High-Level Performance Analysis Model for Mature Offshore Assets

Nurul Huda Azis\textsuperscript{1,2}, Mohd Yusri Mohd Yunus\textsuperscript{1,3,8}, Aaina Syakirah Nor Azizan\textsuperscript{3} and Nurul Ain Ismail\textsuperscript{3}

\textsuperscript{1}Fakulti Teknologi Kejuruteraan Kimia & Proses, Universiti Malaysia Pahang, 26300, Kuantan, Pahang, Malaysia
\textsuperscript{2}Petronas Carigali Sdn Bhd, Peninsular Malaysia Operations, 24300 Kerteh, Terengganu
\textsuperscript{3}Pusat Kelestarian Ekosistem & Sumber Alam, Universiti Malaysia Pahang, 26300, Kuantan, Pahang, Malaysia
\textsuperscript{*Email: yusri@ump.edu.my}

Abstract- In general, most offshore platforms are designed for 20 to 30 years of lifespan. After the field completed its maximum production plateau for a certain period, the reservoir pressure started to deplete, resulting in a decline in production rate until it is uneconomical to produce from the field. This declined production phase is referred to as Mature Offshore Fields/Assets. Almost 90% of offshore platforms in Peninsular Malaysia Assets operated by Petronas Carigali Sdn Bhd (PCSB) are within this phase. The study objective is to establish an analysis tool by consolidating the data from various system resources into a single presentation to provide the status of mature field performance, visualize the area that requires improvement, and subsequently identify performance improvement recommendations. The study will also focus on identifying which data and the resources needed to be extracted and the standards mentioned in guidelines available in the company to be used as a benchmark or comparison. This data compilation is interpreted into a Microsoft Excel spreadsheet and charts. As the study focuses on mature field operations, the three elements been identified as study subjects, i.e. plant utilization as production declining, operating cost and unplanned trips or shutdown. From the data simulation sample, the performance of Field A can be summarized and visualized clearly, and the area of improvement required can be identified with value creation being estimated.

Indexed Terms- Performance analysis, offshore, assets

I. INTRODUCTION

Most offshore platforms are generally designed for 20-30 years [1] by considering the reservoir volume to be extracted, facilities, and well-developed concepts. These reservoirs are explored and discovered using geological assessments, geophysical methods such as seismic surveys and subsequently exploratory and appraisal drilling [2]. The phase without any production is referred to as the discovery phase. The fixed platforms structures are then installed, and the drilling campaign started. Normally, multiple wells drilled in each platform depending on the reservoir locations and volume and production started to increase in this development phase [3] until it reached the mid-life phase whereby the production profile is normally at peak as the reservoir pressure was still high. Once the production started, cash is generated to pay back for the previous investments. However, all offshore facilities are subjected to production decline as the reservoir volume is depleting over time [4]. This phase is referred to as mature operations. The operations can either be continued until reservoir volume is exhausted or redeveloped to increase production and prolong the production profile. The study area will be focusing on specific to this mature operation phase.

More challenges are encountered during the mature phase as the cash generation declines due to production rate decline. At the same time, the operating cost still maintains, if not increasing, leading to reduced profit. Meanwhile, as the mature operations phase normally occurs after a significant number of years in operation and moving towards its end of design life, the equipment started to deteriorate and
incurred higher maintenance costs and caused more unplanned shutdowns. The facilities still need to be
maintained according to the prescribed maintenance plan even though the duty services are far less than
the design capacity. These challenges often call for stakeholders to devise a strategy to improve business
economics by identifying measures such as minimising the unit production cost, process optimization
and simplification, production enhancement, or any combinations of the proposals.

This study will specifically focus on Peninsular Malaysia Assets, whereby around 90% of the assets
within the area are in the mature operations phase. The discussed issues are relevant to these assets,
even though the assessment is carried out independently with varied approaches and some are not
quantitatively measured [5]. Some initiatives were also carried out that were proven successful at
specific platforms but not replicated or assessed at other platforms that potentially have the same issue.

This study aims to develop a standardized analysis tool for mature operations to indicate field
performance, identify the performance gap, recommend the action plan and sample the tool using data
from selected Field A at Peninsular Malaysia Asset. In current practice at PETRONAS Carigali Sdn
Bhd, the most relevant and structured performance analysis specifically addressing the ageing offshore
platforms is normally conducted through Asset Life Extension Study (ALES). ALES intends to
understand the condition of these platforms in detail and provide recommendations that usually involve
major upgrade and improvements to ensure the platforms can operate beyond the design life. However,
this ALES study is very extensive and detailed, quite costly (ranging from MYR200,000 -
MYR300,000) and relatively time-consuming (ranging from 8 months to 16 months) as referred to the
previous record of ALES study for few fields in Peninsular Malaysia Assets operations. It is conducted
by technical experts or consultants, once-off towards the end of the mature operations phase. While
ALES is critically important to address the ageing assets, there is a need to have a simpler, high-level
assessment that can be done and updated periodically to assist the stakeholders in having indicative
operations performance and in establishing the focus for the area of improvements before investing cost
and manhours to conduct the detailed engineering. In summary, the parameters to be assessed are overall
unit production cost consisting of operations, maintenance, logistics costs, and equipment redundancy
philosophy for specific processing systems, namely separation, crude export, and compression systems.

On top of that, the production rate and deferment due to unplanned trips will also be quantified. All the
calculation is done in MYR currency with assumptions on foreign exchange rates, inflation rate, and
Brent crude price in USD currency, production rate (in kilo barrels per day, kbd for crude and
mmscf per day for gas).

II. METHODOLOGY

This project aims to assess the mature offshore operations performance to be able to identify the area
of focus for further improvement. As the performance assessment can cover a wide range of points of
view, e.g. change in operation philosophy, design duties, corrosion management etc., it is important
first to specify the boundary of the assessment and subjects to be focused on [4]. The assumptions to be
used throughout the project will need to be identified and defined. These will derive the extent of work,
data to be collected, and the desired visualization in the result. The study scope is limited to Peninsular
Malaysia Assets offshore platforms type, which is manned Complex Processing Plant and unmanned
remote platforms with general processing systems such as separation, crude export and compression
systems. The boundary and scopes of the study as shown in Table 1.

As depicted in Figure 1, the first step was completed by defining the three elements to be studied.
The plant utilization as a result of decreasing production rate, operation cost analysis and unplanned
trips study. The analysis tool developed is aimed to study those subjects and are sampled using Field
A’s operational days as a case study to demonstrate the data visualization, gap analysis and proposal
for improvement that can be generated using this tool.
Table 1: Boundary and Scope of Study

<table>
<thead>
<tr>
<th>No</th>
<th>Items</th>
<th>The boundary of the Study</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Field location</td>
<td>Field A, Peninsular Malaysia Assets</td>
</tr>
<tr>
<td>2</td>
<td>Type of facilities</td>
<td>Manned Complex Processing Plant (CPP) and Unmanned remote platforms</td>
</tr>
<tr>
<td>3</td>
<td>Subject and Parameters to be assessed</td>
<td>Unit Production Cost (UPC)- MYR/barrel</td>
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<tr>
<td></td>
<td></td>
<td>OPEX for logistics, operation, maintenance (MYR)</td>
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<tr>
<td></td>
<td></td>
<td>Production Manifold system performance (pressure, psi)</td>
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<tr>
<td></td>
<td></td>
<td>Separation Trains (flowrate kilo barrels oil per day, kbd for crude and mmscf per day for gas)</td>
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<tr>
<td></td>
<td></td>
<td>Compression System (flowrate mmscf per day)</td>
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<tr>
<td>4</td>
<td>Assumptions</td>
<td>Brent Crude Oil Price and USD Foreign Exchange rate is assumed using PETRONAS KPBI Subsurface study is excluded</td>
</tr>
<tr>
<td>5</td>
<td>Software or Tools to be used</td>
<td>Microsoft Excel</td>
</tr>
</tbody>
</table>

Figure 1: Project Methodology

2.1 Development of the framework for Analysis Tool

The framework of the analysis tool is developed to understand the type of data required and its resources, either from guidelines or specific reports as shown in Figure 2. For the first element to study the impact of production decline on plant utilization, the data required is the number of equipment available for each system, i.e. separation system, crude export, and gas compression systems. This information can be summarized from the Process Flow Diagram and Operation Philosophy (PCSB ORSA, 2019) accordingly [5]. The design capacity for each equipment is extracted from Equipment Dossiers, and for each system, there is an equipment redundancy philosophy applied.
The design capacity data is then compared with production profile or throughput to understand the percentage of plant utilization and the estimated year that the process can be simplified by removing some equipment. The production profile data to be used for each system are different, such as for separation system, Full-Well-Stream (FWS) profile consolidated from each well is required, whereas, for crude transfer pump system, the export profile (kbpd) is gathered. Meanwhile, for the gas system, it is important to have a detailed profile for each Low Pressure (LP) gas and High Pressure (HP) gas profile. Historical actual production and future forecasts are separate systems or reports, but both are equally important to understand the trend better. For the second element, the operation cost is generated by using activity planning as a basis. By understanding the cost breakdown, it is easier to identify which
area requires improvement and which activities can be optimized to improve the expenditure. The overall cost is compared to the target set in OEMS (cite literature), i.e. the Unit Production Cost (MYR/bbl) to be kept within 30% of the Brent crude price. Using the standard specified, the data required is the sale production profile, Brent crude price and foreign exchange rate. This comparison will demonstrate that the field will start to operate outside of the OEMS required to benchmark the estimated year. The third element, the unplanned shutdown, is analyzed as most mature field deals with ageing equipment tend to break down frequently. From the interview of several personnel in the Production and Reliability team, every unplanned shutdown shall be recorded and categorized into five main categories based on the SPO-12 Coding Guideline, namely due to Process, Wells, Rotating Equipment, External and Others factors. The unplanned shutdown data (actual deferment volume and target volume limit) is extracted from Production Report and matched with the coding report or the root cause in the Reliability report to be visualized into a pie chart. The most contributor to unplanned shutdown can be identified, and necessary improvement can be planned. It is also compared to the standard specified in OEMS for acceptable deferment volume and bad actor identification. After the framework is established on the data required and the data resources, the analysis tool is developed using Microsoft Excel based on the framework. In this study, to simulate the data, Field A was chosen as a case study. Hence, all data relevant to Field A is gathered and then entered into the analysis tool to provide performance, gaps, recommended proposals, and economic analysis for the analysis proposed options. This will give the decision-makers a high-level view on the area of concern and assisting them in deciding the deployment of the resources to carry out further detailed study and/or engineering.

III. RESULTS AND DISCUSSION

The analysis tool template was developed to assess the performance for any field with the same basic processing system. For result discussion purposes, the analysis tool was modelled using Field A’s operational data. The result of the data simulation is summarized into three different sections and charts to address the three subjects under study. For each section, the tool provides analysis interpretation on the gap or focus area and provides recommendations for the next action plan.

3.1 Plant Utilization due to Production Decline

The first element is plant throughput as compared to plant design, visualized in Capacity Limit Chart below. The operation philosophy for equipment redundancy is visualized via the stacked column, i.e. COTP operating philosophy is 3x50%, Gas Scrubbers philosophy is 2x50%, LP compressor is 4x50%, and HP compressor is 2x50%. Figure 3 shows that the production profile is decreasing over time, and the throughput is mostly less than 50% of the design capacity.

Referring to Figure 4 and 5, few gaps and possible value optimizations are identified. The first gap identified is the COTP system. With current production in 2020 and future outlook, the production rate can fit into only one COTP; hence the operation philosophy can be considered to change from 3x50% to 2x100%. By changing the philosophy, one unit of the COTP can be removed or mothballed and operating, and maintenance costs will be reduced by an estimated MYR200,000 yearly. The cost reduction data is estimated using the second element of the tool, i.e. operating cost analysis. Also, it is observed from the chart that starting 2022, the production forecast is estimated to fit into only one unit of LP compressor train. This enables the operating philosophy to change from 4 x 50% to 2x 100%. The two units of Booster compressors (serving LP compression system) can be removed or mothballed to reduce the cost further, estimated at MYR350,000 per year. Also, the LP Gas Scrubber can be accommodated by only one unit instead of two, and permanently shut down the other unit of scrubber together with its two units of condensate pump can reduce the operating cost by MYR150,000 yearly. It can be summarized from this analysis that management can deploy manpower and resources to study this recommendation further by conducting flow assurance, adequacy check and relevant engineering study to ensure the initiatives can be implemented. Also, at the time this analysis is carried out, ALES
for Field A is yet to be scheduled, hence showing that the process simplification and cost optimization can be identified earlier and result in better value optimization.

**Figure 3:** Plant Utilization resulted from Production decline

**Figure 4:** Simulation Result of Plant Utilization (Part A)
3.2 Operation Cost Analysis

In the second section, basic operations and maintenance activities are catalogued and compiled as specified in the Upstream Inspection and Maintenance Guideline (UIMAGe), with recommended frequency and cost as per the existing contract rate. By entering information on how much equipment is available, the manpower available for the field, the mode of logistics being used, and the total yearly operating cost for Field A. Figure 6 shows the total operating cost to the limit of 30% of Brent Crude price. From this figure, it is clear that the production decreases while the operation cost maintains at around the same level. The 30% crude price limit line fluctuates due to the crude price and foreign exchange rate fluctuation itself. The PETRONAS key assumption KPBI was revised to reflect the slow increase in future estimation from the recent major drop in crude oil price. Also, this analysis, shows that Field A operating cost will reach its 30% crude price limit in 2029. By having this forecast upfront, the operation management team will have ample time to strategize the change in how the plant to be operated in future to optimize the cost.

If the chart is further focused on without visualizing the 30% crude price limit line (Figure 7), the total cost breakdown can be understood better. The majority of the cost is contributed by Surface, Maintenance and Logistics cost. With this information, the proposal for reducing the operating cost can be strategized effectively. For example, the operation team will adopt the process simplification as proposed in item 3.1 and reduce the maintenance cost. Also, the maintenance philosophy can be revised to reduce the frequency of maintenance towards the end of life. Meanwhile, the surface and logistic costs can be further reduced by reducing the manpower and the visit frequency to remote platforms.
In the third section, the analysis focuses on identifying trends in equipment integrity, and unplanned deferment as the mature offshore fields are usually aged, and frequent trips are expected. Specifically, for Field A, the platforms are almost 20 years in operation. The equipment integrity is analyzed by consolidating the unplanned plant trips record from 2016 to 2019 and filtering the root cause of the trips. As all the trips were categorized into a coding, repetitive trips due to the same root, the cause will be identified. From data compilation for unplanned trips for Field A in Figure 8, the unplanned shutdowns only contribute to 2.27% from overall plant availability, compared to the benchmark of world class operators specified in OEMS to be below 15%. From this analysis, it indicates that Field A does not address alarming issues on equipment breakdown that affecting plant availability.
Figure 8: Unplanned Shutdown volume percentage for the duration of 2016-2019

The unplanned shutdown records are further analyzed and represented in the pie chart in Figure 9, showing that most of the unplanned deferment or trips are due to wells behavior such as low reservoir pressure, inability to flow, well control tripped, etc. The second root cause category is process control upset, such as gas lift valve stuck, leaking at process control valve, etc. Even though the causes are not repetitive for the same instrumentation equipment, it is noted that the majority of the event is due to valve maintenance. Hence, one of the proposals for improvement to be taken up is improving on valve maintenance scope and inspection. The other root cause falls within external factors, which are usually uncontrollable, such as bad weather and instruction from receiving end at offshore as part of overall gas supply network management. Rotating equipment was found to have a very minimum unplanned trip.

IV. CONCLUSION

Performance analysis is a vital aspect of having an effective operation management system. Without this, the actual performance of any business or operations would not be understood fully. In this study, few problematic areas can be identified from the analysis, and an action plan can be strategized better to address specific issues normally faced by the mature operations phase, namely declining production rate that calls for process simplification and operating cost and maintenance philosophy to be further optimized to ensure business economics. Although the analysis tool is modelled using Field A’s operational data, it can be replicated for any other field with a basic processing system of separation, crude export, and gas compression. The analysis tool or template must be configured once for each field and only require data updates in subsequent years or periods. Automatic data retrieval will improve the tool tremendously as it can provide real-time analysis and reduce the resources and manhours. The analysis tool only provides indicative problems and proposals and is completed with a detailed engineering study. It also does not replace the thorough and holistic assessment of asset life study.
Figure 9 Unplanned shutdown root cause category analysis

REFERENCES