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Computer-aided RCM-based plant maintenance management system

Hossam A. Gabbar*, Hiroyuki Yamashita, Kazuhiko Suzuki, Yukiyasu Shimada

Department of Systems Engineering, Okayama University, 3-1-1 Tsushima-Naka, 700-8530 Okayama City, Okayama, Japan

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Abstract

In most of the industries, classical reliability-centered maintenance (RCM) is employed to decide the maintenance strategies using reliability data without having adequate interaction with the design and operational systems. This means that the RCM process will be conducted with no or limited access to the design and operational data/knowledge. Commonly, the developed maintenance strategies are implemented and managed within the computerized maintenance management system (CMMS), which is usually separate from the RCM automated environment. This paper presents the detailed system design and mechanism of improved RCM process as integrated with CMMS. The proposed solution is integrated with design and operational systems and consolidates some successful maintainability approaches to formulate an effective solution for optimized plant maintenance. The major components of the enhanced RCM process are identified and a prototype system is implemented as integrated with the various modules of the adopted CMMS (MAXIMO™). A case study is used to show the effectiveness of the proposed RCM-based CMMS solution in optimizing plant maintenance over the traditional approaches.

Keywords: RCM; CMMS; Maintenance management; Reliability; Maintenance integrated system

1. Introduction

The old maintenance practices that were commonly used, such as ''Fix it when it breaks'' or ''Preventive maintenance'', could not achieve optimized maintenance with the current market challenges, while having high risk in operation [1].

In the early 1960s, the initial reliability-centered maintenance (RCM) development was done by the North American civil aviation industry. RCM process is intended to determine the most realistic and optimized maintenance requirements of any physical asset to continue its stated operating condition [2]. Many industries have adopted RCM technique to solve many confronted maintenance problems. Unfortunately, it did not work as expected for many reasons: (1) RCM is a time- and effort-consuming process and requires considerable amount of resources, especially for large number of assets for complex plants; (2) the available information is not adequate to decide the suitable maintenance strategy and to optimize its cost as maintenance and operational systems are isolated from design and engineering systems; (3) there are non-engineering factors involved in the maintenance problems i.e. management and human factors.

To overcome some of the highlighted maintenance problems an integrated RCM-CMMS system is proposed so that it can dynamically change the maintenance strategies based on the operating condition of the equipment and other factors affecting the life (age) of the underlying assets. The background of the research idea can be approached from the following different angles:

1.1. RCM utilization in industry

RCM can be considered as an effective tool that incorporates sound guidance for executive managers to attain high standards of maintenance. This includes identifying critical equipments and developing optimal maintenance policy based on reliability data [3]. RCM can be used to formulate maintenance strategies for discrete manufacturing and to perform the failure analysis function, which includes environmental aspects

*Corresponding author. Tokyo Institute of Technology, 4259 Nagatsuda Midori-ku, Yokohama 226-8503, Japan. Tel.: +81-45-924-5258; fax: +81-45-924-5270.

E-mail address: hossam@pse.res.titech.ac.jp (H.A. Gabbar).

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and human factors [1]. Anderson explained RCM management and engineering methods [4]. In such reference, the application of RCM within depot and aircraft maintenance has been explained, where the basic structure of the maintenance strategy decision tree has been utilized effectively in RCM decision engine module.

1.2. Reliability and maintainability methods and approaches

Due to the criticality of plant maintenance optimization issue, many researches are focused on developing reliability, inspection, and/or maintainability methods and models to improve and optimize one or more aspects of plant maintenance and for different plant/system types. A review of some of these approaches will be discussed hereinafter to get useful ideas on how to improve the overall plant maintenance. Among these approaches, Bullough conducted a useful review of the reliability analysis and its application to nuclear plants [5]. A combined solution of RCM and PRA (probabilistic risk assessment) has been experimented in TEAMM approach to prioritize maintenance [6]. In such approach, a satisfactory way has been proposed to quantify safety consequences using PRA. In Japan, a new maintenance standards have been introduced, which covers in-service inspection (ISI), flaw evaluation, and repair procedures [7]. In such standards, failure analysis and acceptance criteria are part of the maintenance evaluation procedure, which made it possible to apply RCM procedures, indirectly, within the maintenance standards. The failure/repair process for repairable items has been explained by [8]. An alternative approach to RCM-based maintenance is the risk-based inspection [9]. In such approach, risk-informed regulations can be very useful to decrease maintenance and inspection work. The proposed reliability-based maintenance will utilize risk-based information as part of the overall plant maintenance strategy, which will be discussed in this paper.

1.3. RCM automation

Attempts are made to automate RCM as integrated within the design environment using fuzzy reasoning algorithms [10]. Such solution proposed optimum maintenance strategies during the design stage, while operational factors are not considered. Fault recovery management mechanism (FRMM) is an integrated system that includes the management aspects of RCM to perform statistical analysis to indicate the actual and critical failure modes for critical events reassessment [11]. From these two examples, both plant design information and operational factors are essential to obtain optimized maintenance strategies.

1.4. Current industrial practices in the area of CMMS

Industries such as oil and gas or nuclear power plants are in need of an efficient computerized maintenance management system to manage their maintenance activities throughout the plant lifecycle. The major problem that faces the implementation of CMMS is that the maintenance strategies are either reflected from the equipment vendor, from similar plants, or from the design environment. The changes in the operating condition are not fully reflected into the maintenance strategies, which are configured within CMMS.

From the above-mentioned background points, the research work offers an automated RCM as integrated with CMMS as part of the plant enterprise engineering environment. The consolidation of some useful reliability and maintainability methods and models will enhance consolidation of some useful reliability and maintainability methods and models will ensure the effectiveness of the proposed solution. In this study, the system architecture of the integrated solution is presented to show the mechanism of the proposed solution. Towards the proper analysis of the solution, business activity models have been developed, which reflects the different activities involved in performing the RCM assessment. The main modules of the proposed RCM computerized module as well as the function decomposition of the integrated solution are identified. The implementation aspects of the proposed solution will be discussed using MAXIMO as an adopted CMMS.

2. Proposed system architecture

Fig. 1 shows the system architecture of the proposed RCM-based CMMS integrated solution. The proposed automated solution includes four main processes: plant design environment [P1], RCM process [P2], CMMS [P3], and operational systems [P4]. The integration with design environment is essential as most of the maintenance strategies are initially decided during the process design stage. RCM component is an expert system that decides the optimum maintenance strategies and calculates the different quantitative parameters of maintenance tasks. CMMS component is mainly used during the operation stage to manage and implement maintenance strategies via extracting asset information along with their functions from design environment (i.e. from the design model). RCM utilizes asset information along with design and operational data/knowledge to perform asset and failure assessments and to build the failure and risk data/knowledge bases.

Starting from the design stage, RCM module will be invoked to suggest the preliminary optimized maintenance strategies for the selected assets based on the process design model. Plant OO model [D1] is the prime