Centrifugal Compressor Maintenance Using Fault Tree and a Bayesian Network Methods for System Reliability Analysis and Dependability

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***Abstract*— The centrifugal compressors (CC) are considered the main pillars of power production units, as their damage leads to the shutdown of the entire unit, which causes great material losses as decrease in production, an increase in maintenance expenses, and others. Therefore, good monitoring and continuous maintenance of the centrifugal compressors may increase the reliability of the system and the continuity of its work permanently, however, this does not make it free from defects and risks that cause damage to some parts such as bearings, shaft, ...etc. Therefore, a thorough examination and diagnosis of compressor components helps a lot to protect them from various defects and increase their life cycle. In this paper, We studied two different cases of two compressors, one of which was subjected to vibrations and the other to high temperatures in the bearings at AL-MERK and BRN units in Algeria. where the unit was completely stopped to fix this defect, this made us think about how to know the main causes of this malfunction. Where we adopted in this paper a hybrid approach, which is a methodology that evaluates the reliability of the system by combining two methods, one traditional and the second based on artificial intelligence, The first is FTA to identify risks and find out the type of defects that cause the main failure, and Bayesian Network relies on artificial intelligence to know the extent of the impact of each event on the system (quantitative analysis), where this study helps in analyzing the system and predicting all the causes that would impede the continuity of the compressors work, Through pre-stored data collected by maintenance experts and monitoring workers, relying on a Bayesian network to identify the fragile components in the system and the most influential ones and calculate the extent of their impact on the system. Finally, by performing this analysis, we found that vibration is the main cause of compressor failure.**

Keywords*— centrifugal compressors component, Fault Tree, Bayesian Networks, diagnosis, maintenance, reliability, dependability

I. INTRODUCTION

The compressors are among the basic components in power units (Oil refineries and natural gas), as they are relied upon to pump natural gas from gas field (deposits) to petrochemical and chemical processing sites.

However, gas compressors are subject to various breakdowns and malfunctions that can affect their efficiency and safety (such as high vibration, overheating in the bearings). Therefore, it is important to rely on new systems to protect the internal parts of the compressor, maintain its safety and ensure its reliability. To help maintenance experts to accurately identify the most important causes that lead to compressor failure, in this paper we have presented an approach linking traditional and smart analysis methods represented in the Fault Tree (FTA) and Bayesian BN, where the first method helps us to identify possible failure patterns (in terms of qualitative) and knowledge of the factors contributing to system failure in a sequential manner from top to bottom (main, sub- and intermediate events) through a graphical representation of the error tree, while the second method (Bayesian network) works to predict the impact of each event on the system (in terms of quantity) based on the primary data obtained by fault tree and maintenance experts, which are better suited to modeling conditional probabilities of events in a probabilistic framework, BN can provide greater flexibility and accuracy, especially when dealing with large volumes of complex systems. By combining the two methods, we were able to obtain logical results that are close to reality, as they allowed us to discover the problems that the compressor encounters during its operation.

Most of the previous studies that dealt with compressor failure analysis either by traditional methods such as fault tree analysis [1] FTA, signal monitoring [2] , and root cause analysis for RCA [3]. Or by artificial intelligence analysis methods such as Bayesian Network [4, 5], neural networks [6, 7], These methods helped in conducting a simplified analysis of the systems, but they remain deficient in some advantages, such as knowing the quality and quantity of events related to failure. For these reasons, most of the studies at the present time have touched on merging the two methods in order to give them greater effectiveness in order to obtain realistic results, such as BN and FTA [8, 9].

To improve the efficiency of centrifugal compressors, we have integrated a fault tree (FT) with a Bayesian network (BN) to predict in advance the errors that lead to centrifugal compressor failures, and take preventive measures to mitigate them and maintain system integrity.

II. RESEARCH METHODOLOGY

One of the traditional or artificial intelligent analysis methods of risks such as a fault tree and bayesian network is often used to detect the causes of failure in various systems. these causes can lead to significant economic and human losses, Through previous studies, we observed that the combining between a traditional and artificial intelligent analysis methods, makes it easier for us to predict the risks that lead to system failures(in terms of qualitative and quantitative analysis) , also, allows us to reach the desirable results such as reducing maintenance expenses, safety works, etc., as well as helping to take preventive measures to maintain reliability.

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Abstract:

Oil and gas refining units are considered among the important establishments in the economy of countries, as they depend on them for the production and export of energy. These units base their work on rotating machines such as gas turbines (GT), gearboxes (GB) and centrifugal compressors (CC), the CC is considered the basic pillar of the unit, it is also the first responsible of the unit shutdown at times, as its damage leads to great economic losses