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PROJEKTI PREDIKTIVNOG ODRŽAVANJA U INDUSTRIJI NAFTE I GASA

PREDICTIVE MAINTENANCE PROJECTS IN THE OIL AND GAS INDUSTRY

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Kratak sadržaj – *U ovom radu identifikujemo tehnike koje se mogu koristiti za održavanje dostupnosti i pouzdanosti opreme na prihvatljivom nivou. Takođe, ćemo pružiti dokaze o povećanju pouzdanosti opreme primenom tehnika prediktivnog održavanja i redizajniranjem postojećih programa održavanja kako bi se obezbedilo postizanje kontinualnog poboljšanja u sektoru nafte i gasa Libije, specijalizovanom za preradu naftnih derivata.*

Ključne reči: *prediktivno održavanje, PdM, održavanje, praćenje stanja, Industrija 4.0, vibracije, pouzdanost.*

Abstract *–In this paper, we attempt to identify techniques that can be used to maintain equipment availability and reliability at an acceptable level and will also provide evidence of increasing equipment reliability by incorporating predictive maintenance techniques and redesigning existing maintenance programs to ensure continuous improvement is achieved in the oil and gas sector in Libya specialized in refining petroleum products.*

Keywords: *Predictive Maintenance, PdM, Maintenance, Condition Monitoring, Industry 4.0, vibration, reliability.*

1. INTRODUCTION

The subject of the research included defining the concept of maintenance in both its traditional and modern parts, and predictive maintenance techniques. Through the theoretical part, the focus was on the analysis of professional and scientific literature. In the practical part of the work, predictive maintenance has been applied to one of the important pieces of equipment in the continuity of the production process, the cooling water pump.

This paper aims to highlight the importance of performing the right maintenance at the right time by analyzing potential failures and failures and eliciting appropriate actions.

Maintenance plans currently in use at AOC are evaluated and compared with maintenance plans developed using literature, articles, case studies, and consultations with management personnel responsible for maintenance. Bearing in mind that properly maintained equipment leads to higher production rates of quality products, this study seeks to identify, introduce, and improve AOC's manufacturing-specific predictive and preventive maintenance to realize potential profitable benefits and maximize maintenance productivity in the economy [1].

NOTE:
This paper resulted from the master's thesis whose mentor was Prof Dr. Aleksandar Rikalović.

The paper consists of six main parts based on two main approaches used in the research, which are practical and theoretical research. The first to fourth parts define the theoretical framework for the general concept of maintenance, its characteristics, classifications, and methods of application in various industries, with a focus on the oil industries. In addition to recounting the development of the Fourth Industrial Revolution, 4IR, or Industry 4.0, resulting from the rapid change in technology, industries, societal patterns, and processes in the twenty-first century due to increased interconnectedness and intelligent automation [2].

The practical approach will focus on the important rotating equipment for the oil industry and its effects on productivity by monitoring the equipment using predictive maintenance and then giving a conclusion and recommendations that must be made to ensure the reliability of the equipment. This formed the basis for practical research in Parts 5 and 6.

2. INDUSTRY 4.0

Industry 4.0 is revolutionizing the way companies manufacture, improve and distribute their products. Manufacturers are integrating new technologies, including the Internet of Things (IoT), cloud computing and analytics, and AI and machine learning into their production facilities and throughout their operations.

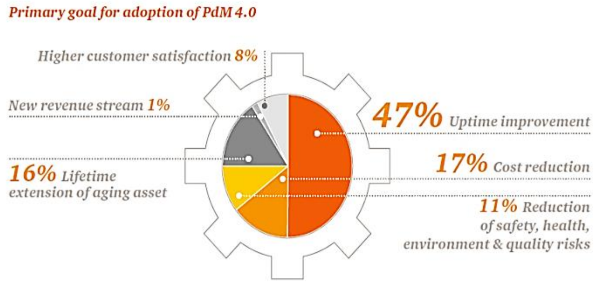
These smart factories are equipped with advanced sensors, embedded software, and robotics that collect and analyze data and allow for better decision-making. These digital technologies lead to increased automation, predictive maintenance, self-optimization of process improvements, and, above all, a new level of efficiency and responsiveness to customers not previously possible.

Developing smart factories provides an incredible opportunity for the manufacturing industry to enter the fourth industrial revolution. Analyzing the large amounts of big data collected from sensors on the factory floor ensures real-time visibility of manufacturing assets and can provide tools for performing predictive maintenance to minimize equipment downtime. Industry 4.0 concepts and technologies can be applied across all types of industrial companies, including discrete and process manufacturing, as well as oil and gas, mining, and other industrial segments.

- ***Most companies want to adopt PdM 4.0:***

almost one in three companies have ambitions to adopt PdM 4.0 in the coming years, it’s worthwhile taking a closer look at what drives companies to implement PdM 4.0.

Respondents expect PdM 4.0 to contribute to further improvements in all 'traditional' value drivers in maintenance and asset management. Uptime improvement is the most important in this regard, with almost half of the companies in our survey identifying it as their primary goal for implementing PdM 4.0 [3].



3. CONCEPT OF MAINTENANCE

The maintenance cost in many industries is higher than operational and production costs due to premature equipment failure. The profitability of any industry generally depends on the maintenance process. Normally maintenance in industries happens when the equipment reaches a certain age or stops working. It is good to do scheduled maintenance, but it doesn't provide any information about the equipment's health in the future. To optimize the production lines and equipment reliability, different types of maintenance can be performed based on the resource [4]. The most common types of industrial maintenance are Figure.

1. Predictive maintenance (PdM).
2. Preventive (scheduled) maintenance.
3. Reactive Maintenance (Breakdown Maintenance).
4. Reliability-Cantered Maintenance (RCM).

3.1. Predictive Maintenance (PDM).

In industrial applications, the term maintenance of the machine can be enhanced through equipment condition monitoring. While the condition of the machine is known at all times, the unexpected process halts due to the machine's failures can be avoided, therefore, the efficiency of the production process will increase significantly.

Moreover, it is possible to plan for maintenance way before the machines fail. There are several condition monitoring methods available. Vibration analysis, lubricant analysis, infrared thermography, electrical monitoring, and acoustic emissions are the most common monitoring techniques available [5].

The most effective condition-monitoring approach would be when two or more of the mentioned techniques are integrated and used together. Predictive maintenance compares the trend of measured physical parameters Against known engineering limits to detect Analyzing and correct Problems before failure occurs.

DATE	Motor NDE			Motor DE			Pump DE			Pump NDE		
	A	H	V	A	H	V	A	H	V	A	H	V
08.12.20	1.80	5.79	4.32	1.16	4.65	1.26	6.44	4.04	5.62	3.64	3.67	4.47
26.02.21	1.38	6.33	4.74	1.16	6.03	1.70	6.89	5.92	5.15	4.06	5.30	4.64

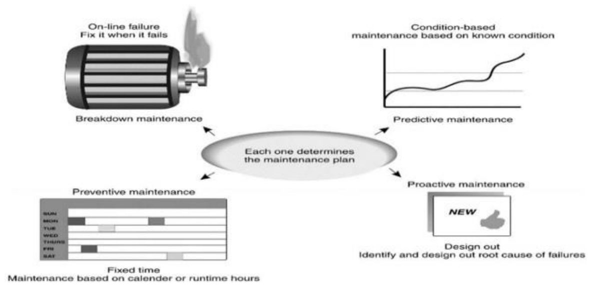
3.2. Preventive maintenance (PM)

Preventive maintenance (PM) is the periodic result of planned interventions or actions that aims to reduce the probability of breakdown that is a cause of loss of production [1]. For preventive maintenance to apply, knowledge of the operation, process, equipment or machinery needs to be in place. PM is time-based and can be a legal requirement governed by regulations and standards for equipment and machinery that if not maintained, can have adverse health effects or injure individuals at work (OHSA, 85 of 1993). Employers remain legally responsible to ensure the safety of employees throughout the life cycle of machinery and equipment at the workplace and need to manage the risk associated with their use. PM is a traditional policy that is utilized throughout the manufacturing process and has been applied to individual components (Liu, 2014).

3.3. Reliability-Cantered Maintenance (RCM)

Reliability-Centered Maintenance integrates Preventive Maintenance (PM), Predictive Testing and Inspection (PT&I), Repair (also called reactive maintenance), and Proactive Maintenance to increase the probability that a machine or component will function in the required manner over its design life cycle with a minimum amount of maintenance and downtime. These principal maintenance strategies, rather than being applied independently, are optimally integrated to take advantage of their respective strengths and maximize facility and equipment reliability while minimizing life-cycle costs. The goal of this approach is to reduce the Life-Cycle Cost (LCC) of a facility to a minimum while continuing to allow the facility to function as intended with the required reliability and availability.

3.4. Reactive Maintenance



The logic of run-to-failure management is straightforward. When a machine breaks, fix it. This ''if it isn't broken, don't fix it''. A plant using run-to-failure management does not spend any money on maintenance until a machine or system fails to operate. Run-to-failure is a reactive management technique that waits for machine or equipment failure before any maintenance action is taken. It is in truth a no-maintenance approach to management. It is also the most expensive method of maintenance management.

4. PRACTICAL APPLICATION OF PREDICTIVE MAINTENANCE

This study was carried out for vibration monitoring of Cooling Water Pumps in **Bahr Essalam Field - Sabratha Platform** affiliated to **Mellitah Oil &Gas Company** in Libya.

Cooling water pumps are used for supplying heat exchangers with cooling water. Their flow rate varies depending on the heat flow to be dissipated. The required head is determined by the type of cooling system.

The manufacturer of the pump is GABBIONETA and the rotation speed is 24.76 (Hz) the lubricant: is oil – AGIP OSO 46. The Drive system for the Cooling Water Pump is an electric motor type three phase by power 900 kW. The manufacturer of the motor is NIDEC.

BM Team performs periodic vibration measurements for the SABRATHA Platform, to establish the operating condition of the rotating equipment, and if necessary to give proper recommendations. CBM Team took the first routine measurements in December 2020 and issued a report regarding the condition of the machines.

On the 9th of January 2021, we received a mail, informing us that the vibration amplitude for the electric motor of the pump 101C, reached an alarming level, and corrective measures needed to be applied. Our recommendation was to stop the equipment and investigate before putting the machine back in operation.

On 26th February, one CBM member was mobilized on the SABRATHA Platform to perform routine vibration measurements and to investigate the high level of vibration for Cooling Water Pump 60-520-PA-101C.

Since CBM second measurements for these machines, we are going to refer to the measurements performed by us, In the table below you can see the vibration amplitude for the two measurements we performed (mm/s RMS).

4.1. Vibration FFT spectrum for pumps

The vibration FFT spectrum shows the exact behavior of the pumps as our last measurement. Pumps are running in cavitation and flow turbulence, with peaks in the spectrum at the running speed and 7x running speed, which is most probably VPF (Vane Pass Frequency), with a high noise floor surrounding VPF (this is a clear pattern for cavitation).

Cavitation can also be confirmed by the noise coming from the pump side which is specific to this phenomenon. The vibration spectrum for the electric motor does not show any mechanical problems; small peaks related to minor electrical problems, only for Cooling Water Pump 60-520-PA-101C, there is a misalignment between the motor and the pump.

Tests conducted present of CBM member. The activity started by monitoring the machine coupled then uncoupled, alignment confirmed is good and the soft foot confirmed its good by losing motor bolts while it is uncoupled, but the vibration still high

A balance of the electric motor fan was done. Another solo run test for the motor was done and found still high vibrations, After some changes of adding and removing weights to the fan, another check was performed by CBM and confirmed that the motor is good.

noticed that motor NDE side vibration values are increasing and decreasing with changes at the discharge line header (Flow-induced vibrations) Which leads to thinking about the nearest piping support (RIGID SUPPORT) as shown below, Put into consideration that the inadequate design of piping & tubing support is one of the main reasons to transmitting the vibration to the entire platform.

With the presence of the pump vendor (GABBIONETA) the activity started with concerned pump **101C** as per our recommendations (The pump is running with high Flow turbulence and cavitation)

The job started by checking the suction strainer, but there was no strainer, strainer was removed a long time ago Currently there is no suction strainer at the suction line. The ammeter was calibrated due to showing abnormal readings in comparison with other motors and accordance with the readings of the control room.

On the 4th of March 2021, we performed the last vibration checks and found still running with high vibration Figure.

5. CONCLUSION

From this study we can conclude the following:

I. The operating parameters for the pump must be checked (suction and discharge pressure, flow), and ensure that the pump is running at BEP (Best Efficiency Point) because pumps operate with major hydraulic turbulence and run randomly in the bore affecting the performance of the pump, impeller, bearings and mechanical seal to the motor.

II. Most of the pipe supports are of the solid type, and they also lack pipe vibration dampers, so it is necessary to replace them with spring supports wherever necessary as shown in the figure below, which will contribute to reducing the transmission of vibrations from the equipment to the rest of the components of the offshore platform.

III. Structural resonance is a common problem in offshore production facilities that causes vibration which should be controlled.

6. LITERATURA

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Short biography:

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