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Design Based Condition Maintenance in Oil and Gas Sector, Compendium of the Techniques and Procedure

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Abstract: Oil and gas production projects, both onshore and offshore, are frequently capital-intensive endeavors with significant financial and environmental consequences if they fail catastrophically. As a result, to ensure that production continues in a safe and reliable manner, an efficient and effective maintenance management technique is essential. This study looks at the current literature on CBM development and applications in the oil and gas industry. CBM is critical to the seamless, uninterrupted, efficient, and safe operation of oil and gas operations, according to new research. Because of the complex and interwoven nature of oil and gas facilities, detailed CBM plans with real-time condition monitoring data collection, analysis, and decision making are required to offer precise information of required maintenance intervals. As a result, more efficient industrial equipment can be used with greater assurance and safety.
Keywords: CBM, Maintenance, Compendium, Procedure, Condition, Oil and Gas

I. INTRODUCTION

Emerging difficulties in the oil and gas industry are causing management of new and old facilities all over the world to adapt. Companies are facing higher extraction costs as a result of: (1) the rapid depletion of conventional crude oil and natural gas reserves, and (2) the challenges posed by the extraction and/or processing of unconventional reserves found in oil sands, coal seam gas (CSG), shale gas [1], underground coal gas (UCG), and reserves located in the depths of the ocean. As a result, as sources become more mature, flow slows and costs rise due to the need for advanced technology to improve recovery. The balancing of equipment availability and pricing is another difficulty that many companies encounter. Furthermore, due to the critical nature of oil and gas operations, unanticipated failures cannot be tolerated.

Many companies are considering a wider automation deployment to reduce the number of employees required and the risks they face in order to increase production while reducing human error and hazard. Unmanned facilities are also becoming more common, especially in remote places. These two trends will almost certainly increase operating costs. Supply instability in the investment world means that investors will seek low-cost manufacturing and maintenance operations to protect their investments [3]. As a result of these trends and issues, oil and gas companies are working to increase output [4] and asset integrity management [5]. Reduced downtime due to unexpected equipment failure, enhanced dependability and maintainability, and greater equipment availability and utilization are all benefits of an effective maintenance program. Equipment's usable life is extended when maintenance is optimized.

A good maintenance program must include proactive or preventative maintenance (PM) solutions. State-based maintenance (CBM) is a PM method that employs diagnostics and prognostics to offer a dynamic awareness of equipment state while in use and to anticipate failure in mechanical systems using condition monitoring data [6]. CBM strategies are currently a major focus of maintenance and maintenance management research due to the aforementioned trends and problems, increased complexity in industrial technologies [7], and developments in condition monitoring techniques that include the use of online systems [8,] CBM strategies are currently a major focus of maintenance and maintenance management research. The efficacy of CBM for enhancing maintenance management, reducing accidents, and maximizing output is demonstrated in current literature on CBM uses in the oil and gas industry [9].

II. CBM IN THE OIL & GAS INDUSTRY

Oil and gas projects are large-scale investments with significant financial and environmental consequences if they fail tragically. As a result, maintenance management is essential for ensuring that production runs smoothly and safely [10]. According to one source, CBM is currently being employed in the petrochemical industry, with condition monitoring of both onshore and offshore oil and gas wells resulting in incremental production advantages of up to 5% [11]. Primary energy sources, such as raw fossil fuels, are extensively traded in the oil and gas industry. Colley and colleagues [12] focus on reducing operating costs, increasing revenues, and reducing greenhouse gas emissions by optimizing the energy consumption of upstream oil and gas facilities, implying that monitoring the 'energy intensity trend' can provide guidance for maintenance management programs. Maintenance management has a direct impact on energy usage and optimization in oil and gas plants, which explains why.

Aside from the large and complex equipment and machinery, such facilities also employ a small personnel. In this case, an effective CBM approach ensures that condition data reaches the right people and that maintenance activities are concentrated where and when they are needed. Large firms are employing information and communication technologies (ICTs) to construct central maintenance hubs that monitor remote facilities and alert and support onsite maintenance personnel [13]. Remote facilities are more typically found offshore in deep water. The enormous difficulties of inspecting offshore oil and gas production facilities in deep water emphasize the importance of permanent condition monitoring equipment [14].

Corrosion is a major problem in oil and gas infrastructure, both onshore and offshore. De Bruyn [15] argues for the need of anticipating and quantifying corrosion-related material degradation, including a study of traditional and novel corrosion monitoring techniques as well as petrochemical industry trends. Another source of failure in oil and gas extraction operations is well flaws, such as sanding and slugging [11].

Oil and natural gas processing plants are massive, complicated operations with a plethora of systems and subsystems operating simultaneously. Within and between each system/subsystem are separators, heat exchangers (condensers, boilers, and re-boilers), valves, scrubbers, accumulators, piping systems, and rotating mechanical systems (induction motors, compressors, pumps, etc). If any of these components fails, it could impede production, pose a health and safety risk, and/or increase the operation's environmental effect. Standby components are possible in some circumstances, but in others, the machinery or equipment is too large, expensive, or complex; these machinery and equipment are typically the best candidates for CBM.

As shown in Figure 1's schematic flow diagram of a typical oil refinery, an oil refinery involves many processes. The diagram displays the various procedures that occur between the crude oil source and the finished goods. Any facility that provides utilities such as steam, cooling water, electricity, or hydrogen is excluded. Figure 2 shows a schematic flow diagram of a typical natural gas processing plant, highlighting the many processes that occur between the entering gas and liquid feedstock and the final end products. The diagram shows only one of many possible gas processing configurations and does not include any facilities that deliver utilities like as steam, cooling water, or power. Plant design planning is difficult, and the end result often varies [16].

Pumps, compressors, and heat exchangers are used in the vast majority of processes [17]. Process factors such as flow rates, pressure, and temperature are regulated by these intermediary components. Major equipment failures in similar plants, according to Azadeh and colleagues [18], are frequently linked to pumps, compressors, and pipelines, and there is a good amount of CBM literature relevant to all of these common components. It is necessary to conduct a more thorough review of the literature pertaining to these and other more significant plant and equipment.

A. Rotating Mechanical Systems

Rotating mechanical systems are used in the majority of industrial processing facilities, including oil and gas facilities. Unbalanced forces, misalignment, incorrect lubrication of ball bearings, metal fatigue and cracks in welded or built parts, and/or ball bearing locking due to excessive heating are all prevented through condition monitoring of these systems, particularly vibration monitoring [19]. Ebersbach and Peng [20] look at using expert systems in conjunction with vibration analysis to help reduce these losses, whereas Saxena and Saad [21] built an artificial neural network classifier for rotating mechanical system condition monitoring.

B. Pumps and Compressors

Pumps and the systems that support them are essential for the efficient movement of fluids in oil and gas operations. These facilities use centrifugal, reciprocating, diaphragm, and rotary pumps [22]. Pump and system condition monitoring is a well-established CBM application and an ongoing research field [23]. Three instances of pump CBM application in the oil and gas industry are presented by Rohlfing [24].

Azadeh and colleagues [18] developed a diagnostic mechanism for pump failures, dividing pump operational difficulties into two categories: (1) hydraulic problems, in which the pump fails to deliver liquid, delivers insufficient capacity, develops insufficient pressure, or loses its prime when starting, and (2) mechanical problems, in which the pump consumes excessive power or develops mechanical difficulties at the seal chambers or bearings; in either case, vibratory feedback is used to diagnose pump failures. Fatigue is a common cause of pump failure [25, 26].

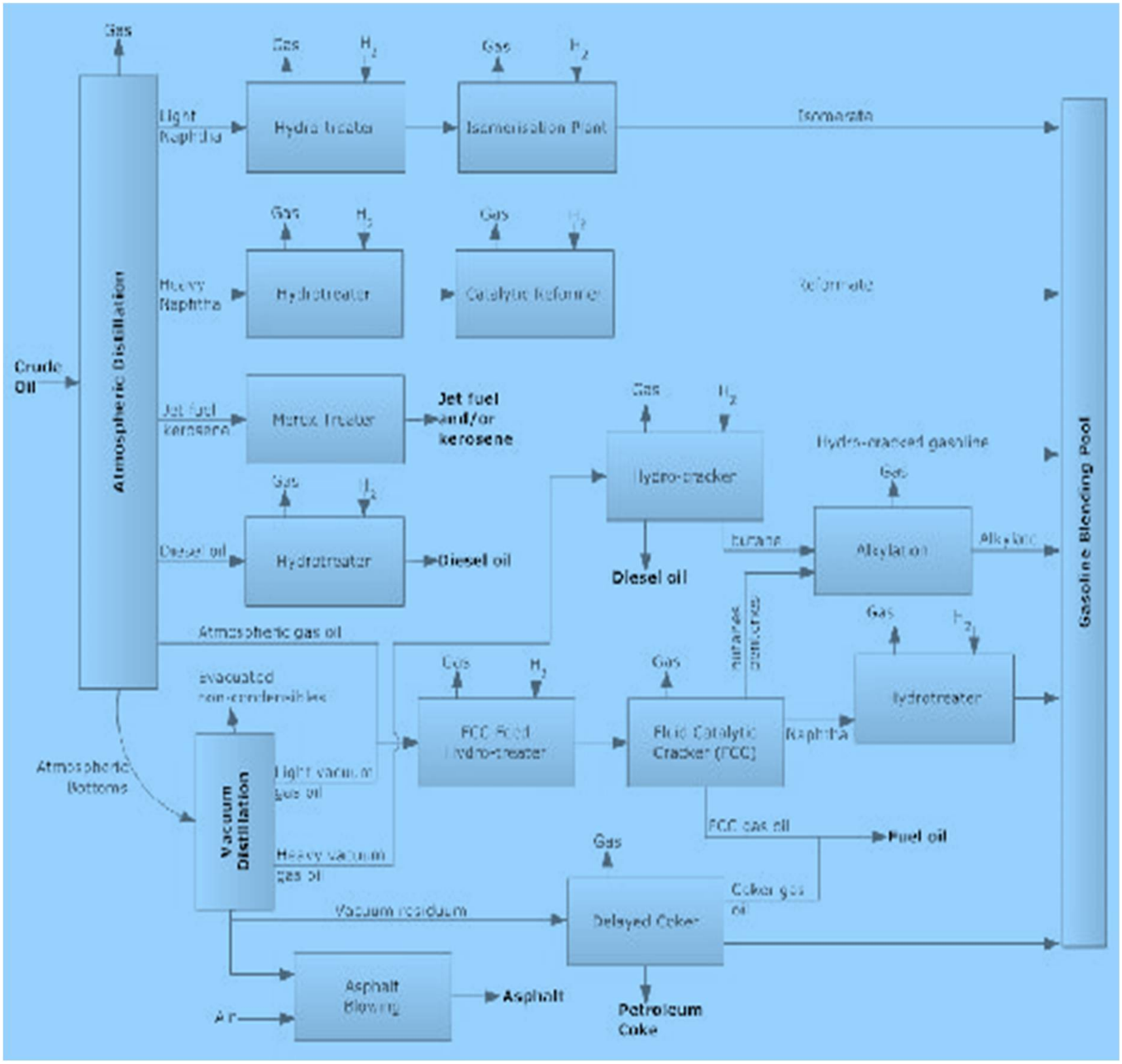

Figure 1: Block schematic overview of oil refinery [27]

Vibration monitoring is particularly well suited to pumps because of the large number of included spinning parts, which may indicate additional movement when problems occur [28]. The use of ultrasonic sensors [29], which presents a new ultrasonic measurement for high-pressure process pumps based on acoustic emission studies, is a relatively recent innovation in pump condition monitoring. Condition monitoring sensors that are permanently installed are appropriate for use in hazardous, corrosive, or inaccessible environments, as well as when pumps are permanently immersed [28]. Pressure is a common process parameter that varies depending on the requirements or stage of the process or operation. The purpose of a compressor is to increase the pressure or energy in a fluid. In the oil and gas business, this is a common practice. The two most common types of compressors used in manufacturing operations are reciprocal and centrifugal compressors [22]. In Carnero's [30] example study, he constructs a model for the selection of diagnostic techniques and instrumentation in a predictive maintenance program using a screw compressor with integrated lubrication and vibration analysis.

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C. Rolling Element Bearings

Rolling element bearings are extensively employed in rotating mechanical systems due to their great carrying capacity and low friction. These bearings are available in a wide range of sizes, from extremely small to extremely large. A range of condition monitoring approaches are suitable for rolling element bearings, according to the literature. Orhan and colleagues [31] present a fascinating three-part case study on the application of vibration monitoring and analysis to rolling element bearings in petroleum refinery machinery. More on the relevance of vibration monitoring to rolling element bearings may be found in [32, 33].

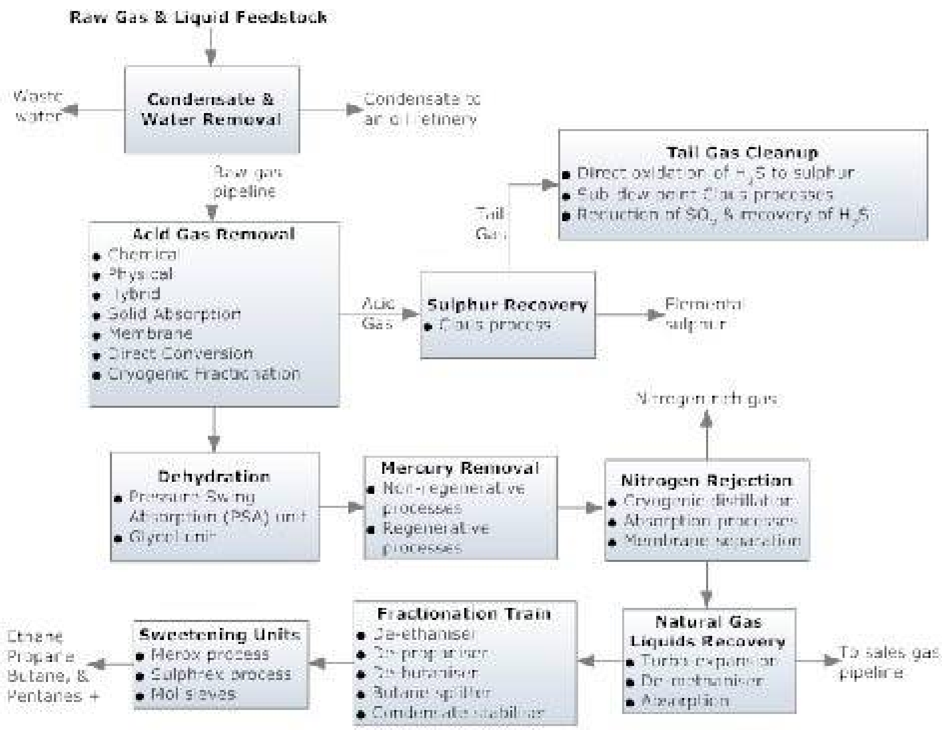

Figure 2: Block schematic overview of gas processing plant [34]

Implementation of integrated condition monitoring techniques has been another topic of research with rolling element bearings. To investigate the wear characteristics of tapered roller bearings, Harvey and colleagues [35] used electrostatic sensors, vibration, and lubricant temperature monitoring, as well as eddy current technology and ferromagnetism to detect debris in the lubrication recirculating system. In a similar study, Craig and colleagues [36] used electrostatic wear-site sensors to detect debris in oil scavenging lines, as well as a vibration accelerometer, thermocouples, inductive and ferromagnetic particle counts, and oil-line sensors to quantify charge during surface wear. Yang and colleagues [37] show how to extract characteristics from signals collected from damaged rolling bearings using a new time-frequency processing technique called basis pursuit. Integrating a variety of condition monitoring tools can provide a clearer picture of bearing condition.

D. Pipelines

Pipelines transport oil, gas, steam, and other goods to and from refineries and processing plants. Sun and colleagues [38] go into deeper into on industrial pipeline reliability. In a technical paper, Yan and Chyan [39] investigate the use of temperature and strain sensors to mitigate undesirable fiber optic non-linearity in oil and gas pipeline monitoring systems. These systems give pipeline structural health information that can detect early signs of degradation, such as corrosion and/or hydrate formation, which can lead to catastrophic failures like pipeline explosions or leaks. One method for detecting leaks is ultrasonic condition monitoring [40]. In many oil and gas operations, failures such as leaks can increase pollution, demonstrating a clear link between maintenance management and pollution [41]. Caputo and Pelagagge [42] identify external interference or third-party activities, corrosion, construction difficulties, mechanical or material failure, ground movements and natural hazards, and operational errors as the chief reasons of leaks. The control of pipeline integrity [43] is an important part of maintenance management.

E. Induction Motors and Gearboxes

Due to their adaptability and longevity, induction motors are a significant piece of machinery in the oil and gas industry, as they are in most industries [44]. Induction motors give spinning mechanical power to a variety of systems in an oil or gas refinery, both large and small, and are thus a research topic [45]. Performance parameter assessments via motor current signature analysis (MCSA) have been used to create CBM techniques [46, 47].

In most rotating systems, the function of a gearbox is to transfer power to a lower rotational speed with more torque in the most efficient and economical way feasible. Gearboxes are an essential piece of equipment in every industry; any mistake in the gears can cause machine downtime and productivity loss. Gearbox condition monitoring techniques include wear debris and vibration [48, 49]. Kar and Mohanty [50] analyze vibration techniques and present a new non-intrusive method for monitoring gear load oscillations using MCSA.

F. Oil/Water Separators and Heat Exchangers

Filters, precipitators, skim tanks and vessels, plate coalescers, flotation units (dissolved gas and dispersed gas), and serpentine-pipe packs are among the oil/water separators used in oil and gas facilities to purify water [51]. De-oiling with hydro-cyclones is a more recent breakthrough in the oil and gas industry. As contemporary oil and gas fields develop, the extracted oil/water/gas mixture has a higher percentage of water, increasing the necessity for secondary de-oiling devices. Bennett and Williams [52] describe the design and implementation of an industrial de-oiling hydro-cyclone with condition monitoring by electrical resistance tomography (ERT). Correct phase detection within the separator is also required to improve operational efficiency [53]. Sulphur dioxide in gas streams is another feature that is frequently investigated [54]. Heat exchangers and heat exchanger networks are used in practically every critical operation in oil and gas processing plants, including the distillation process and reactors. They're utilized to recover heat and conserve energy in the process. Heat exchanger fouling is a major problem since it has both thermal and hydraulic effects on the system, reducing heat transfer and fluid flow. Fouling deposition can reduce the available cross-sectional area for flow, change the tube/surface duct's roughness, and completely block selected tubes, causing flow distribution problems [55].

The four input and exit temperatures can be monitored using process parameter techniques [56]. Sikos and Klemes [57] illustrate the capabilities of their proposed technique for optimisation of dependability, availability, and maintenance using a heat exchanger network from a petroleum refinery facility. Due to the presence of three phases: liquid hydrocarbon, aqueous, and vapour, corrosion is frequently found in overhead condensing systems of atmospheric distillation units. Corrosion control in overhead condensing units can be studied using laboratory instruments that monitor corrosion using the potentio-dynamic polarization technique and quantify dissolved iron using inductively coupled plasma atomic emission spectroscopy.

G. Dehydration Plants and Fluid Catalytic Cracking

The gas dehydration process involves removing water vapour from the natural gas stream to suit sales criteria or other downstream process needs, such as gas liquid recovery. When sour gases like hydrogen sulphide (H_2S) and carbon dioxide are present, water vapour increases the corrosiveness of natural gases (CO_2). The development of hydrates can also be stimulated by natural gas with a high moisture content. Desiccant dehydrators come in two varieties in industry. The first is a solid desiccant dehydrator, which may employ silica gel because of its ability to achieve extremely low dew points [58], and the second is a liquid desiccant dehydrator, also known as a TEG-dehydration plant, which may use triethylene glycol (TEG).

Fluid catalytic cracking (FCC) is the most important and widely used refinery process for converting heavy oils into more valuable products such as gas, liquefied petroleum gas, gasoline, and gas oil through the heat disintegration of petroleum hydrocarbons in the presence of a catalyst. For FCC condition monitoring, the following process parameters are critical: reaction temperature, feed stock preheat temperature, and pressure. Similar characteristics were used by McGreavy and colleagues [60] to demonstrate how neural networks may be utilized as an operational support tool for industrial FCC units. Pedregal and Carnero [61] developed a vibration-based condition monitoring forecasting system to improve the diagnosis of a major component of a retarded cracking machine, which is essential for continued production.

III. ENVIRONMENTAL FACTORS

CBM will be important to oil and gas companies' capacity to maintain operation and production levels when they relocate into increasingly inhospitable environments. First, maintenance intervals are likely to differ from those in more hospitable situations; second, the efficiency and effectiveness of maintenance support services and supply delivery may be harmed [62]. This highlights the need of real-time condition monitoring data in establishing an understanding of various maintenance intervals, MTTF, and MTBF, as well as providing longer lead times for maintenance and operations.

However, caution should be exercised when selecting condition indicators, as those that are vulnerable to environmental or operational variables will almost likely produce condition monitoring data that will mislead subsequent analysis [63]. As plants are increasingly positioned in remote and difficult-to-access places, automation of petroleum production and separation facilities is critical [64]. CBM is unquestionably a crucial tool for maintenance management in the oil and gas sector, both in existing facilities and in future developments dealing with new and complex difficulties. For the oil and gas business to maximize usefulness, relevant CBM tools and processes must be developed.

IV. CONCLUSION

The study has provided a comprehensive platform for selecting, analyzing, and implementing condition-based maintenance solutions that are appropriate for the oil and gas industry. It demonstrates that CBM plays a crucial role in ensuring that oil and gas facilities run smoothly, efficiently, and safely. To give a more accurate picture of the variable maintenance periods, oil and gas facilities require more sophisticated and well-planned CBM programs that incorporate real-time condition monitoring data collection, analysis, and decision making. As a result, the most efficient use of plant equipment would be encouraged, together with increased levels of assurance and safety. Future study into the use and integration of condition-based maintenance technologies particular to the oil and gas sector will aid in the creation of industry-specific condition-based maintenance packages for use in the field.

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