Modeling risk based maintenance using fuzzy analytic network process

Goldy Kumar, J. Maiti

Department of Industrial Engineering and Management, Indian Institute of Technology, Kharagpur, West Bengal 721 302, India

1. Introduction

In recent years, risk of accidents and injuries at the workplace has become a very important criterion for production planning and control, albeit its importance was understood even at the early days of production. Many factors contribute to the occurrence of an accident and careful decisions are to be made to avoid an accident. The maintenance policies practiced is one of the very important policies. An effective maintenance policy can help reduce the risk of accidents to a great extend. So it is very important to consider risk of accident as one of the criterion for selecting the maintenance policy to be employed. The selection of the type of maintenance depends on the equipment as well as the available maintenance facilities and capabilities. Several kind of maintenance strategies have been devised both at the system level and at the component level. In case of complex systems, groups of components with similar operating conditions may be found and treated uniformly during maintenance (e.g., group preventive maintenance policies). Furthermore, at a component level, assumptions are made regarding the effectiveness of maintenance in restoring the component to a good condition (Tan, 1995; Vassiliadis & Pistikopoulos, 2000). As-Good-As-New (AGAN) policies assume, for example, to restore the component to the original condition as was at the beginning of the operation, while As-Good-As-Old (AGAO) policies bring it back to where it was immediately before the failure occurs or the maintenance task started. The analysis and justification of maintenance strategy selection is a critical and complex task due to great number of factors to be considered, many of which are intangible. The method of selecting maintenance policies normally depends on cost of maintenance policies along with other criteria such as added product quality, spare parts availability, and maintenance time (Bevilacqua & Braglia, 2000). The maintenance strategies adopted in industries can be broadly classified and based on the failure distribution of the equipment. It is therefore known as Corrective Maintenance (henceforth, CM), preventive maintenance (henceforth, PM), Shutdown Maintenance (henceforth, SM) and opportunistic maintenance (henceforth, OM). PM can be further classified as Time Based Maintenance (henceforth, TBM) and Condition Based Maintenance (henceforth, CBM).

CM starts once equipment fails. It is, therefore, also known as breakdown maintenance. It is costly for critical equipment and therefore usually is employed for non-critical and sometimes for independent equipment. PM does not wait for an equipment to fail. It usually is based either on failure history of the equipment or the condition of the equipment. In case of the former, maintenance actions start at periodic intervals and the period is estimated based on the failure distribution of the equipment. It is therefore known as TBM. In case of the later, the condition of the equipment is monitored and the maintenance actions start when the condition of the equipment calls for it. It is therefore known as CBM.

TBM is effective in many capital intensive processes but in some cases the rate of deterioration depends on various other factors like operational and environmental conditions in addition to the amount of time elapsed. As a result the extent of operational period may not be adequate to diagnose the product condition for
2. Literature review

2.1. Maintenance selection as a complex multi criteria decision problem

In recent years, multi criteria decision making approach has been gained momentum in the field of maintenance strategy selection. Bertolini and Bevilacqua (2006), Bevilacqua & Braglia (2000), de Almedia & Bohoris (1995), Triantaphyllou, Kovalerchuk, Mann, & Knapp (1997) suggested the use of AHP for maintenance strategy selection considering cost, reparability, reliability, and availability. Bevilacqua and Braglia (2000) also used AHP for selecting the maintenance strategy for an Italian oil refinery based on four important criteria namely cost, damages, applicability, and added value. Bertolini and Bevilacqua (2006) presented a combined analytic hierarchy process and lexicographic goal programming approach to select the best maintenance policies for the maintenance of critical centrifugal pumps in an oil refinery, taking into account budget and maintenance time as constraints. The criteria considered by Bertolini and Bevilacqua (2006) are failure occurrence, its severity and detectability. Recently considering the importance of risk of equipment failure, Arunraj and Maiti (2010) devised a methodology for maintenance policy selection in chemical industry taking risk and cost as the criteria. They utilized AHP and Goal Programming method to arrive at the result. The AHP results show that considering risk as a criterion, Condition Based Maintenance (CBM) is a preferred policy over Time-Based Maintenance (TBM) as CBM has better risk reduction capability than TBM. Similarly, considering cost as a criterion, Corrective Maintenance (CM) is preferred. However, considering both risk and cost as multiple criteria, the AHP–GP results show that CBM is preferred.

2.2. Analytic Network Process

In Analytic Hierarchy Process (Saaty, 1994), the problem of maintenance policy selection is modeled in a form of the hierarchy. So, the components of AHP namely, goal, criteria and alternatives are connected top to bottom. Thus the problem of decision-making can be modeled in a linear top-to-bottom form as a hierarchy. The upper level node in the hierarchy does not depend on the lower levels and the elements present in a node (at the same level in a hierarchy) are also independent of each other.

This one sided network fails to capture the complex interactions and feedbacks which might be present in the system. To get rid of this limitation, the present problem is modeled using Saaty's Analytic Network Programming (ANP) (Saaty, 1996). This is a generalization of previously used AHP where the goal, criteria and alternatives are connected top to bottom. The ANP model is based on the premise that the problem of the decision-making can be modeled in a linear top-to-bottom form as a hierarchy. The upper level node in the hierarchy does not depend on the lower levels and the elements present in a node (at the same level in a hierarchy) are also independent of each other.

Analytic network process has been used in solving many complicated decision-making problems because it is a comprehensive multi-purpose decision making method. There are many studies and applications on ANP. Wua and Lee (2007) developed a method based on the ANP to help companies that need to select knowledge management strategies. Patrovi (2001) quantified strategic service vision using analytic model and Partovi (2006) studied strategic service vision the facility location problem which incorporates both external and internal criteria in the decision-making process. Chung, Lee, & Pearn (2005a) dealt with an application for the selection of product mix for efficient manufacturing in a semiconductor fabricator. In addition to these studies, other studies where ANP was used are: Yurdakul (2003) evaluated long-term performances of production systems; Meade and Presley (2002) evaluated alternative research-development projects; and Mikhailov and Singh (2003) studied the development process of a decision support system.

2.3. Uncertainty in decision making

In both AHP and ANP, there is a need of the integration of the mathematical model to human experiences. In order to prioritize
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات

ISI Articles
مرجع مقالات تخصصی ایران