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Reliability evaluation and Risk based maintenance in a process plant

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Abstract

An effective operation of process plant depends on the maintenance practices followed and its operating reliability. In process plants having increasing demand for its product, the effective operation is very important. This must be met by increasing its production. Prior to an increase in production, reliability evaluation and maintenance planning are unavoidable. Ultimate aim is to increase the performance of the machineries without compromising safety or environmental issues. Maintenance strategies of the plant affect the performance of the machineries and hence affects production. Allocating more maintenance resources for the components having high risk of failure will improve the total availability of the system. Thus it is considered as the first step to improve reliability of components. Calculating availability of the plant will give a good measure of reliability of the components in the system. Assessment of the risk of failure is equally important as reliability evaluation and plays an important role in improving plant availability. This work discusses the importance of evaluating reliability and risk of failure in planning a maintenance schedule and thereby improving availability of the plant. A model for improving plant availability has been proposed. By applying this model, an optimum maintenance schedule for the process plant can be formed. Improvement in availability of plant after employing the optimum schedule was calculated. A case study of a cement plant has been used to demonstrate the methodology. Results indicate that the methodology is successful in identifying the critical equipments and improving the availability of the system.

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Keywords: Reliability, Availability, Risk based maintenance, Fault tree analysis, Risk priority number, Downtime, Ropeways.

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1. Introduction

In today's competitive environment, companies are under intense pressure to sell their products in the market. Process plants having high demand for its product may have to run for more time. Without planning a preventive maintenance schedule, failures can happen in the process systems at any level. Downtime happens only when there is a replacement or repair for worn-out parts. The time for which the components work successfully between its replacements is defined as its life. Reliability, describes the ability of a system or component to function under specified conditions for a specified period of time. It is theoretically defined as the probability of failure, the frequency of failures, or in terms of availability. The use of less reliable components and the lack of perfect maintenance schedule are main concerns and will lead to plant failure eventually. Unexpected failures usually have adverse effects on the environment and may result in major accidents. Various studies have been done in this field by Khan [1] and Haijun Hu [2], shown the close relationship between maintenance practices and the occurrence of failures of the system. The main challenge is to implement a maintenance strategy which maximizes availability and efficiency of the equipment/system, decrease the rate of deterioration of the components, ensures safety and environmental friendly operation, and reduces the total cost of the operation. This can be achieved only by adopting a structured approach to the study of component failure and the execution of an optimum strategy for inspection and maintenance [1].

This paper discuss the importance of evaluating reliability and risk of failure in maintenance planning and thereby improving availability of the plant. A model for maintenance planning is proposed. A case study of a cement plant is used to demonstrate the methodology. Improvement in availability of the plant after employing the proposed risk based maintenance schedule is demonstrated.

2. Proposed model

2.1. Description of the model

One of the main objectives of Risk based maintenance (RBM) is to minimize failures of the components without affecting the environment. This approach uses information obtained from the study of failures and their consequences. Risk analysis is a technique for identifying, characterizing, quantifying, and evaluating the loss due to an event. Risk analysis approach integrates probability of failure and consequence analysis. It aims to improve maintenance planning and decision making by reducing the probability and consequences of failure of equipment. This is done so that the maintenance effort is optimized to minimize the total risk of failure [1]. The proposed model to improve the availability of the system is shown in Figure 1.

For implementing RBM, the system will be divided in to subsystems. Availability of subsystems will be calculated using fault tree analysis (FTA). The modes of failure of each component in the sub system is studied and its effect on the whole system is identified. Next step is to find the critical components. For that, a method called risk priority number (RPN) is used. In risk evaluation step, the estimated risk is compared with an acceptable risk criteria. We identify a specific risk acceptance criteria to be used in a situation depending on the nature and type of the system. Different acceptance risk criteria are available in the literature [2] [3] [4] [5]. In the present study an RPN value is taken as acceptable risk if this value of risk for a component is negligibly affecting the downtime of the whole system. Finally, the estimated values of risk are compared to the acceptable criteria. Thus the subcomponents which exceeds the acceptable criteria are classified as critical components. The study is then focused on the methods to minimize the consequences of these critical components. Thus an optimum maintenance schedule is to be estimated so as to decrease the downtime. The Availability of the system is recalculated after employing the risk based maintenance. This method will decrease the probability of failure of sub components as well.

2.2. Fault tree analysis

Fault tree analysis is a deductive analysis in which the causes of an events are deduced [6]. It gives an illustration of how equipment failure, human error and external factors have contributed towards a failure or event. It uses logical gates and small events to present the path of failures through different steps and hence a fault tree is constructed for the particular event. Root causes for the top event can be found out from various intermediate events [7].