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ANALYSIS OF STABILITY OF *LUBRICATING OIL DISCHARGE* USING THE *INDIVIDUAL MOVING RANGE* (IM-R) *CHART METHOD*

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ABSTRACT

The stability of lubricant oil expenditure at PetroChina International Jabung Ltd with the aim of preventing dead stock. Dead stock is defined as material stock that has not been used or issued for more than five years. The existence of dead stock can lead to excess materials, which results in wasted costs. Specifically, if PetroChina experiences excess materials, the funds used to purchase lubricating oil will not be reimbursed by the state. The data used is oil lubricating production data for the period January 2022-December 2024 each month with a total of 36 observations. To analyze oil lubricating production stability, an Individual Moving Range (IM-R) chart is used, which is a Statistical Quality Control (SQC). The analysis results show several data points that are outside the control limits, indicating special cause variations in the oil lubricating production process. These uncontrolled points indicate that the process is not yet fully stable and can be influenced by factors outside of normal variations. The results of the study provide recommendations in the form of further investigation into the surge in oil lubricating production and optimizing demand planning through ROP/ROQ and SOQ to make oil lubricating production more consistent and avoid the risk of dead stock.

Keywords : IM-R Chart, PetroChina, Process Stability, Oil Lubricating

I. INTRODUCTION

The management of lubricating oil expenditure is a strategic aspect in the upstream oil and gas industry because it is directly related to operational continuity, cost efficiency, and compliance with regulatory requirements [7]. One material that plays an important role in supporting the reliability of production equipment is lubricating oil. Lubricating oil expenditure at PetroChina International Jabung Ltd is carried out continuously to meet operational activities and ensure that equipment can operate optimally. Suboptimal lubricating oil expenditure can lead to dead stock, especially when the amount of lubricating oil spent does not match the needs in the field.

Dead stock is defined as material stock that has not been used or removed for more than five years [4]. Dead stock can lead to excess materials, which results in wasted costs. Specifically, if PetroChina experiences excess materials, the funds used to purchase lubricating oil will not be reimbursed by the state [4]. Prevention of dead stock in Oil Lubricating NG Lube Long Life can be done by observing the stability of expenditure each month. This can help control storage capacity in the warehouse so that storage is not excessive and the movement of Oil Lubricating NG Lube Long Life is not hampered.

Based on PetroChina International Jabung Ltd monthly oil lubricant expenditure data for the period January 2022 - December 2024. The amount of expenditure shows significant fluctuations between months, with the lowest expenditure occurring in May 2023 and the highest expenditure occurring in July 2024. These relatively large expenditures indicate that the pattern of lubricating oil expenditure has not been consistent over time. This inconsistency has the potential to affect inventory management in the warehouse. Therefore, further analysis is needed to evaluate the stability of the lubricating oil expenditure process in order to support more accurate decision-making in inventory management and prevent dead stock.

This study uses individual moving range (I-MR) graphical analysis. Statistical Quality Control (SQC) has a statistical method-based approach that is used to monitor, control, and improve the quality of a production process [6]. In SQC, one of the tools that is often used is a control chart, which serves to monitor or observe the stability of a process and study changes in the process over time [5].

This study aims to analyze the stability of monthly lubricating oil expenditure at PetroChina International Jabung Ltd. using Individual Moving Range (I-MR) control charts, to support decision making related to inventory control and dead stock prevention.

II. METHOD

2.1. Data

This study uses secondary data with a monthly period obtained directly from the field asset department in the stock control section of PetroChina International Jabung Ltd. The data period used is January 2022-December 2024, which is for 3 years with a total of 36 data. The variable analyzed is the amount of Oil Lubricating expenditure.

2.2. Statistical Quality Control (SQC)

Statistical quality control (SQC) is a technique used in problem solving to monitor, control, analyze, process, and improve processes [6]. In this study, SQC was applied to analyze the stability of monthly oil lubricating expenditure. The characteristics of the data used were in the form of one observation value for each period (subgroup size n=1), making the Individual–Moving Range (I–MR) control chart the most suitable method compared to other control charts that require a larger subgroup size [2].

The process condition is declared statistically uncontrolled if there is one or more observation points outside the upper control limit (UCL) or lower control limit (LCL), indicating the presence of special cause variation outside the normal variation expected in process statistical control [1].

2.3. Control Chart

Control Chart is one of the tools (QC 7 tool) 7 quality control tools in graphic form and is used to monitor or monitor the stability of a process and study process changes over time [9]. Control charts are divided into two parts, namely variable control charts and attribute control charts. Variable control charts are control charts used for measurable quality data such as dimensions, weight, and volume. Variable control charts are control charts $\bar{x}$and $\bar{R}, \bar{x}$and $\bar{s}$, and control charts $I - MR$. While attribute control charts are control charts used for quality characteristic data that is not measured with a numerical scale. This attribute control chart consists of a control chart p, np, u and a control chart c [8].

2.4. Individual Moving Range (IM-R) Chart

Subgroups are not practically possible. An I-MR diagram is a combination of an I (Individual) diagram, which displays measurement results, and an MR (Moving Range) diagram, which displays the difference in numbers from one measurement to the next [3]. IM-R control chart is a variable control chart that is used if the number of observations from each subgroup is only one [5].
Moving range is calculated using the following formula:

$$MR_i = |x_i - x_{i-1}| \quad (1)$$

with :

i : the value $i$starts from the second observation data to the las observation

MR_i : moving range data to $- i$

x_i : amount of Oil Lubricating expenditure

x_{i-1} : observation data from the previous month

The control chart has three main lines, namely the Center Line (center line), Upper Control Limit (upper limit), and Lower Control Limit (lower limit) [3]. These lines are determined based on the average value of the individual moving range with its limits.

The individual average is obtained using the formula:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad (2)$$

with:

$\bar{x}$: average amount of expenditure

n : number of observation data

average moving range is obtained using the formula:

$$\overline{MR} = \frac{1}{n-1}\sum_{i=1}^{n-1} MR_i \quad (3)$$

with:

$\overline{MR}$: average moving range

$n-1$: the number of observation data is minus one

In the Individual diagram (I- chart), the boundaries are determined by the formula:

$$CL_I = \bar{x} \quad (4)$$

$$UCL_I = \bar{x} + 3\frac{\overline{MR}}{d_2} \quad (5)$$

$$LCL_I = \bar{x} - 3\frac{\overline{MR}}{d_2} \quad (6)$$

with :

CL_I: center line (center line) for I-chart

UCL_I: upper control limit (upper limit) for I-chart

LCL_I: lower control limit (lower limit) for I-chart

d_2: 1.128 (constant value with $n = 2$ the IM-R chart constant value table)

Meanwhile, for the moving range diagram (MR- chart), the limits are calculated using the formula:

$$CL_{MR} = \overline{MR} \quad (7)$$

$$UCL_{MR} = D_4 \times \overline{MR} \quad (8)$$

$$LCL_{MR} = D_3 \times \overline{MR} \quad (9)$$

with :

CL_{MR}: center line for I-MR *chart*

UCL_{MR}: upper control limit for I-MR *chart*

LCL_{MR}: lower control limit (lower limit) for$I-chart$

D_4: 3.267 (constant value with $n = 2$ the IM-R chart constant value table)

D_3: 0 (constant value with $n = 2$ the IM-R chart constant value table)

III. RESULTS AND DISCUSSION

3.1. Calculating Moving Range Values

The first step in analyzing the IM-R control chart is to calculate the MR value using Equation (1) based on the absolute difference between the two Oil Lubricating expenditure data.

$MR_i = |x_i - x_{i-1}|$

$MR_1 = \lvert x_2 - x_1 \rvert$	$MR_1 = \lvert 11.000 - 12.400 \rvert = 1.400$
$MR_2 = \lvert x_3 - x_2 \rvert$	$MR_2 = \lvert 1.400 - 11.000 \rvert = 9.600$
⋮	⋮
$MR_{35} = \lvert x_{36} - x_{35} \rvert$	$MR_{35} = \lvert 7.000 - 10.800 \rvert = 3.800$

3.2. Average Individual Value

After obtaining the MR value for each period, the next step is to calculate the average individual value and moving range using Equation (2) and Equation (3) based on Oil Lubricating material expenditure data.

Individual average value is obtained from dividing the Oil expenditure by Lubricating with the number of observations $n = 36$. This value is used as the center line on the individual control chart.

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$
$$\bar{x} = \frac{1}{36}\sum_{i=1}^{36} x_i$$
$$\bar{x} = \frac{1}{36}\sum_{i=1}^{36} (12.400 + 11.000 + 1.400 + \cdots + 7.000)$$
$$\bar{x} = \frac{1}{36} 468.200$$
$$\bar{x} = 13{,}005.56$$

From the calculations obtained, the average individual value $\bar{x} = 13{,}005.56$ shows that the average amount of Oil Lubricating expenditure is $13{,}005.56$ liters.

The average MR value is obtained from the sum of MR divided by the number of observations $n = 36$. This value is used to determine the average absolute data variation of two Oil Lubricating data.

$$\overline{MR} = \frac{1}{n-1}\sum_{i=1}^{n-1} MR_i$$
$$\overline{MR} = \frac{1}{36-1}\sum_{i=1}^{36-1} MR_i$$
$$\overline{MR} = \frac{1}{35}\sum_{i=1}^{35} MR_i$$
$$\overline{MR} = \frac{1}{35}(1.400 + 9.600 + 14.600 + \cdots + 3.800)$$
$$\overline{MR} = \frac{1}{35}\ 359.000$$
$$\overline{MR} = 10{,}257.1429$$

Based on the calculation, the average MR value is obtained of 10,257.1429 liters. This value indicates that there is an average difference in Oil Lubricating material expenditure of 10, 257.1429 liters between one period and the next.

3.3. IM-R Chart Control Limits

After obtaining the MR value, the average value of the individual and the average value of MR, the next step is to calculate the control limits. The control limits are CL, UCL, and LCL which are calculated based on Equations (4), (5), (6) for individuals and Equations (7), (8), (9) for the moving range. Calculating the control limits aims to separate normal and abnormal variations.

Control limits are calculated based on the individual mean values and the moving range average, using a constant d_2 for the subgroup size. $n = 2$ which is 1.128. This calculation is used to determine the Center Line (CL), Upper Control Limit (UCL), Lower Control Limit (LCL) on the individual control chart.

$CL_I = \bar{x}$
$CL_I = 13{,}005.56$
$UCL_I = \bar{x} + 3\ \frac{\overline{MR}}{d_2}$
$UCL_1 = 13{,}005.56 + 3 \times \frac{10.257{,}1429}{1.128} = 40{,}285.19$
$LCL_I = \bar{x} - 3\ \frac{\overline{MR}}{d_2}$
$LCL_1 = 13{,}005.56 - 3 \times \frac{10.257{,}1429}{1.128} = -14{,}274.08$

Control limits are calculated using constants D_3 and D_4 for subgroup sizes. $n = 2$ which is equal to $D_3 = 0$and $D_4 = 3,267$. with an average MR of 10,257.1429 liters. This calculation is used to determine the Center Line (CL), Upper Control Limit (UCL), Lower Control Limit (LCL) on individual control charts.

$CL_{MR} = \overline{MR}$
$CL_{MR} = 10{,}257.1429$
$UCL_{MR} = D_4\ .\ \overline{MR}$
$UCL_{MR} = 3.267\ \times\ 10{,}257.1429 = 33{,}510.09$
$LCL_{MR} = D_3\ .\ \overline{MR}$
$LCL_{MR} = 0 \times\ 10{,}257.1429 = 0$

3.4. IM-R Chart

Once all calculati.ons are complete, the next step is to input the NG Lube Long Life Oil Lubricating expenditure data into Microsoft Excel version 2021 to view the NG Lube Long Life Oil Lubricating graph. This graph shows whether the NG Lube Long Life Oil Lubricating data is within control limits or experiencing abnormal variations, so the company can make the right decisions for future material expenditures.

Procedure Steps:

1. Enter individual data values (x_i) into column A (e.g., A2:A37 for 36 observations).
2. Calculate moving ranges in column B: $MR_i = |x_i - x_{i-1}|$ starting from B3 (B2 blank).
3. Compute centerlines: $\bar{x}$ as AVERAGE(A2:A37) in a summary cell: $\overline{MR}$ as AVERAGE (B3:B37)

4. Calculate limits: $CL_I = \bar{x}$, $UCL_I = \bar{x} + 3\frac{\overline{MR}}{d_2}$, $LCL_I = \bar{x} - 3\frac{\overline{MR}}{d_2}$, $CL_{MR} = \overline{MR}$, $UCL_{MR} = D_4 \,.\, \overline{MR}$, $LCL_{MR} = D_3 \,.\, \overline{MR}$.
5. Plot: select data ranges for I and MR, insert scatter chart with lines, add horizontal lines for CL/UCL/LCL using error bars or secondary series.

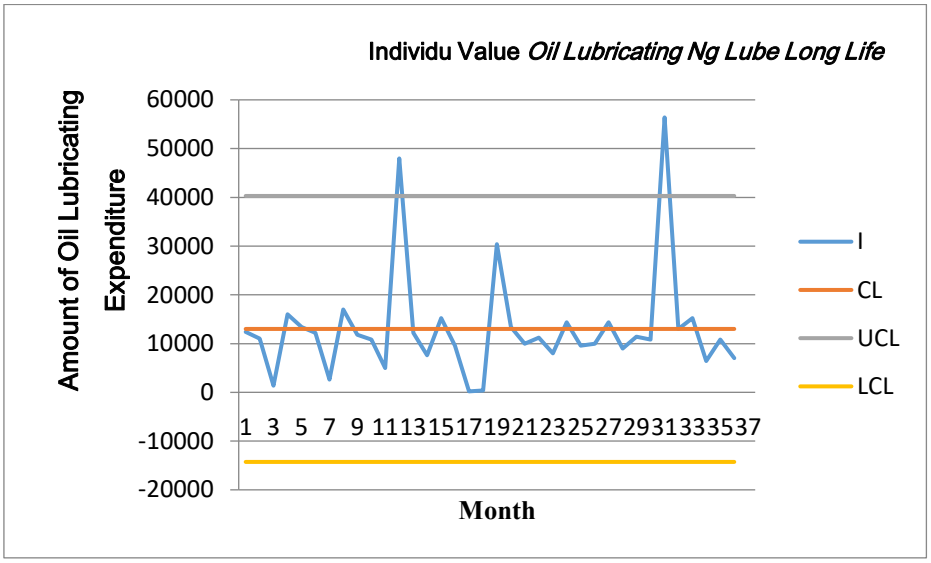

Figure 1. Individual Chart output results

Figure 1 shows the results of the Individual Chart. The vertical axis (Y) shows the amount of NG Lube Long Life Lubricating Oil expenditure while the horizontal axis (X) shows observations by month. The Individual Chart shows the number of observations as many as 36 points. The Center Line is at 13,005.56 the Upper Control Limit is at 40,285.19 and the Lower Control Limit is at -14,274.08 In general, all data points are within the control limits, which indicates that the process is statistically in control. However, there are quite striking fluctuations in values, especially at the points of December 2022 and July 2024 which are close to the UCL. This indicates uncontrolled variations due to several influencing factors.

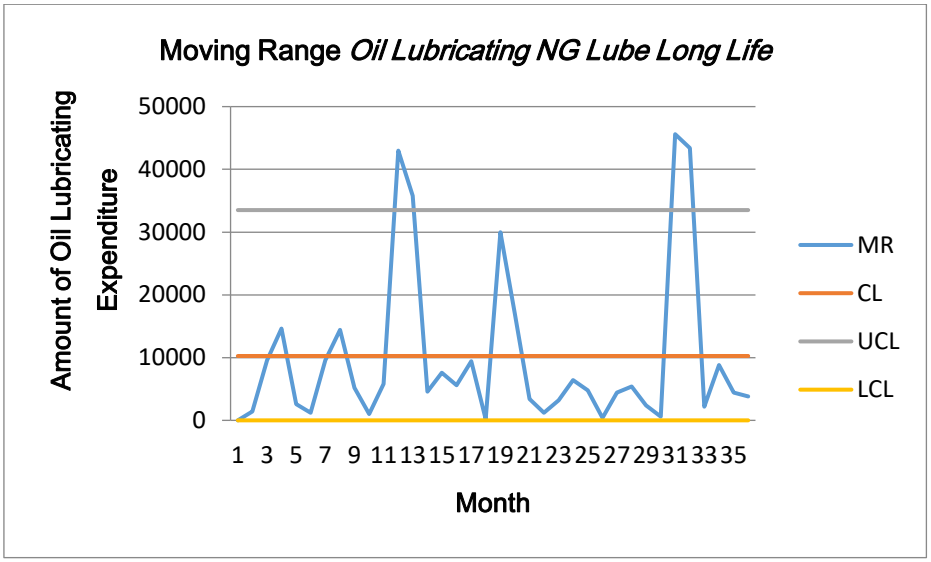

Figure 2. Moving Range Chart output results

Figure 2 shows the moving range results. The vertical axis (Y) shows the amount of NG Lube Long Life Oil Lubricating expenditure, while the horizontal axis (X) shows observations by month. The Moving Range chart shows the range of movement from one data point to the next. The centerline (CL) of the range is at 10,257.1429 with the UCL around 33,510.09 and the LCL at 0 (because the moving range cannot have a negative value). Four significant spikes are seen at points in November 2022, December 2022, June 2024, and July 2024 that approach or exceed the control limits. This indicates a large variation between four consecutive observations at these points. This change could occur due to several influencing factors. Overall, this control chart shows that NG Lube Long Life Oil Lubricating material expenditure experienced quite large variations, with several points outside the control limits. This indicates the need for further action to identify the cause of these variations.

IV. CONCLUSION

Based on the analysis of NG Lube Long Life Oil Lubricating material expenditure data for the period January 2022 to December 2024 using the Individual Moving Range (I-MR) Chart method, it shows that the average amount of Oil Lubricating material expenditure is 13,005.56 liters per month, although most of the data is within the statistical control limits, there are several points that are outside the control limits. On the individual chart, there are 2 points (in December 2022 and July 2024) that are outside the control limits, while on the moving range chart, there are 4 points (in November 2022, December 2022, June 2024 and July 2024) that are outside the control limits, this indicates a large variation, this indicates the need for further action to identify the cause of the variation.

Based on the analysis, it can be concluded that the oil lubricating production process at PetroChina International Jabung Ltd. is not yet fully statistically controlled. Therefore, the following recommendations should be considered:

1. Further investigate the surge in Ng Lube Long Life Oil Lubricating production between December 2022 and July 2024 to determine whether it was due to special operational needs or discrepancies in recording.
2. Optimize demand planning through ROP/ROQ and SOQ to ensure more consistent Ng Lube Long Life Oil Lubricating production and avoid the risk of dead stock.

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