Chapter 14

Predicting Uncertain Behavior and Performance Analysis of the Pulping System in a Paper Industry using PSO and Fuzzy Methodology

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ABSTRACT

The main objective of the present study is to permit the reliability analyst or system manager to analyze the failure behavior of the system in a more consistent and logical manner. As the collected or available data from various resources are uncertain and imprecise due to various practical constraints and hence the performance of the system cannot be made up to desired levels. To cope with such situations and subjective information in a consistent and logical manner, fuzzy methodology is one of the most vital and effective tool. To this effect a structural framework has been developed by the authors for analyzing and predicting the system behavior. The pulping unit of paper industry has been taken as an illustration. The failure rates and repair times for all the constituent components are obtained by solving availability-cost optimization model using particle swarm optimization and genetic algorithm. To increase the performance of the system, various reliability parameters are computed with the obtained results using a confidence interval based fuzzy lambda-tau methodology. Sensitivity as well as performance analysis of the system performance has been done for ranking the critical component of the system as per preferential order. The computed results are compared with existing fuzzy lambda-tau and traditional (crisp) methodology results.

1. INTRODUCTION

Due to continuous advancement in technology, industrial systems are becoming complex and expensive to operate and maintain. In the modern day electronic, manufacturing and industrial systems, reliability and safety analysis and assessment of complex systems is becoming more and more difficult task due to the fact that the reliability and safety of manufacturing systems depend not only on all failed states of system components, but also on the sequence of occurrences of those failures (Birolini, 2007). However, failure is an unavoidable phenomenon associated with the technological advancement of the equipments used in all industries. Any unfortunate consequences of unreliable behavior of such equipments or systems have led to the desire for reliability analysis. Therefore. In recent years system reliability becomes an important issue in evaluating the performance of an engineering system by eliminating or reducing the likelihood of failures and thus increasing their desired life and operational availability.

To maintain the reliability of sophisticated systems to a higher level, the systems' optimum structural design or highly reliable components of these systems are required, rather both of them may be sought simultaneously. Implementation of these methods to improve the system availability or reliability will normally consume resources such as cost, weight, volume etc. So the system reliability cannot be further improved effectively by considering these constraints. Replacement of lesser reliable components with highly reliable components can improve the system reliability but the cost constraints may violate. While improving the reliability of systems and their components, the associated cost also increases. Increasing attention needs to be given to reduce the cost during production, operation and maintenance of the systems. These objectives can be achieved with the reliability based design of the systems and optimization of the maintenance and operational activities in the industrial systems to ensure their

full utilization. Thus. In the present scenario of global competition and faster delivery times, it is an important topic for decision-makers to fully consider the actual business and the quality requirement together. This is the reason why there is a growing interest in implementation and investigation of reliability principles for industrial systems.

1.1. Reliability/Availability of a Series-Parallel System

Series-parallel system indicates that sub-systems in which several components are connected in parallel, and then in a series, or subsystems that several components are connected in series, and then in parallel. The reliability or availability of a series-parallel system has drawn continuous attention in both problem characteristics and solution methodologies. Under a repairable series-parallel system framework, availability is one of the most important measures than reliability for measuring the effectiveness of maintaining systems, because it includes reliability as well as maintainability. Availability comprises reliability and recovery part of unreliability after repair, indicating the probability that repairable systems or components maintain the function at a specific moment. Generally, system availability can be improved either by incremental improvements of component availability or by provision of redundant components in parallel, both methods result in an increase in system cost. Therefore, optimization methods are necessary to obtain allowable costs at the same time as high availability levels. Extensive research efforts have addressed the development of efficient algorithms for the determination of optimal inspection and maintenance strategies which includes a gradient search method, dynamic programming, integer programming etc. Comprehensive overviews of these models have been addressed by the researchers in their review articles (Kuo et al., 2001; Gen & Yun, 2006). Traditionally, analytical and Monte Carlo methods have been used for

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