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A Comparison of Multi-Criteria Decision Making Approaches for Maintenance Strategy Selection (A Case Study)

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ABSTRACT

The growth of world-class manufacturing companies and global competition caused significant changes in the manufacturing companies operations. These changes have affected maintenance and made its role even more crucial to stay ahead of the competition. Maintenance strategy selection is one of the strategic decision-making issues that manufacturing companies in the current competitive world are facing. In this paper, a comparison between different Multiple Criteria Decision Making (MCDM) approaches is conducted in a dairy manufacturing factory to rank the maintenance strategies. The aim is to suggest an appropriate approach for the best selection of the maintenance strategy. The decision-making elements including evaluation criteria/sub-criteria and problem alternatives, i.e., maintenance strategies are determined and a group of experts from the case-study factory are asked to make their pair-wise comparisons. The pair-wise comparison matrix is constructed by using the crisp and triangular fuzzy numbers, while the aggregation of individual priorities (AIP) approach is utilized to aggregate the decision-makers' judgments. The priority vectors of decision elements are calculated by Mikhailov's fuzzy preference programming (FPP) methods and the final weights of the decision elements are found. Results show that when the effectiveness of one element on the other elements is higher, it will have greater weights; and therefore, the results from the analytic network process (ANP) method is completely different from those of the analytic hierarchy process (AHP). The reason for the differences between the AHP and Fuzzy AHP (FAHP) with the ANP and Fuzzy ANP (FANP) is that both AHP and FAHP evaluate the criteria only based on the level of importance and do not consider the interdependencies and interactions among the evaluation elements. In this research, a predictive maintenance is selected as the most appropriate strategy in the case company and the preventive strategies outperformed the corrective strategies. The results of this research are consistent with the results of previous studies found in the literature.

KEYWORDS

Analytical Hierarchy Process (AHP), Analytical Network Process (ANP), Fuzzy Set Theory, Maintenance Strategy Selection, Multi-Criteria Decision Making

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1. INTRODUCTION

In the past, many companies considered maintenance as an inevitable source of cost. For these companies, maintenance operations have a corrective function (fix it on failure) and are only executed in emergency conditions. Today, this form of intervention is not acceptable because of certain critical elements such as product quality, plant safety, and increased costs of maintenance departments (Bevilacqua and Braglia, 2000). Furthermore, in the current competitive world, manufacturing firms attempt to improve their performance in terms of cost, quality, and flexibility, in an effort to compete with other firms of the global marketplace (Ertugrul Karsak and Tolga, 2001). In the manufacturing firms, various problems such as manufacturing technology selection, maintenance strategy selection, machine location, and evaluation of quality function would influence production cost, product quality, and product delivery-time (Bashiri, Badri, and Hejazi, 2011). As indicated by Mobley (2002), one third of all of the maintenance costs are wasted as a result of unnecessary maintenance. The use of inefficient maintenance policies considerably increases the direct maintenance costs (Rastegari and Bengtsson, 2014). On the other hand, the manufacturing firms are under a great pressure to continuously reduce their production costs. One of the main expenditure items for these firms is their maintenance costs, which can comprise up to 15%-70% of the overall production costs according to the type of industry (Bevilacqua and Braglia, 2000; Rastegari and Bengtsson, 2015).

In recent years, the importance of maintenance strategy selection has been increased due to the critical role it has for increasing the availability, the safety, and the mean time to failures, improvement of system reliability and product quality, reducing shutdown time of factory, and preventing unnecessary investments. Various methodologies have been used for selecting a suitable maintenance strategy in the literature as presented as follows. Triantaphyllou, et al. (1997) have suggested a method to address criticality of the criteria related to the problem of maintenance strategy selection. They first prioritized the maintenance strategies using the AHP and then performed a sensitivity analysis on different criteria to identify the most important one. The maintenance strategy selection was presented by Luce (1999), Okumura and Okino (2003) based on different production loss and maintenance costs incurred by different maintenance strategies. Azadivar and Shu (1999) proposed a method for selecting an appropriate strategy for each class of systems in a just in time environment exploring 16 characteristic factors that could play a role in the maintenance strategy selection. Using the AHP method for the maintenance strategy selection was suggested by Bevilacqua and Braglia (2000). Al-Najjar and Alsyouf (2003) and Sharma, et al. (2005) evaluated the maintenance strategies through the fuzzy interference system (FIS) and the fuzzy multi-criteria decision-making methods. Mechefske and Wang (2003) used the fuzzy linguistic variables to evaluate and select the optimum maintenance strategy and condition monitoring technique. Bertolini and Bevilacqua (2006) presented a combined model based on the AHP and the goal programming (GP) to identify the best maintenance strategy for the critical centrifugal pumps in an Italian oil refinery.

Wang, et al. (2007) evaluated different maintenance strategies based on the FAHP. In their study, a new method is also proposed for obtaining the priorities from the fuzzy pair-wise comparisons matrix. A combination of the FAHP and TOPSIS methods was utilized by Shyjith et al. (2008) to select an optimum maintenance strategy for textile industries. Jafari, et al. (2008) applied a fuzzy Delphi method in simple additive weighting (SAW) for the maintenance strategy selection which could determine the best maintenance strategy by considering the uncertainty levels and considering various maintenance criteria and their importance. Arunraj and Maiti (2010) used the combination of AHP and GP for the maintenance strategy selection based on the risk of equipment failure and the maintenance cost. They applied this approach in a case study in a benzene extraction unit of a chemical plant. Cheng and Tsao (2010) suggested the ANP method to select an optimum maintenance strategy for rolling stock in a railway system.

Bashiri et al. (2011) developed a new interactive method based on the fuzzy linear assignment method for an efficient maintenance strategy selection which uses the quantitative and qualitative data