MCDA Techniques in Maintenance Policy Selection

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María del Carmen Carnero Moya
University of Castilla-La Mancha, Spain

INTRODUCTION

Traditionally maintenance departments have taken decisions based on their experience or supported by the advice of system sales staff or consultants. In other functions, however, decisions are taken, increasingly, based on techniques which provide an optimal, objective decision, which guarantees that it can be justified to management. Thus, maintenance departments of companies should begin to use these techniques in decision-making. Among these techniques is Multiple Criteria Decision Analysis (MCDA) which, due to its versatility, ease of application in some cases and excellent results in different areas of application, could increase the role of maintenance in companies and help to achieve world-class competitiveness.

There are very many mathematical models techniques for optimization applied to maintenance (Wang, 2012), but most of them optimize a specific maintenance policy and have an important mathematical component which makes it impossible in practice to apply these models to industry. Nevertheless, the applicability of these models to solving real problems is a key question in maintenance (Scarf, 1997) and can be one of many reasons why there is low efficiency in maintenance in industry at the moment.

There exist, in the maintenance field, many literature reviews, such, for example Baker and Christer (1994), Christer (1999), Garg and Deshmukh (2006), Dhillon and Liu (2006), Kans (2009), Sharma, Yadava, and Deshmukh (2011), Simões, Gomes, and Yasin (2011), Wang (2012), and Prajapati, Bechtel, and Ganesan (2012).

There is however no article which analyzes the contributions made by applying MCDA to maintenance, unlike the large number of papers which review the literature in other fields. This chapter, therefore, sets out a review of the literature which brings together articles that apply MCDA techniques for decision-making in the choice of maintenance policy. The most commonly applied MCDA, trends in the number of contributions, the criteria applied, and possible gaps that could lead to interesting future work are suggested. Although the number of contributions is much lower than in other areas, the aim is to show those which do exist and to favour the practical application of MCDA in maintenance so as to guarantee the success of decisions in this field.

BACKGROUND

This chapter distinguishes between maintenance policy and maintenance strategy; the latter is considered as an integrated series of decisions taken in four structural and six infrastructure decision elements (Pintelon & Pinjala, 2006). Some authors, however, use the same term for both concepts.

The choice of maintenance policies has been little analysed in the literature despite its importance for companies (Bertolini & Bevilacqua, 2006; Wang, Chu, & Wu, 2007). Until very recently this decision was taken based on the experience of the maintenance staff. However, this is a complex decision as it combines technical requirements for each machine with the business strategy. Thus, it is a decision which requires a great deal of thought, as different quantitative and qualitative criteria must be considered, which justifies the use of MCDA techniques.

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Different types of maintenance policies can be defined:

- Corrective Maintenance (CM), carried out after a failure with the aim of returning the machine to a state in which it can perform its desired function (Kelly, 2006).
- Preventive Maintenance (PM), carried out at set intervals throughout the working life of the machine, with the aim of reducing the probability of problems or wear in the machine (Kelly, 2006).
- Condition Based Maintenance (CBM) or Predictive Maintenance (PDM). Is based on the control of physical parameters (vibrations, temperature, particle content of lubricant, etc.) of a working machine that can be registered, periodically or continuously, by a set of sensors, to detect an abnormal situation, allowing necessary maintenance activities to be carried out before any failure occurs (Bevilacqua & Braglia, 2000). Most of the literature on CBM considers the same maintenance policy as predictive maintenance (Mobley, 2002), and this is what is applied in this article; nevertheless, some research distinguishes between them.
- Opportunity-based Maintenance (OM), which involves using the stoppage of a system due to a fault in a component to carry out preventive maintenance in other components which are working normally (Pintelon & Gelders, 1992).
- Total Productive Maintenance (TPM) is defined by Nakajima (1988) as productive maintenance involving total participation in addition to maximizing equipment effectiveness and establishing a thorough system of planned preventive maintenance. Among these key points is to obtain the most efficient use of the machine, to involve the whole company in prevention of maintenance, preventive maintenance and improvement-related maintenance and to encourage the use of preventive maintenance based on small autonomous groups.
- Reliability Centered Maintenance (RCM). RCM is a systematic methodology for the allocation of efficient predictive and preventive maintenance aimed at preventing the dominant causes of failure of critical equipment, and, in turn, towards achieving acceptable levels of equipment availability and costs by reducing corrective maintenance (Martorell et al., 1999).

MAIN FOCUS

Table 1 gives a summary of the criteria used in the choice of a maintenance policy. A considerable amount of normalization has been necessary in the creation of the table, as in general each author gives a different name to the same concept. In many cases the criteria are not defined and only a list of criteria to be used is given. It has also been found that in many studies the criteria are duplicated, and, for example, customer complaints and customer satisfaction are considered as different criteria when they are in fact dependent. Some contributions include an analysis of the causes of failures in the analysis, although this criterion is not found explicitly in the multicriteria model; nevertheless, it has been incorporated as a criterion in Table 1.

It can be seen from Table 1 that interest in the choice of best maintenance policy is a very recent concern, as there are no papers from before 1998. It can also be seen that there is an exponential tendency in respect of the number of studies into the question.

There is great variety among the criteria used, although the spare part cost or minimizing inventories is the most frequent, followed by investment cost, reliability or Mean Time Between Failures (MTBF), maintenance cost, training cost, safety of personnel, maintainability or Mean Time To Repair (MTTR), product quality, and safety of equipment and facilities. A normalized procedure