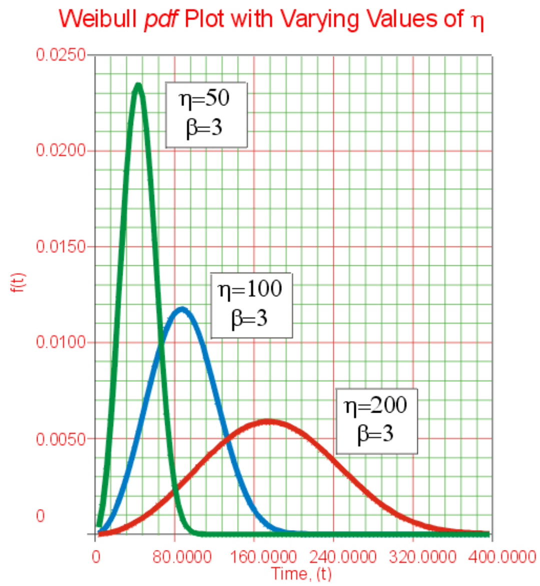
- Failure forecasting and prediction.
- Maintenance planning and cost effective replacement strategies.

- Calibration of complex design system i.e. CAD/CAM, finite analysis… etc.
- Evaluating corrective action plan.
- Spare parts forecasting.









$$f(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1} e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}}$$

$$f(T) \geq 0,\ T \geq 0 \text{ or } \gamma,\ \beta > 0,\ \eta > 0,\ -\infty < \gamma < \infty$$

Where,
β is the shape parameter, also known as the Weibull slope.
η is the scale parameter.
γ is the location parameter.

Weibull plots are informative to the trained eyebecause the trained eye still can:

- Identify mixtures of failure modes
- Identify problems with the origin not located at zero
- Investigate alternate aging parameters
- Handle data where some part ages are unknown, and
- Construct a Weibull curve when no failures have occurred.

OTHER INPUTS ELEMENTS

Living RCM program is always affected by various inputs that results from a multiple sources. Each one of these inputs can affect the LRCM program. Some of the more common ones are as follows:

1) Root-cause evaluations

Root cause evaluation is having the main function to prevent that occurrence of failure from ever happening again.

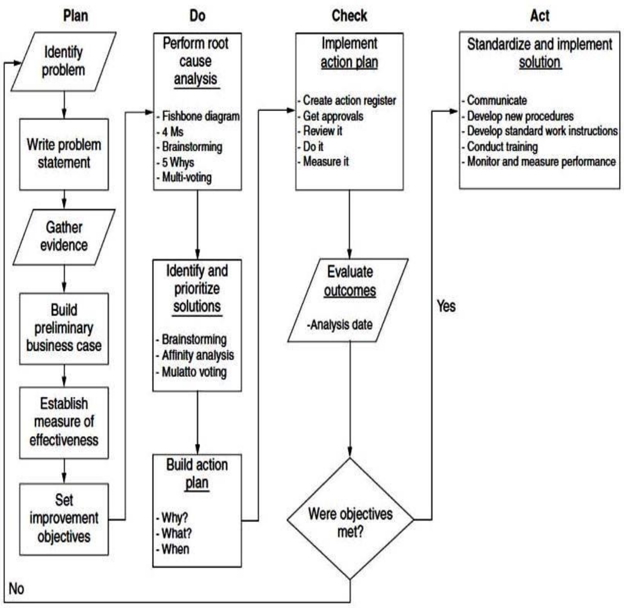


Fig.4. the PDCA process

2) Industry failure data

This is another source of input to the living program. Industry failure data share by many company with each other and entails first using deductive logic to find the mechanical and human causes of the failure, and thenusing inductive logic to find the latent causes. In addition, it should also lead to the changes needed to prevent the recurrence of failure.

3) Engineering evaluations

An engineering evaluation is a complete and thorough inspection of techniques and procedure. It is similar to a root cause evaluations.

VII. CONCLUSIONS

Following conclusions can be obtained from the study:

- The RCM process is not perfect and may require periodic adjustment to the baseline results. Because design equipment and operating procedures may change over a time and these changes can affect the baseline results. Hence, above activity suggested to LRCM.
- It is essential for a living program to have some logic embedded in the process; otherwise, i shall oscillate the PM program in a back-and-forth manner by extending periodicities and then having to reduce them because we extended them too far.
- Decision model and weibull distribution analysis provides the information & data necessary for design improvement as well as adjustment of these items where its inherent reliability starts to be inadequate.
- Decision model and weibull distribution analysis of LRCM achieve these goals at minimum cost and economic consequences of operational failure.
- The primary benefits of weibull analysis is the abilty to provide reasonably accurate failure analysis and failure forecasts with extremely with small samples.
- Weibull indicates a useful graphical plot of the failure data. The horizontal scale is a measure of life or aging & vertical scale is the cumulative percentage failed.
- The Weibull plot is extremely useful for maintenance planning, particularly reliability centered maintenance. Betaindicates scheduled inspections and overhauls are needed or not. If beta is less than or equal to one, then overhauls are not cost effective. When beta is greater than one, overhaul period or scheduled inspection interval is read directly from the plot at an acceptable probability of failure.
- There are five craft feedback categories: good (5), above average (4), average (3), below average (2), and poor (1). The feedback is based on the condition of the PM task and not on the overall condition of the equipment.Intelligence has been added to the decision process to account for other influences that can affect the category grade.

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