

Chapter 14

A Hybrid Multiple Criteria Decision Making Technique for Prioritizing Equipments

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ABSTRACT

Prioritization of equipment is an important factor for decision making to optimize maintenance management in Reliability Centered Maintenance (RCM). Many factors must be considered as part of the prioritization of equipment for maintenance activities. Consequently, evaluation procedures involve several objectives and it is often necessary to compromise among conflicting tangible and intangible factors. Multiple Criteria Decision Making (MCDM) is a useful approach to solve these problems. In this study, a hybrid model is developed for prioritizing the equipment in hybrid flow systems. The first stage involves identifying the criteria. The second stage is prioritizing the different criteria using fuzzy Analytical Network Process (ANP), in which the weight of each criterion is calculated using modified fuzzy Logarithmic Least Square Method (LLSM) to overcome the criticism of inconsistency, unbalanced scale of judgments, uncertainty and imprecision in the pair-wise comparison process, then finally ranking of equipment using fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

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1. INTRODUCTION

Once a system or a piece of equipment is purchased, it must be maintained. Tsang (2002) argues that experience, judgment and vendor recommendations are the common bases for determining the content and frequency of a maintenance task. Maintenance can be defined like the activities intended to preserve or promptly restore the safety, performance, reliability, and availability of plant structures, systems, and components to ensure superior performance of their intended function when required (Weinstein & Chung, 1999).

Production and service systems are heavily affected by their respective maintenance systems. Maintenance systems operate in parallel to the production systems to keep them serviceable and safe to operate at minimum cost. One way to reduce the cost of operation and production is to optimize utilization of maintenance resources (Duffuaa & Al-Sultan, 1997). Historically, maintenance activities have been regarded as a necessary expense that belongs to the operating budget. It is a common item on the list of cost-reduction programs. However, maintenance, as a support function in businesses, plays an important role in backing up any emerging business and operation strategies (e.g., lean manufacturing, just-in-time production and six sigma programs). The effectiveness of maintenance management depends significantly on proper deployment of resources in the form of spare parts and other maintenance materials, manpower, necessary tools and instruments, and ultimately life cycle profit for an organization (Sherwin, 2000). But since, organizational resources are limited and scarce, prioritizing critical equipments for assigning resources is essential.

Many potential criteria, such as availability, risk, maintainability, bottlenecks, utilization, breakdown cost etc. must be considered in the ranking of equipment for maintenance. Therefore prioritization of equipment can be viewed as a MCDM problem in the presence of many quantitative and qualitative criteria. The MCDM methods

deal with the process of making decisions in the presence of multiple criteria or objectives. Analytic Hierarchy Process (AHP) is now widely used by both researchers and practitioners (Ghodsypour & Brien, 1998; Min, 1992). But theoretically, the AHP methodology is valuable when the decision-making framework has a unidirectional hierarchical relationship among decision levels. However, Carney and Wallnau (1998) point out that the evaluation criteria for alternatives are not always independent of each other, but often interact with one another. An invalid result can be drawn in such a complex environment. Moreover, AHP is not practically usable if the number of alternatives and criteria is large, since the repetitive assessments may cause fatigue in decision-making (Briand, 1998).

Some of the methods available in literature tend to treat each of the selection criteria and alternative equipment as an independent entity. This however, is seldom the case in the real world industrial context in which selection criteria and alternative equipment are in fact characterized by interdependence. Moreover, it is very common that hybrid flow systems existing in process industries. In hybrid flow systems, the products flow through multiple parallel pass. Related or unrelated similar machines generally installed in parallel paths. Hence, a critical study is required to prioritize the equipment for the purpose of maintenance when compared to machines installed in job order industries. ANP can therefore be adopted to accommodate the concern of interdependence among selection criteria or alternatives.

The traditional ANP requires crisp judgments. However due to the complexity and uncertainty involved in real world decision problems, a Decision Maker (DM) may sometimes feel more confident to provide fuzzy judgments than crisp comparisons. This makes fuzzy logic a more natural approach to this kind of problems.

A number of methods have been developed to handle fuzzy comparison matrices. Van Laarhoven and Pedrycz (1983) suggested a fuzzy LLSM to

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