Proceedings of the 2019 Winter Simulation Conference
N. Mustafee, K.-H.G. Bae, S. Lazarova-Molnar, M. Rabe, C. Szabo, P. Haas, and Y.-J. Son, eds.

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

Daniel Gaspar

Department of Mechanical Engineering
Institute Polytechnic of Viseu, ESTGV
Campus Politécnico, Repeses
Viseu, 3500-010, Portugal

Luis Andrade Ferreira

Department of Mechanical Engineering
University of Oporto, FEUP
Rua Dr. Roberto Frias, s/n
Porto, 4200-465 Portugal

ABSTRACT

This work use the concept of "component importance" in the field of reliability to measure and simulation. The simulation of system of components or equipment allow to analyse and optimize the maintenance work. The aim of this work is to obtain the best inspection intervals and to optimize cost of maintenance. This approach intend to contribute to change the classical reliability analysis performed in industrial companies. New models of reliability with simulation can be adopt 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 analyses 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 meas*ure" 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 see in literature, as see in Rausand (2004).

Consecutive *k-out-of-n* systems can be categorized into Consecutive *k-out-of-n:G* and Consecutive *k-*

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:

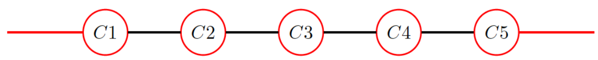

Figure 1: RBD structure diagram of centrifugal pump.

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.

	Import.Birbaum					**Improvement Potential**					**Risk Reduction Worth**					**Criticality Import.**				
Time	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
T	0.001	0	0.001	0	0	0.001	0	0.001	0	0	1.001	1	1.001	1	1	0.001	0	0.001	0	0
S	0.009	0.003	0.008	0.002	0.002	0.009	0.003	0.008	0.002	0.002	1.009	1.003	1.008	1.002	1.002	0.008	0.003	0.007	0.001	0.001
A	0.062	0.023	0.055	0.014	0.014	0.061	0.023	0.055	0.014	0.014	1.066	1.024	1.059	1.014	1.014	0.051	0.019	0.046	0.012	0.011

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 ***C4*** and ***C5*** appear the most important, although their importance is different from scenario to scenario and time horizon.

REFERENCES

Chiang, D. T. and Niu, S. C. 1981. "Reliability of Consecutive k-out-of-n: F System". IEEE Transactions on Reliability, 30(1):87–89. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.

Kontoleon, J. 1980. "Reliability Determination of a Successive r-out-of-n: F System". IEEE Transactions on Reliability, 29(5):437–437. Piscataway, New Jersey: Institute of Electrical and Electronics Engineers, Inc.

Rausand, M. and Høyland, A. 2004. "System Reliability Theory: Models, Statistical Methods, and Applications". Wiley Series in Probability. Hoboken, New Jersey: Wiley, Inc.

Silva, J. L. H. 2016. "Análise de Falhas em Elementos Mecânicos: Aplicação de Métodos Fiabilísticos". PhD thesis, FEUP. Oporto: Universidade do Porto.