SIMULATION IN RELIABILITY FIELD USING “COMPONENT IMPORTANCE” INDICATOR - AN APPLICATION IN CHEMICAL INDUSTRY

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ABSTRACT

This work uses the concept of “component importance” in the field of reliability to measure and simulate. The simulation of system of components or equipment allows to analyze and optimize the maintenance work. The aim of this work is to obtain the best inspection intervals and to optimize the cost of maintenance. This approach intends to contribute to change the classical reliability analysis performed in industrial companies. New models of reliability with simulation can be adopted and in this work the linear models of consecutive $k$-out-of-$n$ is used. Finally, the modeling and simulation is applied in chemical industry and more particularly in oil centrifugal pumps.

1 INTRODUCTION

The major challenge for a maintenance engineer is to implement a maintenance strategy, which maximizes the availability and efficiency of the equipment and controls the rate of equipment deterioration. A good maintenance strategy ensures safe operation, and minimizes the total cost of the operation. This can only be achieved by adopting a structured approach to the study of equipment failure.

The data analysis, from exhaustive fieldwork, will allow us to extract data that serves to illustrate and exemplify our methodology. It should be noted that the systems were considered in the adult phase of life and, consequently, with a constant average failure rate.

The study analyzes the data and applies it in the three models simulated and classifies the components by degrees of importance for three types of intervals: semester, semi-annually and annually. The scenarios are compared, the results criticized and finally, various conclusions are reached.

2 IMPORTANCE COMPONENTS MEASURE AND CONSECUTIVE $k$-OUT-OF-$n$ SYSTEMS

In a system some components are more important for the system reliability than other components.

The objective of the “component importance measure” is to help to allocate inspection and maintenance resources to the most important components or improve better preventive maintenance tasks. Birnbaum (1969) proposed the following measure of the reliability importance of a component $i$ at time $t$ can thus be written as:

$$I^B(i|t) = h(1_i, p(t)) - h(0_i, p(t))$$

This is to say that $I^B(i|t)$ is equal to the probability that $(1_i, X(t))$ is a critical path vector for component $i$ at time $t$. The other criteria to measure the component importance used are Improvement potential IP ($i|t$), Risk Achievement Worth $IRAW(i|t)$, Risk Reduction Worth $IRRW(i|t)$ and Criticality Importance $ICR(i|t)$. The explanation of each criteria and mathematical formulation can be seen in literature, as seen in Rausand (2004).

Consecutive $k$-out-of-$n$ systems can be categorized into Consecutive $k$-out-of-$n$:G and Consecutive $k$-
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out-of-n:F systems. A Consecutive $k$-out-of-$n$:G system is an $n$ component system that functions whenever at least $k$ consecutive components are functioning. A consecutive $k$-out-of-$n$:F is an $n$ component system that fails whenever at least $k$ consecutive component are failed.

The consecutive $k$-out-of-$n$:F system was introduced by Kontoleon (1980), Chiang and Niu (1981) and explain the relevance of such a system to telecommunication and oil pipeline systems.

3 SIMULATION STUDY

The centrifugal pump is one of the most used electro-mechanical machines in the petrochemical industry. There are many ways of describing, classifying and systematizing a centrifugal pump in the literature; this depends on the type of pump, its application, type of industry, liquid, etc. The classification adapted was from Silva (2016), which simplifies and defines the pump in the following scheme:

![Figure 1: RBD structure diagram of centrifugal pump.](image)

The simulation developed three scenarios: the first scenario is the simple case of a series system 5-out-of-5. In the second and third scenarios, the faults are provided in consecutive blocks and, therefore, we can simplify and consider the case where the system have two consecutive faults (2-out-of-5:F) or, at least two components working (2-out-of-5:G).

To compute a simulation of “importance components” an algorithm using the R software was developed and used the Weibull distribution to all components.

4 RESULTS AND CONCLUSIONS

The case study also developed the “component importance” indicator, for different time horizons: quarterly, semi-annual and annual. Four criteria have been chosen, which have provided very interesting results. The action and use of this information depends on the organization and its planning and definition of the maintenance policy and strategy. The components that are most important need, of course, more preventive maintenance, inspection routines, etc.

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Table 1: Component importance Simulation system 5-out-of-5.

In this case, for the three proposed scenarios, there are differences in the criteria, which can also help us to better understand which components are really important or not. In all the scenarios, components $C_4$ and $C_5$ appear the most important, although their importance is different from scenario to scenario and time horizon.

REFERENCES


