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Effect of Venting Equipment Installation on Oil Production Stability

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ABSTRACT

Electric Submersible Pumps (ESPs) are one of the most prominent artificial lifting methods in the oil and gas industry today. In the operation of Electric Submersible Pumps on wells in the Ko-Pet field, a gas lock may occur when liquid and gas separate in the tubing above an electric submersible pump and inside the pump. This study aims to determine the effect of installing venting equipment on oil well production. Venting equipment was installed in three oil wells: KI090, KI183, and KI495 in the Ko-Pet oil field. From the production data, it was found that the installation of Venting Equipment affected production stability, namely by increasing the fluid that could be pumped by the ESP to the surface facility. The installation of venting equipment increased oil production by 1251 barrels or an increase of 8%. Electrical Submersible Pump performance was more stable because the gas lock problem can be overcome by continuously releasing the casing pressure with venting equipment.

KEYWORDS: *Electric Submersible Pump, Venting, Well, Oil field.*

1.0 INTRODUCTION

In the oil sector, there are two ways to lift fluids from the subsurface to the surface: natural and artificial. Natural flow can occur if the pressure below the surface/inside the earth is higher than the hydrostatic pressure of the well so that the fluid can flow to the surface. If the hydrostatic pressure of the well is lower than the subsurface/inside-the-earth pressure, the artificial lift method will be applied so that the fluid can be lifted to the surface [1]. In the oil sector, there are many choices of artificial flow, including Sucker Road Pump (SRP), Gas Lift, Progressive Cavity Pump (PCP), Hydraulic Pump Unit (HPU), and Electrical Submersible pump (ESP). Planning for the use of ESP is greatly influenced by the conditions of well productivity and the nature of the fluid which is influenced by the conditions and pressure of the reservoir. ESP is a centrifugal pump driven by electricity consisting of several stages (levels) with a single suction type, where each stage has one diffuser and impeller mounted on a shaft [2].

Several obstacles are often experienced in the operation of ESP on wells in the Ko-Pet field. One is the gas lock problem in the Ko-Pet KI090, KI183, and KI495 wells, where a lot of free gas content is produced, collected, and enters the ESP. Assuming the amount of free gas produced in the well is sufficient and collected, the performance of the ESP will be disrupted and cause several problems with the ESP. This gas lock condition can be seen on the amp chart, where the amp chart graph is drawn with an even line and then decreases due to compressed gas until the amp chart curve moves irregularly and decreases under underload conditions. The ESP will stop automatically during this under-load condition because no fluid is being pumped [3].

The gas lock can be overcome by doing Casing Pressure Release (CPR) work and installing a perculator, these temperature and pressure parameters are essential for optimizing the performance and efficiency of the gas [4],[5]. CPR is a job that is done by releasing free gas by opening the casing valve at the wellhead. A perculator or venting line is a tool in the form of a chimney-like channel that is installed on the surface by connecting the casing pipe to the casing valve. By performing CPR continuously using this Venting Equipment, the accumulation of gas trapped in the casing annulus can be reduced until the pressure on the well surface is equal to atmospheric pressure. By reducing the pressure caused by the accumulation of trapped gas, the performance of the ESP will be maintained. This study will focus on the effect of installing venting equipment to maintain the stability of oil production in the Ko-Pet KI090, KI183, and KI495 field wells containing gas accumulation that causes gas lock [6],[7],[8].

Oil and gas often referred to as hydrocarbon fluids are non-renewable fuels and are found in storage rocks at depths of hundreds to thousands of feet below the ground surface. To obtain hydrocarbon fluids from storage rocks, exploration, and exploitation activities are needed to be able to lift the fluid to the surface so that it can be utilized [9],[10]. The surface flow control or X-mastree (Figure 1) [11] represents an essential element of wellhead apparatus within the petroleum and natural gas sector. It constitutes an intricate configuration of valves, pressure gauges, and various control mechanisms specifically engineered to modulate the transmission of hydrocarbons and additional fluids from the wellbore to the surface.

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Lifting hydrocarbon fluids from wells to the surface can be done in two ways, namely: natural flow and artificial flow. Natural flow techniques can occur when the pressure in the earth is still able to push fluid to the surface, while artificial flow techniques are used when the pressure in the earth is no longer able to push fluid to the surface. Determination of artificial flow techniques is influenced by several variables, including location/place (onshore or offshore), accessibility of power sources (electricity and gas), storage rock conditions (Gas Oil Ratio, well productivity, water cut, and bottom well flow pressure), fluid conditions (viscosity and sand content), wellbore conditions (temperature, depth, and slope), economics and the amount of well production [12-14].

2.0 RESEARCH METHOD

2.1 Venting Equipment Installation Design

Installation of Venting Equipment in the KI090, KI183, and KI495 fields in the design will be installed through a 2-inch casing head valve connected to a 2-inch pipe and connected to the Venting Equipment (perculator or venting line) according to the analysis of the fluid content in the casing annulus in the form of Gas containing water or dry Gas/gas does not contain water [15],[16]. Figure 2 is a picture of the design plan and installation of a 2-inch casing annulus at the wellhead

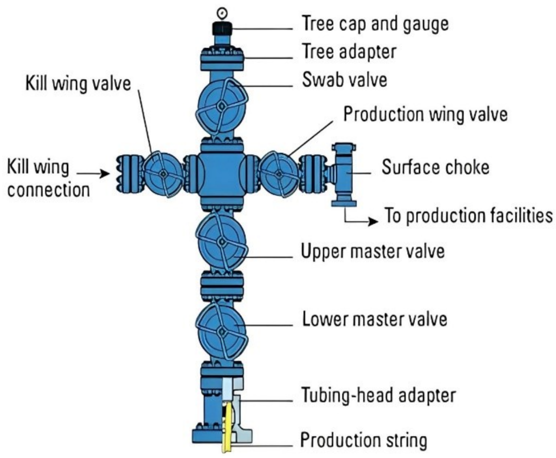

Figure 1: X-mastree [9],[11]

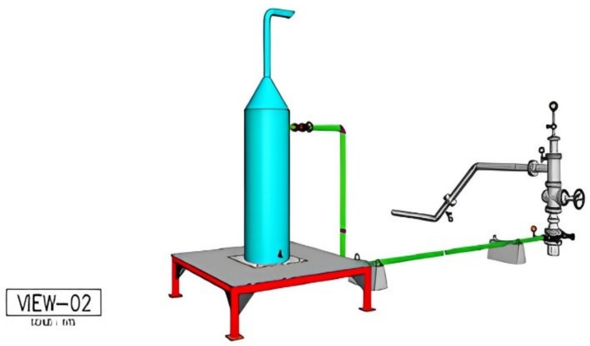

Figure 2: Design of venting equipment

After analyzing the data and discussing the gas lock that affects production stability, it is necessary to evaluate the relevance and suitability of the data and the research objectives. Evaluation is a stage to determine whether the results of this final assignment are acceptable or not. If it is not acceptable, the data analysis will be repeated until the results are obtained that are appropriate and relevant to the research objectives. After the research results have been accepted, conclusions are immediately drawn regarding this final assignment.

2.2 Wells Groups Based on Venting Equipment

A flowchart outlining the decision-making process for selecting appropriate venting equipment for various industrial applications is presented in Figure 3. The flowchart is structured to guide users through a logical sequence of considerations for wells grouped based on venting equipment to be installed (venting line or perculator).

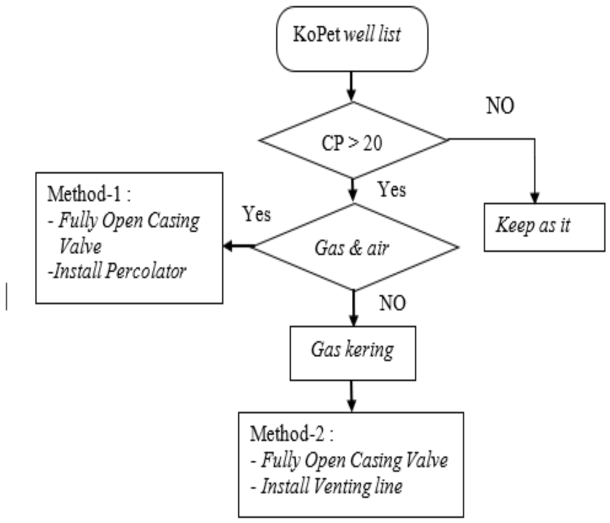

Figure 3: Venting Equipment installation selection diagram

The methodology applied to determine the type of reservoir fluid used 2 methods. The first method was with laboratory testing where the fluid properties were obtained from the results of well samples. The composition and properties of the fluid from laboratory experiments are used to identify reservoir fluids. Through these laboratory experiments, critical fluid characteristics such as composition and physical properties are identified, enabling an accurate classification of the reservoir fluid type. Laboratory analysis provides direct and reliable data essential for understanding the nature of the fluid within the reservoir.

The second method used the McCain guidelines based on the evaluation of production data that can confirm the type of reservoir fluid. Referring to the McCain guidelines, the type of reservoir fluid can be determined based on the GOR. According to these guide lines, the classification is based on the Gas-Oil Ratio (GOR), which serves as a key indicator of fluid characteristics. By analyzing production data in conjunction with the McCain guidelines, the reservoir fluid type can be determined more comprehensively, complementing the insights gained from laboratory testing. Therefore, this dual-method approach ensures a robust and accurate identification of reservoir fluid properties.

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3.0 RESULT AND DISCUSSION

3.1 Analysis Data of gas Sampling

In this study, gas sampling was conducted from the annulus casing in the KI090, KI183 and KI495 fields to be analyzed by the internal lab support team of PT. ABC. Table 1 is the gas sampling data conducted in 5 different fields as a sample comparison. To analyze the gas composition in the annulus casing of the KI090, KI183, and KI495 fields, gas samples were collected and subsequently analyzed by the internal laboratory support team of PT. ABC. Table 1 provides a comprehensive overview of the gas sampling data obtained from all fields, facilitating a comparative assessment of their gas compositions.

The data and gas sampling analysis on five wells in the Ko-Pet area is depicted in Figure 4. There are three wells with high water content, namely KI090, KI183, and KI495. The three fields are known to have water content with a range of 35 - 42% and three types of dominant gases, namely (Carbon Dioxide, Methane, and Propane). Figure 4 presents a graph of data and gas sampling analysis conducted on five wells located in the Ko-Pet area

Table 1: Percentage of gas sampling contains in the Ko-Pet field

Facility Name	KI090	KI183	KI221	KI430	KI495
Carbon Dioxide	34.31	60.53	60.54	53.37	53.37
Water	38.85	42.25	8.41	7.78	35.46
Methane	6.5	9.69	9.69	12.86	12.86
Propane	4.4	5.37	5.37	6.69	6.69
Butanes	3.76	4.03	4.03	5.55	5.55
Ethane	2.52	3.54	3.54	3.86	3.86
Nitrogen	0.94	3.54	3.54	2.84	2.84
Pentanes	1.92	2.19	2.19	3.16	3.16
Hexanes	2.57	1.33	1.33	1.92	1.92
Heptanes	1.8	0.63	0.63	0.85	0.85
Octanes	1.44	0.46	0.46	0.54	0.54
Nonanes	0.62	0.17	0.17	0.19	0.19
Decanes	0.26	0.06	0.06	0.07	0.07
Hydrogen sulfide	0.01	0.02	0.02	0.03	0.03
Undecanes	0.09	0.02	0.02	0.02	0.02
Dodecanes	0.03	0.01	0.01	0.01	0.01

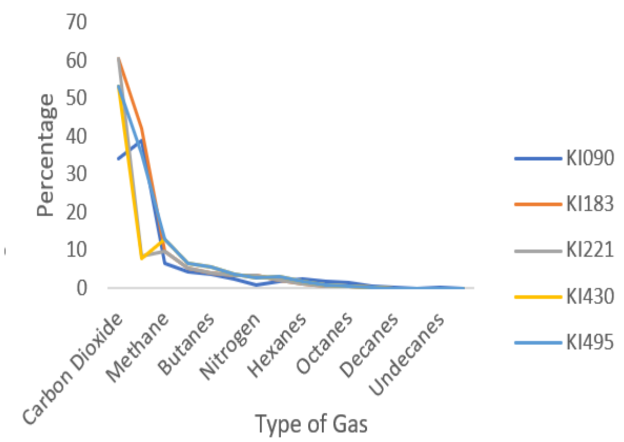

Figure 4: Gas sampling from oil well

Among these wells: KI090, KI183, and KI495 exhibit notably high water content. The water content in these wells ranges from 35% to 42%, indicating significant water presence compared to the other wells analyzed. This characteristic highlights the distinct hydrological conditions within these specific fields, which may impact their gas production potential and associated processes.

Additionally, to high water content, these wells show the prevalence of three dominant gases: carbon dioxide (CO_2), methane (CH_4), and propane (C_3H_8). The dominance of these gases suggests unique geological or chemical conditions that influence their generation and accumulation. Understanding the relationship between water content and gas composition in these wells can provide valuable insights into the area's reservoir characteristics and guide future exploration and production strategies.

Based the data in Table 2 and Figure 5, it can be seen that in the Ko-Pet KI090 well, the content in the casing annulus was categorized as Gas containing water with a water content of 38.85% and gas content (carbon dioxide, Methane, and Propane). The improvement of the installation of venting equipment as a tool to perform casing pressure release (CPR), can reduce the water content measured in the venting equipment chimney from 38.85% to 8.41% or a decrease of 30.44%.

Table 2: Gas sampling contain

Properties	Before Mol %	After Mol %
Carbon Dioxide	53.37	54.32
Methane	12.86	13.26
Water	35.46	8.29
Butanes	5.55	6.13
Pentanes	3.16	4.04
Propane	6.69	3.98
Ethane	3.86	3.78
Nitrogen	2.84	2.61
Hexanes	1.92	1.88
Heptanes	0.85	0.85
Octanes	0.54	0.54
Nonanes	0.19	0.19
Decanes	0.07	0.07

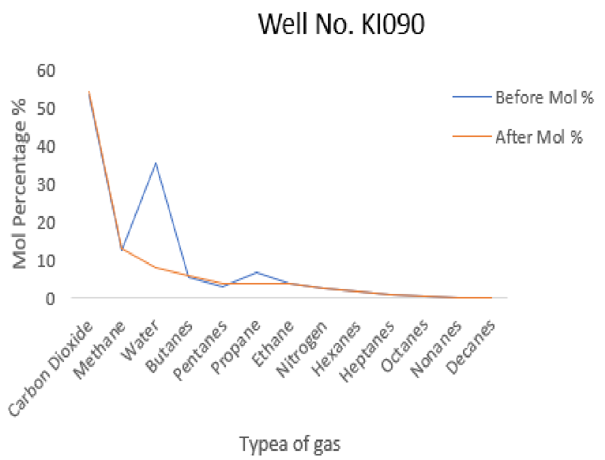

Figure 5: Gas Sampling Contain

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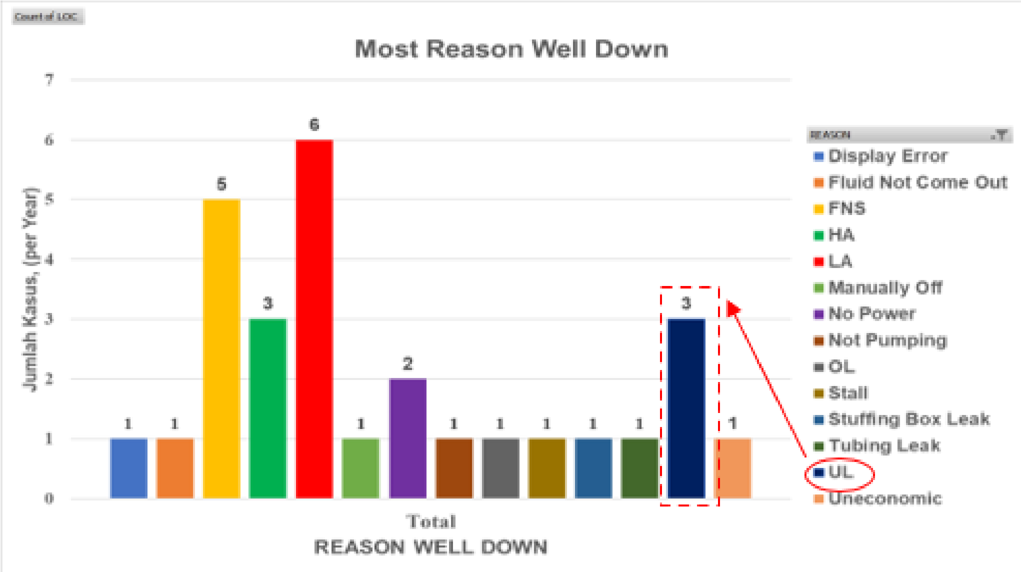

Figure 6: Well-down reason

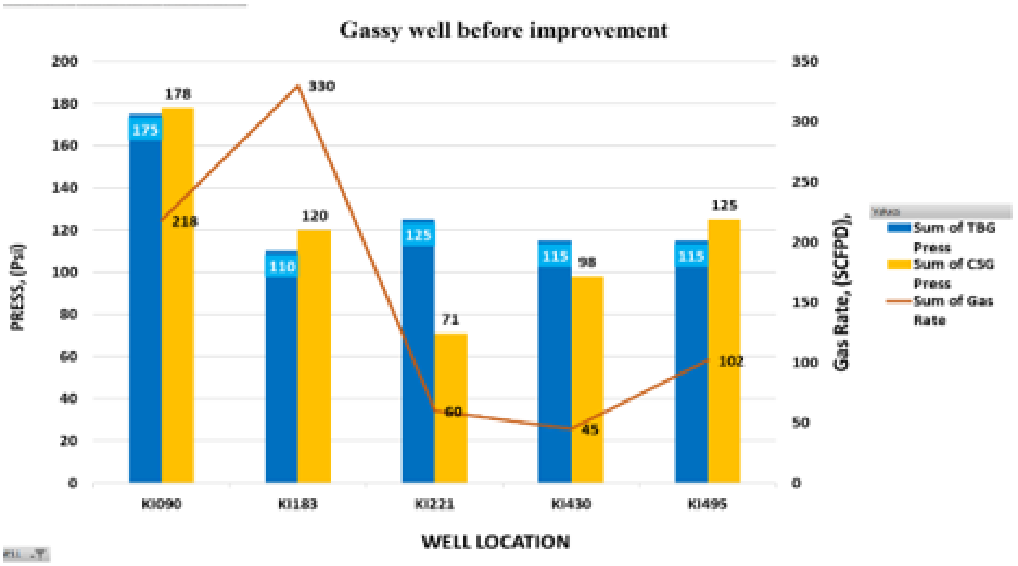

Figure 7: Gassy well

3.2 Well-down Reason

From the graph in Figure 6, it can be seen that one of the causes of well/ESP down (accumulation of reasons that often occur in one year on average in oil wells in the Ko-Pet field) is Gas lock, marked with underload reason. This is to the theory of (Bagci et al., 2010) [3] and Sumarna, (2011) [17] in his book states that underload occurs when the current is lower than the normal running ampere. From the graph, well/ESP down occupies the top three events below Low Amp and Fluid Not Support.

The graph in Figure 6, it is evident that one of the primary causes of well/ESP (Electrical Submersible Pump) downtime in the Ko-Pet field is gas lock. This issue, which represents a significant accumulation of incidents occurring annually in oil wells, is identified under the category of under-load. The occurrence of under-load aligns with the theoretical explanations provided by Bagci et al. (2010) [3] and Sumarna (2011) [17]. According to their studies, under-load arises when the electrical current drawn by the ESP is lower than the standard operational amperage. This condition can lead to decreased efficiency and eventual downtime in the pumping system.

The graph further illustrates that well/ESP downtime due to gas lock is one of the top three most frequent events, ranking below only two other causes: low ampere and fluid not supporting. These findings highlight the critical impact of under-load on the operational reliability of ESP systems in oil wells. Addressing this issue is essential for improving pump performance and reducing downtime in the Ko-Pet field.

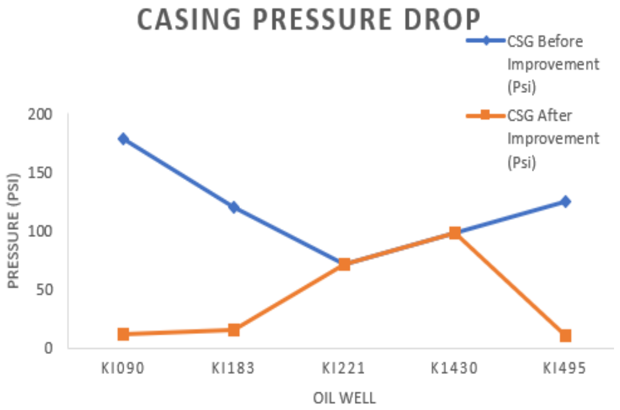

Figure 8: Casing pressure reduction graph

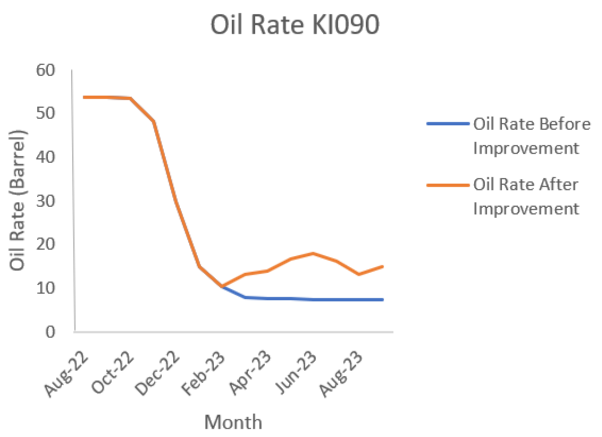

Figure 9: Oil production at well KI090

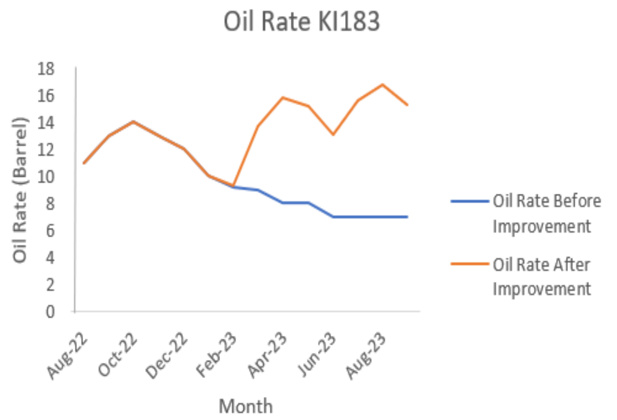

Figure 10: Oil production at well KI183

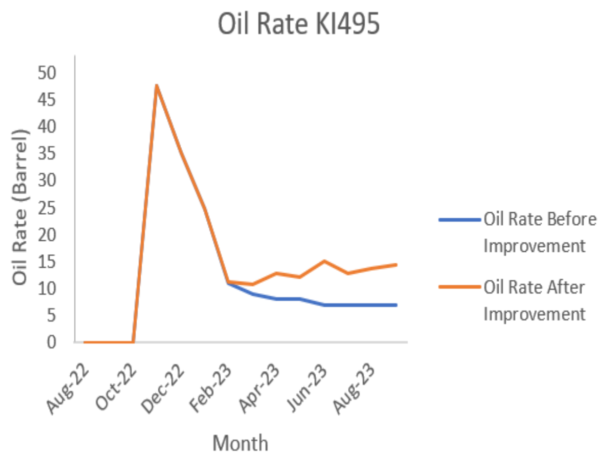

Figure 11: Oil Production at well KI495

3.3 Data on Gas-Bearing Wells

From the graph in Figure7, it is known that three wells have gassy characteristics and cause an increase in pressure in the casing annulus, namely KI090, KI183, and KI495. Table 2 shows that the gas pressure in the three fields is between 102 Psi and 330 Psi and the highest is in the KI183 well. In addition to having a high gas rate, in these three wells, there is an increase in the casing annulus, which is higher than the tubing pressure. This may suspect the cause of the ESP down due to the gas lock.

3.4 Casing Pressure Annulus

The analysis of annulus casing pressure data revealed notable anomalies in the KI090, KI183, and KI495 fields. These anomalies were characterized by pressure levels that significantly deviated from the expected range, indicating irregular behavior within the system. As a result, the pressure in the casing annulus was observed to be higher than normal, raising concerns about the structural and operational integrity of the well. Elevated annular pressures can lead to safety risks, operational inefficiencies, and potential environmental hazards if not addressed promptly.

By the analysis of the main cause in the fishbone diagram, the main reason was found to be the absence of a tool to remove/release gas. Hence, this problem to be resolved by installed a casing pressure reduction graph venting equipment tool, which was as a Casing Pressure Release (CPR). From the casing pressure data, a very significant decrease in casing pressure was obtained from an average of above 120 Psi to a maximum of 15 Psi. The casing pressure reduction graph is presented in Figure 8.

3.4.1 Oil Production at Well KI090

In Figure 9, it can be seen that oil production in KI090, which initially (before improvement) experienced a decline from August 2022 to January 2023. However, after the improvement, there was an increase in average production of 14.5 barrels from the original average production of 7.9 BOPD or an increase in average production of 84% from production on the baseline.

3.4.2 Oil Production at Well KI183

In Figure 10, it can be explained that oil production at KI183, which had previously experienced a decline since October 2022, however, after improvements were made, there was an increase in average production of 14.35 barrels from the average production before improvement of 7.75 BOPD, or an increase in average production of 85% from production on the baseline.

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3.4.3 Oil Production at Well KI495

In Figure 11, it can be explained that oil production at KI495, which initially experienced a decline since November 2022. However, after improvements were made, there was an increase in average production of 12.8 barrels from an average initial production of 8 BOPD. In other hand, it was an increase in average production of 61% from production on the baseline.

4.0 CONCLUSION

Based on the data analysis, it was found that the installation of Venting Equipment affects production stability, namely by increasing the fluid that the ESP can pump to the surface/surface facility. In the forecast, oil production in the Ko-Pet field was estimated to decrease from an average of 1154 barrels in the period May 2022 to January 2023 to an average of 709 barrels in the period February 2023 to September 2023 or 63% would experience a decrease in production. However, with the improvement of the installation of Venting Equipment, oil production can be maintained and even increased to 1251 barrels or an increase of 8%. This is because the performance of the ESP was more stable. After all, the Gas lock problem can be overcome by continuously carrying out casing pressure release with the venting equipment. The data obtained from this study, it can concluded that by installing venting equipment can reduce or even eliminate the accumulation of gas trapped in the casing annulus, so that the potential for built pressure can be prevented by continuously releasing the casing pressure using venting equipment. From the casing pressure data, a very significant decrease in casing pressure was obtained from an average of above 120 Psi to a maximum of 15 Psi or the casing pressure decreased to an average of 125%.

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