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Development of a Risk Matrix and Extending the Risk-based Maintenance Analysis with Fuzzy Logic

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Abstract

Unexpected failures, the loss of production, and higher maintenance costs are major problems of manufacturing systems. Hence, certain investigating methods, such as Risk-based maintenance (RBM), help to deal with such issues. An important element of the RBM planning is to assess the consequences of action and prioritization of maintenance tasks based on the risk of potential failures. The main purpose of this classification is the right choice for maintenance strategy, maintenance intervals, and a certain level of spare parts in the storage. This manuscript illustrates the use of fuzzy logic for the minimization of suboptimal classifications, and it suggests a fuzzy inference system (FIS) for overcoming the challenge mentioned above. Membership functions and the rule base are developed. It is possible to integrate the suggested approach to currently existing computer-aided maintenance management system (CMMS) in a manufacturing firm (MF).

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Keywords: classification; fuzzy logic; manufacturing systems; risk-based maintenance; risk matrix

1. Introduction

The performance of production/manufacturing is heavily influenced by the maintenance productivity e.g. Parida and Kumar [1], which concerns significant endeavors that deal with inspections, scheduled cleaning, adjustments, repairs and replacements of machinery in the manufacturing firm to ensure operational reliability, and final product

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quality. This was shown in the works by Duffuaa and Daya [2], Daya et al. [3], Daya and Duffuaa [4], Wenchi et al. [5]. The output of manufacturing process is dependent on the performance of machinery as defective products from previous machinery can accumulate or disturb the subsequent process and overall quality. This has been further exacerbated by the increasing trend on mechanization and automation and the role of machinery in production operations become significantly important factor. Hence, it is vital to keep the performance of machinery in an ideal condition and operate effectively, like says Kurniati et al. [6].

Inherently, the equipment or machinery experiences aging and deteriorate with time and/or level of usage in a manufacturing process, which has direct/indirect impact on the overall quality of the manufactured products. In this context, it is possible to characterize the diminished product quality by increasing the rejection rate and declining the performance of particular machinery. As the rejected (or non-conformed) products cause the deterioration of the downstream process, it is not possible to segregate the maintenance tasks of machinery from the overall manufacturing process management tasks, Wenchi et al. [5]. Moreover, the performing maintenance at the right time on the right machinery by the right personnel is crucial to restore them to an acceptable condition. Hence, it is vital using effective machinery prioritization approaches to schedule maintenance tasks and assign them into different maintenance strategies (i.e. preventive or corrective) as appropriately based on the risk [i.e. risk based maintenance (RBM)] of the potential failures. As shown in the work by Ratnayake et al. [7]. Fig. 1 illustrates the machines classification matrix in relation to maintenance strategies.

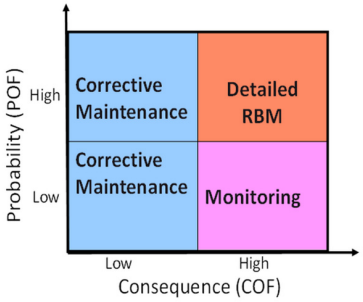

Fig. 1. Screening matrix.

Currently, some of the MFs use empirical models to classify machinery for performing maintenance tasks; it was shown in the papers Ratnayake [8, 9]. However, it has been revealed that the empirical models based classification requires further fine prioritization of the machinery for allocation of existing resources for performing maintenance tasks. Hence, it is vital developing RMB approach for prioritization and classification of machinery for effective scheduling of maintenance tasks. First, this manuscript explains the weaknesses of the currently existing empirical model based approach. Then, it suggest a risk matrix to make machinery prioritization and classification by taking personal safety (PS), percentage non-conforming products (PNCP), time to failure elimination (TTFE), availability (A) of a machinery per month for manufacturing tasks, and failure frequency [i.e. number of breakdowns (NoB) per month] into consideration. Finally, it demonstrates a fuzzy logic based approach that supports the use of risk matrix to make optimal prioritization and classification of machinery (i.e. how fuzzy logic enables to minimize sub-optimal classifications, when RBM scheduling is made with the support of a risk matrix).

2. Case study and industrial challenge

The case study manufacturing firm (MF) is located in the area of Podkarpackie Province (Poland). It mainly manufactures plastic products for domestic usage (e.g. garden tools and technological tools). Currently the MF uses scheduling (or time based) or corrective maintenance strategies for each machine which has been used in the manufacturing process. At the end of each year of manufacture/production, the maintenance personnel are responsible to prepare a schedule for preventive maintenance inspection (Note: as a rule of thumb, every machine has to be inspected after 2700 machine hours) focusing on the manufacturing operations that have to be performed in the subsequent year. However, it has been that the maintenance tasks are not properly implemented. For instance, the