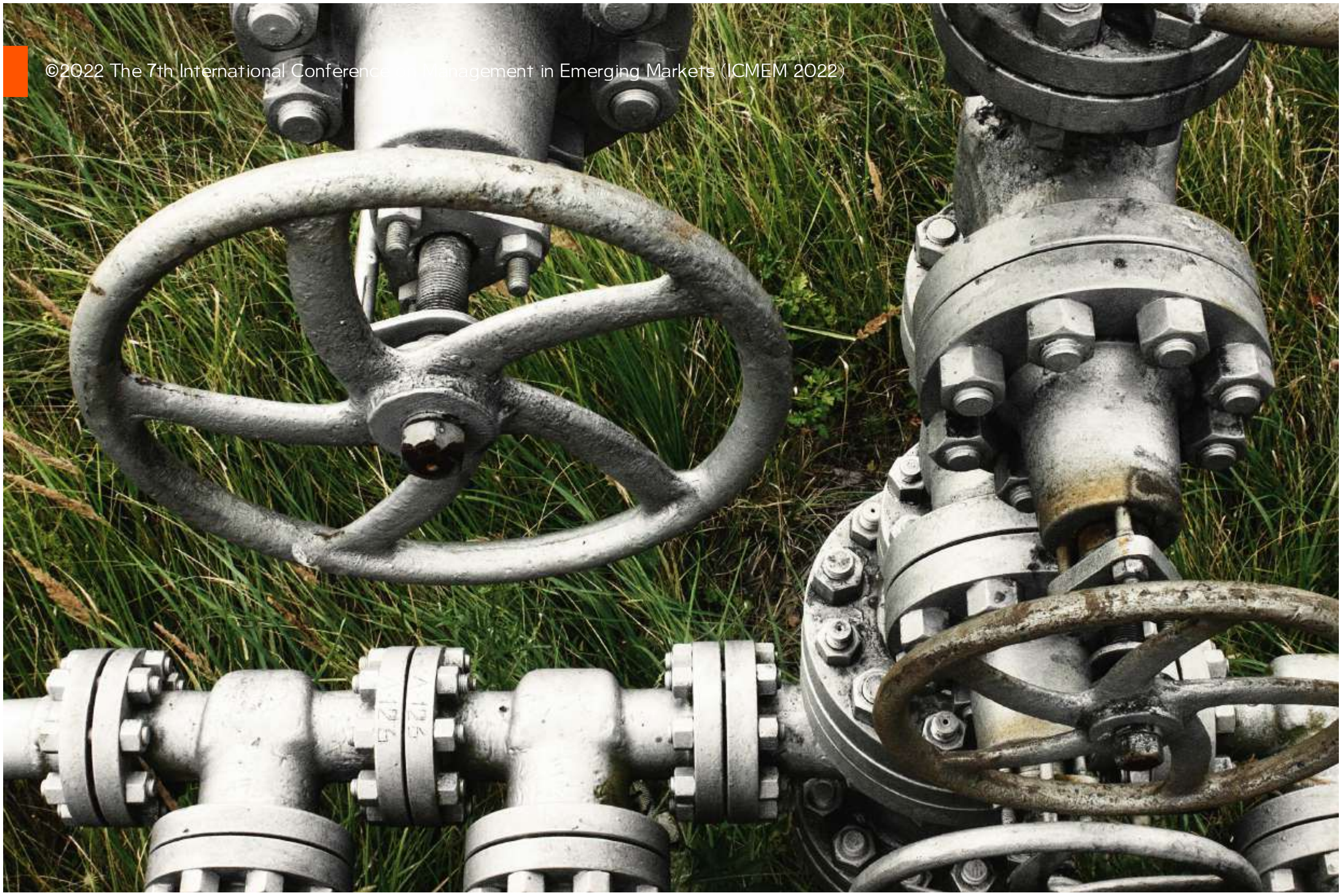

Paper 50

Reduce Unplanned Shutdown on Surface Facilities of Oil and Gas Plant Process

Yedi Rahmat Supriyadi

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Abstract - The purpose of this study is to assess the impact of equipment condition monitoring and asset management based on historical data management on reducing unplanned shutdowns and improving plant reliability to meet company expectations and maintain the safety of upstream oil and gas business installations. The scope of research is limited to the application of condition monitoring analysis methods, big data management and the concept of operation on turbomachinery in surface facilities in maintenance activities in upstream oil and gas business.

The research approach is carried out quantitatively and qualitatively. The quantitative approach uses references to experience in employment in the field of maintenance of surface facilities, the use of turbomachinery equipment operating data including organizational and human capital influence in upstream oil and gas industries. The utilization of library reviews on Statistical Quality Control is used to facilitate the realization of the purpose of this research.

Condition monitoring is an innovation in the field of equipment maintenance and is the basis for the formation of predictive maintenance methods. The study is to ensure that big data analysis is the main capital to reduce unplanned plant shutdown in the oil and gas industry.

Keywords - Oil and Gas shortfall, Surface Facilities, Preventive Maintenance, Predictive Maintenance, CMIMS (Computerized Maintenance Inspection Management System), Unplanned shutdown, Turbo-compressor, Obsolescence, spare parts, Availability, Reliability, Artificial Intelligent, Statistical Quality Control, Six Sigma, innovation and design thinking, Knowledge Management

I. INTRODUCTION

Along with the maturity of oil and gas producing wells in Indonesia, the unplanned shutdown of well production must be minimized as much as possible. The unplanned shutdown or unexpected equipment breakdown in oil and gas production has the potential to result in a temporary decline in production (until the well can be reproduced after a malfunction or failure mode can be overcome), or a continuous / permanent production loss due to sensitive well conditions.

The current oil and gas balance, especially in Indonesia, has a deficit and is getting wider every year. The oil balance deficit can be seen in chart 1 illustrates that the oil deficit was triggered by an increase in oil demand by 5.2% to 1.65 million barrels per day followed by a decrease in oil production by 3.5% to 805 thousand barrels per day.

This then encourages upstream oil and gas companies to always innovate to find efficient and effective ways to control failure modes that may arise so that unplanned shutdown events can be minimized

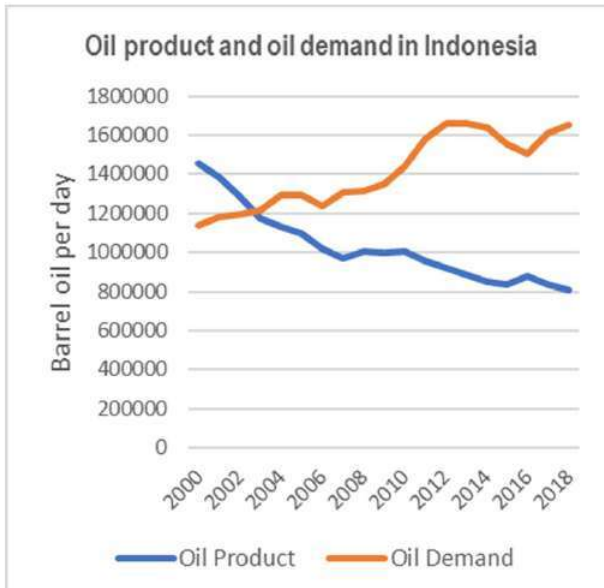

Chart 1: Deficit oil balance Indonesia (source: https//databoks.katadata.co.id)

The unplanned shutdown event could be caused by automatic shutdown system and manual shutdown (involving manual intervention), to protect assets against an event that has the potential to endanger the safety of oil and gas installation operations. Plant shutdown automatically occur because of the presence of safety devices to protect the operations of oil and gas processing plant with the right level of safety, such as fire and gas detectors, pressure/temperature/level safety devices, vibration sensors, and others. Unplanned shutdown events can also be caused by failures in production equipment including other causes that are not related to operations equipment.

A. Definition and Classification

Clarity of definition differences between unplanned shutdown and planned shutdown must be done first so that the control of failure modes can be carried out in a targeted manner.

For oil and gas companies in Indonesia, the definition of unplanned shutdown refers to PTK-041 SKK Migas as follows: Unplanned shutdown is the unplanned (uncontrolled) or unexpected partial or complete termination of production facilities due to equipment failure and abnormal operating conditions. The definition of Planned Shutdown is the temporary suspension of part of oil and gas production facilities in a planned and controlled manner to carry out scheduled activities such as maintenance and others.

The classification of each unplanned shutdown event is to maintain accuracy in the search for root cause and prioritize in solving problems quickly. Based on observations and work experience in an oil and gas company in Indonesia, the classification of unplanned shutdowns globally is illustrated in figure 1.

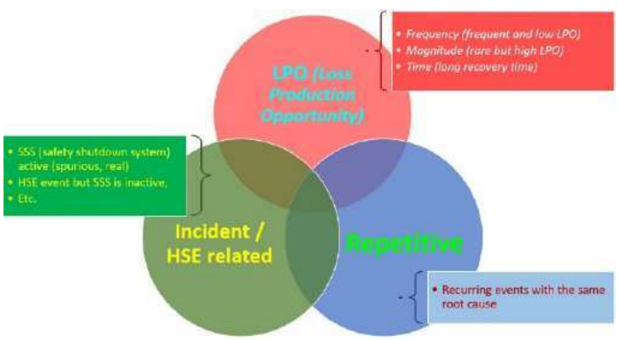

Figure 1: Setting Priorities in Handling Unplanned Shutdowns

Based on quantitative research, it consists of six practical ways to manage the classification of unplanned events in an upstream oil and gas company in Indonesia as follows: Monitoring settlement steps in each case of unplanned shutdown by related entities, Setting a priority scale on solving unplanned shutdown problems, Identifying bad actors for continuous improvement, Root cause analysis (RCA) of the occurrence of unplanned shutdown problems, Establishing initiatives and updated ways to prevent repeated events due to the same root cause in the future, Documentation of problems for historical data purposes as lesson learnt

B. Purpose of Study

Qualitatively, this study intends to prove a statistical quality control algorithm whether the algorithm can be used to process data from condition monitoring as an alternative predictive analysis tool. Proof of the use of the algorithm will be carried out by processing data running on turbomachinery equipment.

In addition, quantitatively this study also aims to examine what factors can contribute to reducing unplanned shutdowns and surviving, and even increasing equipment reliability.

This research will provide benefits to the upstream oil and gas industry. This research will contribute and increase insights to reduce unplanned shutdowns, especially in the surface facility team, maintenance, inspection and field management team. For example, understanding the importance of condition monitoring, big data management and analysis, as well as predictive analysis, oil & gas industry professionals, who handle operation surface facilities can develop policies, strategies, initiatives, and innovations to improve the ability to predict changes and respond quickly and appropriately while optimizing the use of existing facilities and manpower and optimizing operating costs.

C. Review of Surface Facilities Maintenance Strategy in upstream Oil and Gas Industry

Maintenance is a system for maintaining, monitoring, managing findings, analyzing, failure prevention-prediction, repairs, and also to modify any equipment and systems available in the company area to ensure that the physical asset continues to do whatever its users want it to do in the context of its current operation and is always in an acceptable condition to operate according to the envelope design that complies with safety and environmental standards or regulations. Maintenance strategies can be categorized into two strategies, which are proactive maintenance and reactive maintenance.

The strategy to achieve maintenance objectives starts from the project phase (design / engineering, construction, commissioning and start-up), during the operational phase and up to the mothballing / decommissioning phase. It became very clear that the maintenance strategy should be set up as early phase as possible of the facility development phase to avoid difficulties during the operational phase.

II. LITERATURE REVIEW

A. Nature of Condition Monitoring

Condition monitoring is an activity to collect, monitor and analyze the overall performance of the facilities and periodically to predict abnormal conditions during operation using certain techniques (such as vibration analysis, lubrication analysis, working temperature analysis, efficiency analysis, measurement technic, etc.). Preference is given to non-intrusive techniques (ultrasound, infrared thermographs, acoustics, laser-tools alignment, etc.) because of production constraint and exposure to hazards (toxic substances, electricity, etc.).

The results of the condition monitoring analysis are used to intervene in Condition-Based Maintenance to avoid any surprises (breakdowns), to reduce reactive maintenance, to optimize Predictive Maintenance activities and also to improve the quality of Preventive Maintenance.

B. Proactive and Reactive Maintenance

Proactive maintenance is failure-finding activities to find and detect hidden failure modes as much as possible, by using the appropriate technology, involves a plan-do-study-act (PDSA) cycle to emphasize learning and improvement with the main goal is to avoid repetitive failures. Proactive maintenance consists of preventive maintenance (PM), predictive Maintenance (PdM) and condition-based maintenance (CBM). Preventive maintenance (PM) is time-based maintenance which is carried out based on the operating time limit given by the OEM (Original Equipment Manufacturer). Assets or equipment must be shut down and dissembling is required on the equipment to carry out the PM program. The results of the PM are recorded and used as a reference to make decisions on the need for further maintenance. Predictive maintenance (PdM) is data-based maintenance, which is an activity of identifying data, data trends and predicting when a failure will occur. This method collects and analyzes real-time data on equipment performance, where this process is carried out when the equipment is operating normally. Condition based maintenance (CBM) is a maintenance activity with good planning, be it in the form of repair, replace or restore as a follow-up to the results of condition monitoring of PM and PdM activities. Proactive maintenance is carried out to extend the operating time of an asset, prevent unexpected breakdowns, and costs saving purposes.

The reactive maintenance strategy is failure-based maintenance as illustrated on figure 2. Reactive maintenance is a maintenance activity (repair, replace, restore) to overcome emergency problems and reduce negative effects on the consequences of failure of the asset or equipment. These failures occur because failure mode could not be or unable to be captured by proactive maintenance activities. Thus, the occurrence of reactive maintenance activities must be reduced

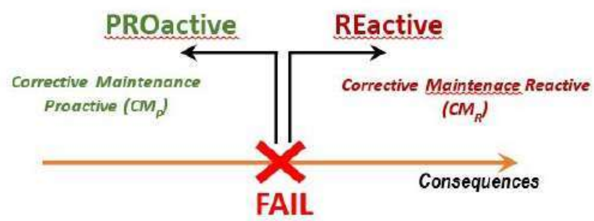

Figure 2: Illustration of proactive and reactive maintenance against failure events

C. Role of Turbomachinery in Upstream Surface Facilities Oil & Gas Industry.

According to the criticality assessment of equipment in upstream oil and gas production, it consists of 3 classifications of equipment, which are vital, important and secondary equipment. Vital equipment is equipment the failure of which immediately causes a loss of production, decreases the level of safety and affect the environment. Important equipment or critical equipment, is equipment the failure of which increases the risk of production loss, might affect the environment or is necessary of health and general welfare of personnel. Secondary equipment is equipment the failure of does not affect production, safety or environment.

Turbomachinery is an engine that deals with the transfer of energy between fluids (liquids & gases) and rotors (rotating shafts). Based on the OREDA Offshore and Onshore Reliability Data Handbook, in machinery system there are 6 classes of equipment, which are compressors, gas turbines, pumps, combustion engines, turboexpanders and steam turbines.

Turbomachinery in the upstream oil and gas industry holds an important role in ensuring the running of the production process at the oil and gas plant. In this study, it is limited to study how to reduce unplanned shutdown in turbo-compressors (centrifugal gas compressor driven by gas turbine) and turbo-generators (electrical generator driven by gas turbine). Gas compressors are the main equipment to export gas products to the customers. The turbo-generator is the main power generation equipment to provide electrical energy so that the production process can operate as it should be. Based on its operational function, turbomachinery is categorized as vital equipment or important equipment.

III. REDUCE UNPLANNED SHUTDOWN IN UPSTREAM OIL AND GAS INDSTRY

A. The decline in production and the increasing demand for oil and gas urge every upstream oil and gas companies to take initiatives and innovate to reduce activities and events that result in loss of production (operation shortfall).

Performing reactive maintenance is resulting in a high production shortfall because reactive maintenance takes longer time and is not planned, costly and requires a lot of workers. Therefore, condition monitoring must be encouraged to cross the boundaries of production efficiency in order to achieve the goal that until now seems unattainable, which is zero unplanned shutdown

A. Liquid or Agile Maintenance Organization

In general, most of organization structures are rigid organizations. Rigid Organization structure is not really adaptable with disruption, composed mainly in horizontal line and high in vertical line, not agile and have long process in decision making and there is no data exchange activities.

To face the challenge of achieving objective to reduce unplanned shutdown, organization shall become liquid organization, which is mainly decentralized and agile business model, make short process of decision making in organization, create big data and perform data exchange across functional to make precise decision. Each of the "Agile Team" have ability and capability to exploit local-opportunities to maximize potential. Figure 3 is the liquid organization model for maintenance activities to improve the quality of PM and PdM activities. This agile organization also encouraging innovation by prioritizing the concept of design thinking through structural processes, production team could focus on many new sights, very practical.

Figure 3: Liquid Organization for Maintenance Work

B. Operator driven reliability, Level 1 Maintenance

Level 1 routine or "first line" maintenance or operator driven reliability is maintenance activities that normally carried out by the production operators without specific tools. The purpose of level 1 maintenance is to optimise maintenance and operations work load, improves knowledge and awareness of production operators, encouraging ownership of plant and equipment.

Typical level 1 maintenance tasks which is mainly work, such as: routine greasing with no "grease gun", oil topping up, visual oil quality monitoring (e.g.: if oil bottle is dirty, oil emulsified, etc.), gauge zero adjustment, chart replacement on recorders, housekeeping, etc.

Strengthening level 1 maintenance activities means sharpening predictive maintenance because condition monitoring is also carried out by production operators, increasing information and data so that predictive failure analysis can be done in more precisely.

In this level 1 maintenance, the production operators will be assisted by the field maintenance team, as part of coaching, whenever required. Knowledge maintenance methods are indispensable to ensure that the correct transformation of data into information and transform the information into explicit knowledge so as to the sustainability of the history of the equipment and the expertise of the production operator

C. Big Data Analytics

In this study, the Statistical Quality Control (SQC) method was used to analyze a failure event in one of the turbo-compressor units in an upstream oil and gas company in Indonesia. Failure of the turbo-compressor unit was occurred in quarter-4 of 2019, it was a surprise event and was not detected early even though the condition monitoring activities in the turbo-compressor unit has been carried out carefully through data retrieval from readings of about 230 sensors in real time.

This SQC covers the quantitative aspects of quality management. Managing performance quality using SQC techniques involves periodic sampling of a process and analysis of this data using statistically derived performance criteria. This SQC is to convert the data to become information about the equipment condition.

Graphs X - and R- (range) are used in the control of statistical processes. In attribute sampling, the condition is good or bad, it falls into a category or not, and this is a go or no-go situation. In variable sampling, it needs to be measured in a specific unit of measurement, and then a control chart is developed to determine the acceptance or rejection of the process based on those measurements.

Upper control limit for $\bar{X} = \bar{\bar{X}} + A_2\bar{R}$ (1)

Lower control limit for $\bar{X} = \bar{\bar{X}} - A_2\bar{R}$ (2)

Upper control limit for $R = D_4\bar{R}$(3)

Lower control limit for $R = D_3\bar{R}$ (4)

Number of observations in each sample is 5 observations.

Table 1: Factor for R-Chart (source: Jacobs, F. Robert, Operation and Supply Chain Management)

Number of Observations in Each Sample n	Factor for $\bar{X}$-Chart A_2	Factors for R-Chart: Lower Control Limit D_3	Factors for R-Chart: Upper Control Limit D_4
2	1.88	0	3.27
3	1.02	0	2.57
4	0.73	0	2.28
5	0.58	0	2.11
6	0.48	0	2.00
7	0.42	0.08	1.92
8	0.37	0.14	1.86
9	0.34	0.18	1.82
10	0.31	0.22	1.78
11	0.29	0.26	1.74
12	0.27	0.28	1.72
13	0.25	0.31	1.69
14	0.24	0.33	1.67
15	0.22	0.35	1.65
16	0.21	0.36	1.64
17	0.20	0.38	1.62
18	0.19	0.39	1.61
19	0.19	0.40	1.60
20	0.18	0.41	1.59

Dry gas seal behavior of turbo-compressor was observed because dry gas seal was failed at that time. In January 2019, Turbo-compressor was in its best performance because the condition was ideal, such as: gas turbine (as driver) was just overhauled, operation condition was ideal at that time (e.g.: clean gas on dry gas seal). This condition used as baseline (chart 2).

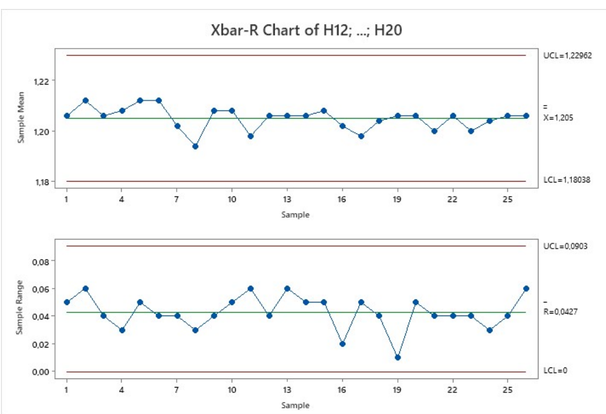

Chart 2: Turbo-compressor dry gas seal baseline

Based on the observation of turbo-compressor's dry gas seal by using SQC along the year 2019, it found that the test failed starting from June 2019 (chart 3). It is proven that the indication was considered as early warning prior to the failure occurred in quarter-4 of 2019

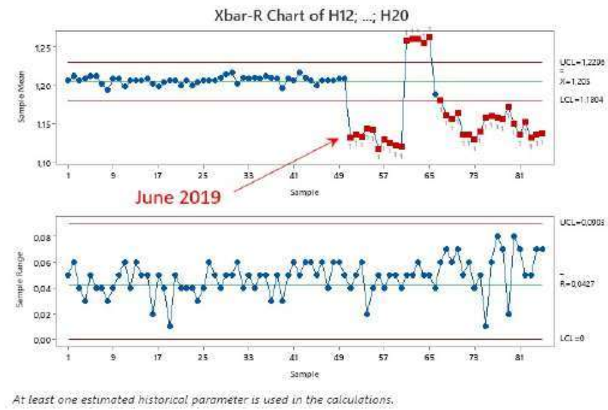

Chart 3: Dry gas seal test result by SQC

D. Back-up/Redundancy System Optimization

Equipment redundancy strategy aims to avoid major incidents if there is a failure in the equipment. Redundancy is generally applied to vital equipment based on its criticality assessment.

However, in some cases the occurrence of unplanned shutdowns is due to mistaken in establishing a running policy on equipment with the redundancy arrangement. One of the reasons is that redundant equipment operates outside the design limit of the equipment, lower or higher than the manufacturer's recommended operating conditions.

Six sigma can be used as a statistical methodology that is applied to recognize and correct problems that arise, so as to increase productivity and effectiveness. The mission of six sigma is to continuously try to suppress variations that can result in defects in the process, with which must be suppressed under mean time between failure (MTBF), maintenance efficiency and accuracy of running policies over equipment with redundancy / sparring units.

E. Provision and Predicting Critical Spare Parts

Spare part management to be carried out through the material management module at CMIMS and under the responsibility of the supply chain team. Spare part availability will be assessed by type, criticality, and consumption history. Therefore, material management is highly recommended to be integrated with CMIMS so that consumption history can be maintained and sustained as the basis for analysis to determine the minimum stock requirement and avoid the unavailability of spare parts to carry out maintenance activities.

In the new project phase, the identification and quantity of parts must be determined and must be available prior to project submission. Reserve requirements should take into account the degree of criticality of each equipment, the amount of equipment on site and the delivery time. Identification and quantity set-up of parts should cover the entire operational life. The participation of the surface facilities maintenance team during the project phase is necessary to ensure that all necessary parts are available for continued operation.

IV. RESULT AND DISCUSSION

Big data management in the field of maintenance surface facilities is carried out both manually and digitalization. CMIMS (Computer Maintenance Inspection Management System) is a system that is widely used to manage data maintenance manually. Sensor reading installed in the equipment is a method of condition monitoring in real time data and digitalization by collecting and storing data through PDCS (Process data Control System), PI (Plant Information), and data in back-up through external storage devices. The operating data that has been monitored and collected requires data processing, analysed and compared with baseline historical data ideal operating conditions.

Statistical Quality Control can be used to do predictive analysis on maintenance activity. However, expertise and experience are required to correctly select which parameter to be monitored. This is because there are huge data on machinery parameter, especially turbomachinery. Wrong selection on parameter data will lead to wrong conclusions.

In this case example, Statistical Quality Control could show healthy and unhealthy condition of the machine. Even though the dry gas seal was still working within its operational range (there was no alarm nor alert when it ran along 2019, but this Statistical Quality Control method could show significant abnormal behavior of the machine starting in June 2019. Statistical Quality Control can be used for Predictive Maintenance. Therefore, production loses because of unpredictable breakdown equipment can be avoided in the future.

V. CONCLUSION

More in-depth analysis is needed because the damage is not due to age, some of the symptoms of failure are not visible and some cannot be measured directly by the measuring instrument. The behavior of the equipment needs to be monitored from time to time. By using this Statistical Quality Control platform, the condition monitoring team can capture and observe the indication of hidden failure consequences and achieve efforts to reduce unplanned shutdowns in upstream oil and gas industry operations.

On the other hand, the condition monitoring team can determine the type of algorithm to develop AI -based software (Artificial Intelligent) according to the needs of operations management to reduce unplanned shutdowns. Condition monitoring teams can choose partnerships to develop AI as a tool to reduce unplanned shutdowns and efficiently improve operational reliability.

Figure 4 is a resume of this study to find a solution to reduce unplanned shutdowns in surface equipment in upstream oil and gas companies.

Figure 4: Elements to reduce unplanned shutdown

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