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Short communication

Performance modeling in critical engineering systems using RAM analysis

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Abstract

Reliability, availability and maintainability (RAM) analysis of system is helpful in carrying out design modifications, if any, required to achieve minimum failures or to increase mean time between failures (MTBF) and thus to plan maintainability requirements, optimize reliability and maximize equipment availability. To this effect, the paper presents the application of RAM analysis in a process industry. Markovian approach is used to model the system behavior. For carrying out analysis, transition diagrams for various subsystems are drawn and differential equations associated with them are formulated. After obtaining the steady state solution the corresponding values of reliability and maintainability are estimated at different mission times. The computed results are presented to plant personnel for their active consideration. The results proved helpful to them for analyzing the system behavior and thereby to improve the system performance considerably by adopting and practicing suitable maintenance policies/strategies.

Keywords: System; Reliability; Availability; Maintainability; Markov models

1. Introduction

To remain competitive and to provide timely and accurate services the companies are viewing reliability and maintainability issues as a part of corporate quest to improve quality of the products/processes and services delivered. A company cannot adopt a rapid response strategy if its systems are unavailable and unreliable. Therefore, the management of many companies such as Procter and Gamble, Dupont, Ford and Eastman chemicals has looked towards adopting effective maintenance management practices [1,2]. Various innovative techniques such as Total productive maintenance (TPM), Total quality management (TQM), Business process reengineering (BPR), Material requisite planning (MRP), Just in time (JIT) etc. are being used as drivers by the business houses to promote their products and processes [3–6]. But there is no doubt that the success of these innovative programs mainly depends upon the reliable operation of production systems. A company cannot achieve success if its systems are unavailable and unreliable. Increasingly, companies are viewing reliability and maintainability issues as part of the corporate quest to improve quality by imbibing lean manufacturing, JIT, six-sigma mantras to achieve customer satisfaction and remain competitive [4]. The management is highly concerned with reliable operation of production systems. To this effect the knowledge of behavior of system, their component(s) is customary in order to plan and adapt suitable maintenance strategies. These challenges imply that a new and pragmatic approach towards reliability, availability and maintainability (RAM) of production systems in unison must be adopted because organizational performance and survivability hinges a lot on reliability and maintainability of its components/parts and system(s) as a whole. Among various tools of technology for performance modeling (Root Cause Analysis, RCA; Failure Mode and Effect Analysis, FMEA; RAM; Quality Control Tools), RAM an engineering tool evaluates the equipment performance at different stages in design process. It addresses both operation and safety issues and aims to identify areas with in the system or process where improvement actions can be initiated. With RAM analysis of the system key performance metrics such

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as Mean Time to Failure (MTTF), Equipment down Time (EDT) and System Availability values (A_{sys}) can be ascertained. The information obtained from analysis helps the management in assessment of the RAM needs of system.

For the last four decades reliability analysis has been established as a useful tool for risk analysis, production availability studies and design of systems [7–12,16]. Reliability techniques have been applied in three main areas in process industry: (i) production availability studies in conceptual design (RAM analyses), (ii) safety (risk analysis) and (iii) maintenance (criticality analysis, life cycle cost) [7]. Much effort has been made to compile and analyze reliability data for generic use. For instance, Cochran et al. [8] presented a practical case study of reactor regenerator system in Fluid Catalytic Cracking Unit of a petroleum refinery using generic Markov models to estimate system availability. Dai and Jia [9] collected failure data of vertical machining center, analyzed it and based on the analysis provided ways to improve the reliability of machining center. Hauptmanns [10] in his work on process plant safety developed a system called Semi-Quantitative Fault Tree Analysis (SQUAFTA) characterized by different probability or frequency ranges. The developed system provides characterization of the expected frequency of an undesired event in the analyzed plant in terms of one of the following qualifiers: "highly probable", "probable", "possible", "improbable" or "highly improbable". Liberopoulos and Tsarouhas [11] presented a statistical analysis of failure data of an automated pizza production line. The analysis includes identification of failures, computation of statistics of the failure data, and parameters of the theoretical distributions that best fit the data, and investigation of the existence of autocorrelations and cross correlations in the failure data. The analysis is meant to guide food product machinery manufacturers to improve the design and operation of the production lines. Schoenig et al. [12] presented an aggregation method using Markov graphs for the reliability analysis of hybrid systems. The method allows the designers to have an exact representation and better overview of the system states.

As evident from the above studies, much effort has been made to develop system models to solve the problems of reliability. Owing to their complexity, the production systems are generally vulnerable to various kinds of disturbances, the nature (hydraulic, pneumatic, electronic and electrical), the number of failures and the time required to locate them. These failures not only add to downtime but also incur additional operation and maintenance costs. Quickly finding out the cause(s) of failure(s) and taking appropriate remedial actions is very important. In this respect the paper attempts to provide a case-based approach to conduct RAM analysis of a system based on Markov modeling to obtain RAM indices for measuring the system performance so that a company wide maintenance planning system could be made for effective maintenance and operation of system. The proposed method may help the reliability analysts/engineers/practitioners not only to carry out design modifications, if any, required to achieve minimum failures but also offers added benefits such as to conduct cost-benefit analysis, operational capability studies, inventory and spare parts management, repair and replacement decisions and to establish maintenance programs. Fig. 1 shows the role of

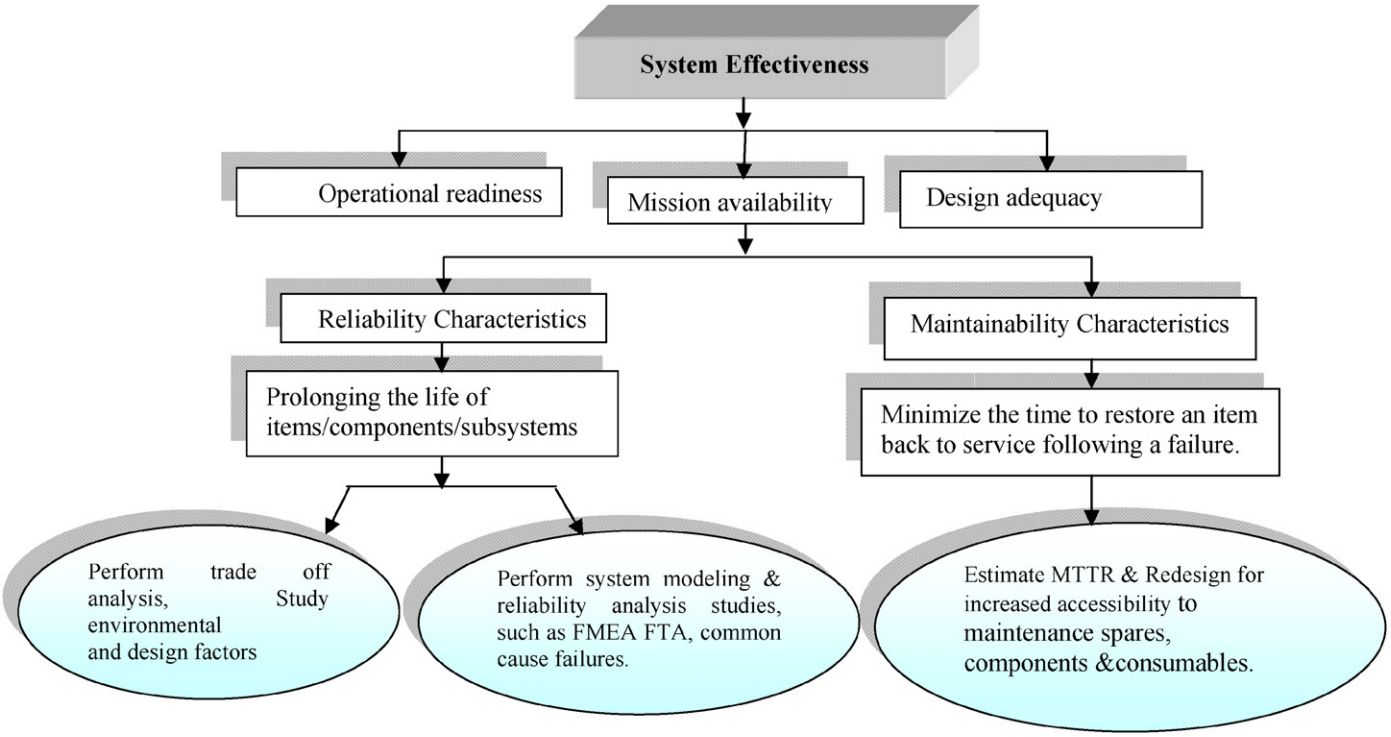

Fig. 1. Framework for improving system effectiveness.