Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 189 (2015) 303 – 313

Procedia
Social and Behavioral Sciences

XVIII Annual International Conference of the Society of Operations Management (SOM-14)

Evaluation of Maintainability Index of a Mechanical System using Graph Theoretic Approach

Rajesh Kr Singh*, Pravin Kumar, Blesson Joseph, Himanshu Sharma

Mechanical and Production Engg. Department, Delhi Technological University, Bawana Road, Delhi 110042

Abstract

In globalised economy, all mechanical systems need to be highly productive and efficient. Lead time reduction and defect reduction is big challenge for production managers in shop floor. Effective maintenance plays very crucial role in improving productivity of any production system. Therefore analysis of maintainability of a system is crucial. Maintainability is the design attribute of a mechanical system, which facilitates the various related maintenance activities and plays a significant role during the working period of any mechanical system. In this study, compressor is considered as mechanical system. Graph Theory Approach is suggested for the evaluation of the Maintainability Index of this system. Maintainability of a mechanical system is modelled in terms of the Maintainability Attributed Digraph, wherein the maintainability attributes are identified as the features or characteristics which determine and indicate the ease in the maintenance of a system. Nodes of the digraph represent the system maintainability attributes while their inter-relation is represented by the edges. This digraph is translated into a one-to-one matrix known as the Maintainability Permanent Matrix (MPM) and based on this matrix; the Variable Permanent Function for Maintainability (VPFM) is proposed, which is characteristic of the Mechanical system. Logical Ranking and numerical values are assigned to these attributes. After substituting these values in the MPM or the VPFM; Maintainability Index of the mechanical system is evaluated. Higher the value of the Index indicates higher the maintainability of the mechanical system. This procedure can be employed at the design stage of a product for the development of maintainable systems. This will also help in benchmarking the performance of a mechanical system with the best in industry.

Keywords: Maintainability index; Diagraph, Productivity; Mechanical system

* Corresponding author.
E-mail address: rksdce@yahoo.com

doi:10.1016/j.sbspro.2015.03.226

1. Introduction

In present context of globalization all mechanical systems are required to be highly efficient and cost effective. It can be only achieved by improving maintainability of the system. Maintainability is defined as probability that a failed component or system will be restored to a specified condition within a specified time, when maintenance is performed in accordance with prescribed procedures. It is the ease with which a product can be maintained in order to isolate defects or their cause. In some situations, maintainability involves a system of continuous improvement - learning from the past in order to improve the ability to maintain systems, or improve reliability of systems based on maintenance experience. Maintainability determines the ease with which various maintenance activities can be carried out such as inspection, repair, replacement and diagnosis. Thus, it is an important aspect of the life-cycle design of a mechanical component and plays a pivotal role during the service period of the product. Better maintainability of a mechanical component would imply that the downtime of the equipment is low, therefore productivity will be high. It also means that the time to carry out the preventive maintenance is low as well as the time taken in fault analysis, i.e. inspection, repair or replacement (depending upon which ever is applicable) and subsequent operations are low.

Maintainability has attained great significance since the advent of serious substitute components which compete for their share in the market. Hence, high maintainability is desired to maximize the availability of the equipment for productive utilization and the economic life-span of the component. This would also mean minimizing the production loss or efficient working of the component due to breakdowns. Historically, maintainability was thought of as a corrective maintenance tool which had its significance only when there was a breakdown and the component was required to be restored to the original condition. Quantifiable measures of such a maintainability is calculated in terms of Mean Time To Repair (MTTR), Mean Time Between Maintenance (MTBM), mean system downtime, Mean Time To Restore, maintenance work hours per operating hours or maximum time in which a certain percentage of failures must be repaired. One major flaw with this concept of maintainability is that is reliant on prototype demonstration and pre-existing history of the component, in the absence of which, suitable quantitative index cannot be evaluated, and also, it renders it futile for implementation on new designs. Also, methods that involve MTTR are generally based on labor cost or cost incurred during downtime. The flaw with this is that its significance on design level is nil as no interpretation can be made and thus any improvement in the design cannot be thought of based on the minimum required maintainability of a component or its expected maintainability.

The process of harnessing the benefits of defining maintainability at the design stage of a mechanical component has to start with defining the maintainability goals and concepts. Based on these, maintainability is allocated to each component of a system which determines what design methods need to be implemented. Various secondary factors need to also be considered such as personnel including ergonomics, training for the crew, safety requirements, et cetera. Based on these, a prototype may be developed to carry out maintenance and analysis, or simply prediction and assessment can be done. If all the goals defined prior to design are met, the design is completed and implemented.

2. Literature Review

GTA approach has been developed over time and has been employed for various decion making processes. Gandhi and Agrawal (1996) have applied Graph theory as a logical and system approach in which they used the graph theory and the matrix approach as a decision-making method in the manufacturing environment. Sabharwal and Garg (2013) determined the cost effectiveness index of remanufacturing by a graph theoretic approach. This study has illustrated haw to make a decision by a firm for remanufacturing its used and discarded products, based on its economic viability. Different parameters are selected and their significance is shown for the decision and then the several qualitative and quantitative parameters have been enlisted, based on which the digraph is established and the maximum and minimum values of cost effectiveness index are calculated. Kulkarni (2005) used this approach for evaluating the Total Quality Management (TQM) of a firm based on which ranks can be developed and comparative studies can be made about the performance of a firm regarding its quality management. A study based on a digraph theoretic method is also done by Wani and Gandhi (1998) for evaluation of maintainability index of mechanical