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Preventive maintenance decisions through maintenance optimization models: a case study

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Abstract

Technology has always been a key driver of change in industry, leading enterprises to adopt methods to improve maintenance decisions and striving for maintenance excellence. This paper reports a procedure to support the planning of preventive interventions to be integrated in a computerized maintenance management (CMMS) that is discussed considering the difficulties in its implementation. A basis to get a new CMMS function that allows obtaining the optimal periodicity of preventive interventions is provided. To this end, failure records based on equipment`s FMEA and reliability study are highlighted to provide more robust inputs to maintenance models and consequently accurate solutions.

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Keywords: Failure Analysis, Maintenance Optimization Models, Preventive Maintenance, Reliability Analysis.

1. Introduction

To achieve excellence in maintenance the balance of maintenance performance, risks, and costs must be taken into account in order to achieve good quality solutions [1]. This includes developing tactics that maximize the benefits of maintenance strategies, which are usually classified in two major categories, corrective maintenance (CM) and preventive maintenance (PM) [2,3]. CM can originate high costs which also include loss of production incurred due to equipment downtime and, therefore, PM should be performed to reduce these costs whenever it

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reduces the likelihood of the failure occurrence. However, a too high frequency of preventive maintenance interventions can also result in high costs, once resources may be wasted without been necessary [4,5]. In order to support PM decision making and replace subjective decisions by objective decisions, maintenance optimization models have been developed. Maintenance optimization models are applied in order to find a balanced maintenance solution that is closest to an objective under certain criteria [6].

The work presented in this paper is part of an ongoing project and aims to incorporate a new function in the existing computerized maintenance management (CMMS) of an automotive company to assist failure analysis and optimal periodicity definition of preventive interventions, considering costs [5]. This paper reports the implementation of the procedure to support the planning of preventive interventions, which is discussed considering the necessary data and its proper organization, and the critical factors for its implementation. The paper begins with a brief review of time-based maintenance, reliability analysis and maintenance optimization models, in Sections 2. Then, Section 3 presents the proposed procedure and its application and validation through a numerical example. Finally, in Section 4 some conclusions are drawn.

2. Literature Review

Time-based maintenance (TBM) also referred in literature as predetermined maintenance is a PM technique [3]. TBM is performed in accordance with established intervals of time or number of units of use, without previous condition investigation [7]. The general process of TBM implementation includes failure data analysis and maintenance decision making process [3]. The next subsections address the existing methods to perform failures analysis and the maintenance models.

2.1. Failure analysis

A failure is defined as an event in which the ability of an item to perform a required function ends [7]. According to Moubray [8], functional failures identification is followed by the identification of failure modes (which are the events that causes a functional failure) and the determination of the associated failure effects, that can be understood as what happens when a failure mode occurs. This is done by performing a failure mode and effect analysis (FMEA) for each function item. Liu et al. [9] define FMEA as a structured, bottom-up approach that starts with known potential failure modes at one subsystem level and investigates the effect on the next subsystem level. FMEA may be the source for virtually all subsequent reliability analyses and assessments because it forces an organization to systematically evaluate equipment and systems weaknesses, and their interrelationships that can lead to product unreliability [10].

Item´s reliability is one of the inputs for the application of maintenance optimization models. So, failure analysis through component reliability study must be performed to this end. It can be carried out using various statistical tools and, the most common is the Weibull distribution [11]. This probability distribution has been widely used to model the times to failure of components due to its ability to model various life time distributions, including increasing, decreasing, or constant hazard rates [3,12]. Data are essential inputs for building decision models that support evidence-based physical asset management. It must be recognized that mathematical models by themselves do not guarantee that the right decisions will be made, if the data used do not have the required quality [13]. The optimization of TBM decisions requires good quality and timely obtained data. Consequently, it is crucial that failure records, typically maintained in database of CMMSs, are properly treated and organized.

2.2. Maintenance optimization models

Dekker [14] defines a maintenance optimization model as a mathematical model in which the costs and benefits of maintenance are quantified in order to obtain an optimal balance between them. Maintenance optimization models aim to evaluate and compare maintenance polices, to determine how often to inspect or to maintain an item and to help to determine effective and efficient schedules and plans [15]. Dekker [14] concluded that there are several case studies published which shows that mathematical models are a good way to achieve both effective and efficient maintenance. However, the author identifies a several factors which may hamper the application of