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Analysis of P670 Pump Machine Effectiveness through OEE and TPM Methods at PT. XYZ

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ABSTRACT

PT. XYZ is a cooking oil manufacturing company. The machine used in the processing is the P670 pump machine, which causes a decline in the CPO process, resulting in an increase in the defect rate. This study was conducted to evaluate machine performance and defect factors using the OEE and TPM methods. The OEE analysis showed a value of 84%, which is below the international standard of 85%, and identified Six Big Losses with the highest percentage being Idling & Minor Stoppages Losses at 43.80%. In addition, five factors were identified, namely man, method, machine, material, and environment. Based on these results, improvements were made, namely cleaning schedules, adding alarm control sensors, machine maintenance, and operator training. To ensure effective implementation, a special team of technicians and operators was formed to oversee the implementation of improvements, evaluate by comparing OEE values before and after, conduct training every 2 weeks or once a month, assign a work area coordinator, develop a structured maintenance schedule, and establish a routine cleaning duty roster. Companies must apply these results to reduce losses in terms of time, product defects, effectiveness, and machine performance.

INTRODUCTION

The manufacturing industry is currently growing rapidly. Competition between companies requires them to be able to produce large quantities of goods while maintaining quality. In this situation, operational efficiency is one of the main keys for companies to survive and continue to grow. One of the most important aspects of this efficiency is the performance of the production machines used every day on the factory line (Adam & Mustofa, 2025). When machines are not working optimally, the production process can be disrupted. Time is wasted, product quality declines, and it can even cause huge losses for the company. That is why machine maintenance systems are so important. It is not just a matter of repairing machines when they break down, but also of preventing damage from occurring in the first place. According to (Ramadhani et al., 2022), Proper machine maintenance can help companies maximize the use of their resources and maintain production stability.

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PT. XYZ is a cooking oil manufacturing company that uses palm oil as its raw material. The performance of production machines has continued to improve over time due to high product sales capacity, but machine performance in the production area, especially in the refining department, has declined. As a result, PT. XYZ is responsible for the production and machine maintenance phases, and the processing of crude palm oil (CPO) requires many machines and equipment. Some of these are very important because they cause failures in the event of damage. The maintenance method system implemented plays an important role in determining the operational success of the company's facilities in carrying out the processing process. Damage occurring during the production process (breakdown) reflects a failure in the maintenance system implemented.

Figure 1. Repair of P670 Pump Machine

Recently, there have been frequent problems with production machinery, particularly related to pressure instability in the P670 pump and engine rotation, resulting in a decrease in Crude Palm Oil (CPO) passing through the CPO input process to the plant. This has led to an increase in defective products, causing losses for the company.

Previously, the company had never resolved issues using methods to maintain machine performance. Therefore, analysis will be conducted using the Overall Equipment Effectiveness (OEE) and Total Productive Maintenance (TPM) methods, as these methods are suitable for improving machine performance and effectiveness. OEE identifies Six Big Losses as a reference for assessing the effectiveness of machine or equipment use more accurately, thereby helping to determine areas that require improvement and performance enhancement (Wahid et al., 2022). TPM is a maintenance method that covers all aspects of company operations and aims to increase productivity or profits in an industrial environment, with the main objectives of achieving zero damage, zero product defects, and zero workplace accidents (Rafliadi et al., 2025). Therefore, a method is needed to measure the effectiveness of the P670 pump machine in order to improve its performance and maintain the quality of the production process desired by the company.

RESEARCH METHODS

Flowchart Diagram

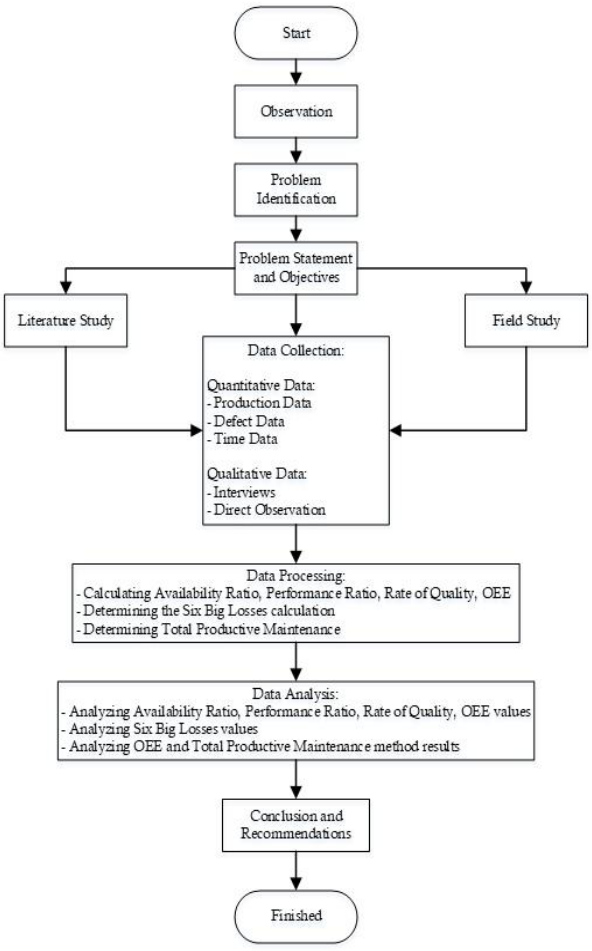

Figure 2. Flowchart Diagram

Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) is a comprehensive measure that indicates the theoretical performance and productivity of machines and equipment (Susanto et al., 2021). OEE measurement provides benefits for companies in assessing the effectiveness of their equipment or machinery, as well as determining its suitability for continued use in the production process. The suitability of equipment or machinery can be evaluated based on targets set by the company (Mulyati et al., 2022).

The world-class standard for OEE values is as follows (Putera et al., 2025) :

Table 1. Standar World Class OEE

Description	Value
Availability Ratio	90%
Performance Ratio	95%
Rate of Quality	99%
OEE	85%

To find the OEE value, you can use the three main ratios with the formulas below (Alfarisi & Andesta, 2024) :

$$OEE = Avaiability\ x\ Performance\ x\ Quality\ rate \quad (1)$$

- Availability Ratio
  A ratio that describes the utilization of available time in machine operations. Calculations used to measure the Availability Ratio (Suyatmo et al., 2023).

$$Availability = \frac{Planned\ Production\ Time - Downtime}{Planned\ Production\ Time} x100\% \quad (2)$$

- Performance Ratio
  A ratio used to describe the ability of equipment to produce goods or products, expressed as a percentage. Calculations used to measure the Performance Ratio (Ihsan, 2024).
  $$Performance\ Ratio = \frac{Output\ Total\ Production\ x\ Ideal\ Cycle\ Time}{Operation\ Time} x100\% \quad (3)$$

- Rate of Quality
  A ratio that describes the ability of equipment to produce products that meet standards. Calculations used to measure the Rate of Quality (Sabri & Geubrina, 2022).
  $$Rate\ of\ Quality = \frac{Output\ Actual\ Product - Total\ Product\ Defect}{Output\ Actual\ Production}\ x\ 100\% \quad (4)$$

Six Big Losses

The Six Big Losses method is an approach in production management that aims to identify and minimize six major categories of losses that can impact efficiency and productivity in a manufacturing environment (Putra et al., 2023).

Table 2. Six Big Losses Category

Six Big Losses Category	OEE Loss Category	OEE Factor
Equipment Failure Setup and Adjustment	Downtime Losses	Availability (A)
Idling & Minor Stopages Reduce Speed	Speed Losses	Performance (P)
Reduce Yield Quality Defect	Defect Losses	Quality (Q)

- Equipment Failure Losses
  Losses caused by equipment/machine defects and requiring repairs (Wibero, 2024).
  $$Equipment\ Failure\ Losses = \frac{Downtime}{Loading\ Time}\ x\ 100\% \quad (5)$$

- Set Up and Adjustment Losses
  Time lost due to machine setup, from the time the machine stops until it operates normally/starts the production process (Primula & Hamdy, 2023).
  $$Rate\ of\ Quality = \frac{Setup\ Time}{Loading\ Time}\ x\ 100\% \quad (6)$$

- Idling and Minor Stoppage Losses
  Losses caused by the machine stopping for a short time and having to be restarted, with no repairs required (Andri & Marikena, 2023).
  $$Idling\ and\ Minor\ Stoppage\ Losses = \frac{(Total\ Target - Total\ Production)\ x\ Ideal\ Cycle\ Time}{Loading\ Time}\ x\ 100\% \quad (7)$$

- Reduced Speed Losses
  Losses caused by machines operating slower than they should or below standard (Setiawannie & Marikena, 2022).
  $$Reduced\ Speed\ Losses = \frac{(Actual\ Cycle\ Time - Ideal\ Cycle\ Time)\ x\ Process\ Production}{Loading\ Time}\ x\ 100\% \quad (8)$$

- Quality Defect and Rework Losses
  Losses caused by products not being manufactured correctly from the beginning of the process (Pamungkas et al., 2024).

$$Quality\ Defect\ and\ Rework\ Losses = \frac{Ideal\ Cycle\ Time - Total\ Product\ Defect}{Loading\ Time}\ x\ 100\% \quad (9)$$

- Yield/Scrap Losses
  Losses caused by defects at the beginning of the production process (Musyafa'ah & Sofiana, 2022).

$$Yield\ Scrap\ Losses = \frac{Ideal\ Cycle\ Time - Number\ of\ Initial\ Production\ Defects}{Loading\ Time}\ x\ 100\% \quad (10)$$

Total Productive Maintenance (TPM)

A machine maintenance system that aims to reduce or eliminate machine breakdowns, the application of TPM principles can encourage improved performance and efficiency of machines or equipment, increased productivity, improved quality performance, reduced inventory, reduced workload, and fewer accidents (Syarifuddin et al., 2025).

According to (Ariyanto et al., 2024) the definition of Total Productive Maintenance (TPM) includes the following five elements :

1. TPM aims to create a Preventive Maintenance (PM) system to extend the service life of machinery/equipment.
2. Preventive Maintenance aims to maximize the Overall Effectiveness of machines/equipment.
3. TPM can be applied to various departments (engineering, production, maintenance).
4. TPM involves everyone from the highest levels of management to employees/production floor operators.
5. TPM is a development of a maintenance system based on preventive maintenance through motivational management.

RESULTS AND DISCUSSION

Data Collection

Data collection was conducted from August 1 to 19, 2025, through direct observation, interviews, and documentation at PT. XYZ, consisting of data on production, defects, and time. Those involved included employees/operators, supervisors, and quality control personnel.

Table 3. P670 Pump Machine Data

Time (Day)	Production time (Minute)	Loading Time (Minute)	Down Time (Minute)	Planned Down time (Minute)	Actual Cycle Time (Minute)	Product Defect (ton)	Output (ton)	Ideal Cycle Time Company (Minute)
01/08/2025	840	180	600	60	2,4	3,48	348,81	1,5
02/08/2025	1440	1000	420	20	1,86	7,73	773,86	1,5
03/08/2025	1440	1140	280	20	1,84	15,61	780,96	1,5
04/08/2025	1440	1100	320	20	1,84	11,69	779,46	1,5
05/08/2025	1440	1120	300	20	1,85	22,45	774,36	1,5
06/08/2025	1440	1060	360	20	1,86	38,6	772,06	1,5
07/08/2025	1440	1368	72	20	1,86	38,61	772,26	1,5
08/08/2025	1440	1360	80	20	1,88	13,85	765,16	1,5
09/08/2025	1440	1366	74	20	2,03	14,47	708,87	1,5
10/08/2025	1440	1355	85	20	1,9	19,16	755,36	1,5
11/08/2025	1440	1368	72	20	2,78	7,71	517,32	1,5
12/08/2025	1440	1363	77	20	1,91	16,87	752,86	1,5
13/08/2025	1440	1350	90	20	1,85	15,06	775,46	1,5

14/08/2025	1440	1340	100	20	1,84	13,36	779,56	1,5
15/08/2025	1440	1328	112	20	1,86	12,22	770,76	1,5
16/08/2025	1440	1361	79	20	1,91	17,91	752,86	1,5
17/08/2025	1440	1365	75	20	1,92	18,45	749,16	1,5
18/08/2025	1440	1352	88	20	1,85	13,21	776,26	1,5
19/08/2025	1440	1368	72	20	2,04	12,9	705,47	1,5

Source: Company Data

Data Processing

The processing on the P670 Pump machine in the process of processing palm oil into cooking oil will be calculated based on Availability, Performance, Quality, and OEE. A fishbone diagram will be created to identify the contributing factors, suggestions for improvement, and TPM analysis.

OEE Calculation for P670 Pump Machine

The steps for calculating OEE on the P670 pump machine are as follows :

a. Availability Ratio Calculation

Calculation example for August 1, 2025 :

Production Time = 840 minute

Planned Downtime = 60 minute

Downtime = 600 minute

Loading Time = Productione Time – Planned Downtime = 840 – 60 = 780 minute

$$\text{Availability} = \frac{780 - 600}{780} \times 100\% = 23{,}08\%$$

The results of the Availability Ratio calculation are shown in table 4 below :

Table 4. Availability Ratio Calculation

Date	Machine Working Time (Minute)	Planned Downtime (Minute)	Downtime (Minute)	Loading Time (Minute)	Availability (%)
01/08/2025	840	60	600	780	23,08%
02/08/2025	1440	20	420	1420	70,42%
03/08/2025	1440	20	280	1420	80,28%
04/08/2025	1440	20	320	1420	77,46%
05/08/2025	1440	20	300	1420	78,87%
06/08/2025	1440	20	360	1420	74,65%
07/08/2025	1440	20	72	1420	94,93%
08/08/2025	1440	20	80	1420	94,37%
09/08/2025	1440	20	74	1420	94,79%
10/08/2025	1440	20	85	1420	94,01%
11/08/2025	1440	20	72	1420	94,93%
12/08/2025	1440	20	77	1420	94,58%
13/08/2025	1440	20	90	1420	93,66%
14/08/2025	1440	20	100	1420	92,96%
15/08/2025	1440	20	112	1420	92,11%
16/08/2025	1440	20	79	1420	94,44%
17/08/2025	1440	20	75	1420	94,72%
18/08/2025	1440	20	88	1420	93,80%
19/08/2025	1440	20	72	1420	94,93%
Average	**1408,42**	**22,11**	**176,63**	**1386,32**	**85,74%**

Based on Table 4 above, the calculation results show that the average Availability Ratio from August 1 to 19 was 85.74%, which still does not meet the international standard of 90%.

b. Performance Ratio Calculation

Calculation example for August 1, 2025 :

Output Total Production = 348,81 ton

Actual Cycle Time = 2,40 menit/ton
Operation Time = 840 menit

$$\text{Performance Ratio} = \frac{2{,}40 \times 348{,}81}{840} \times 100\% = 99{,}66\%$$

The results of the Performance Ratio calculation are shown in table 5 below :

Table 5. Performance Ratio Calculation

Date	Production Time (Menit)	Output Total Production (Ton)	Ideal Cycle (Menit)	Performance (%)
01/08/2025	840	348,81	2,4	99,66%
02/08/2025	1440	773,86	1,86	99,96%
03/08/2025	1440	780,96	1,84	99,79%
04/08/2025	1440	779,46	1,84	99,60%
05/08/2025	1440	774,36	1,85	99,48%
06/08/2025	1440	772,06	1,86	99,72%
07/08/2025	1440	772,26	1,86	99,75%
08/08/2025	1440	765,16	1,88	99,90%
09/08/2025	1440	708,87	2,03	99,93%
10/08/2025	1440	755,36	1,9	99,67%
11/08/2025	1440	517,32	2,78	99,87%
12/08/2025	1440	752,86	1,91	99,86%
13/08/2025	1440	775,46	1,85	99,63%
14/08/2025	1440	779,56	1,84	99,61%
15/08/2025	1440	770,76	1,86	99,56%
16/08/2025	1440	752,86	1,91	99,86%
17/08/2025	1440	749,16	1,92	99,89%
18/08/2025	1440	776,26	1,85	99,73%
19/08/2025	1440	705,47	2,04	99,94%
Average	**1408,42**	**726,89**	**1,96**	**99,76%**

Based on table 5 above, the calculation results show that the average Performance Ratio from August 1 to 19 was 99,76%, which meets the international standard of 95%.

c. Calculation of Rate of Quality

Calculation example for August 1, 2025 :
Output Actual Production = 348,81 ton
Product Defect = 3,48 ton

$$\text{Rate of Quality} = \frac{348{,}81 - 3{,}48}{348{,}81} \times 100\% = 99\%$$

The results of the Rate of Quality calculation are shown in table 6 below :

Table 6. Rate of Quality Calculation

Date	Output Total Production (Ton)	Product Defect (Ton)	Quality (%)
01/08/2025	348,81	3,48	99,00%
02/08/2025	773,86	7,73	99,00%
03/08/2025	780,96	15,61	98,00%
04/08/2025	779,46	11,69	98,50%
05/08/2025	774,36	22,45	97,10%
06/08/2025	772,06	38,6	95,00%
07/08/2025	772,26	38,61	95,00%
08/08/2025	765,16	13,85	98,19%
09/08/2025	708,87	14,47	97,96%
10/08/2025	755,36	19,16	97,46%
11/08/2025	517,32	7,71	98,51%
12/08/2025	752,86	16,87	97,76%
13/08/2025	775,46	15,06	98,06%
14/08/2025	779,56	13,36	98,29%

15/08/2025	770,76	12,22	98,41%
16/08/2025	752,86	17,91	97,62%
17/08/2025	749,16	18,45	97,54%
18/08/2025	776,26	13,21	98,30%
19/08/2025	705,47	12,9	98,17%
Average	**726,89**	**16,49**	**97,78%**

Based on Table 6 above, the calculation results for the Rate of Quality from August 1 to 19 show a figure of 97,78%, which does not meet the international standard of 99%.

d. OEE Value Calculation

OEE = 86% x 100% x 98% = 84%

The OEE calculation results are shown in figure 2 below :

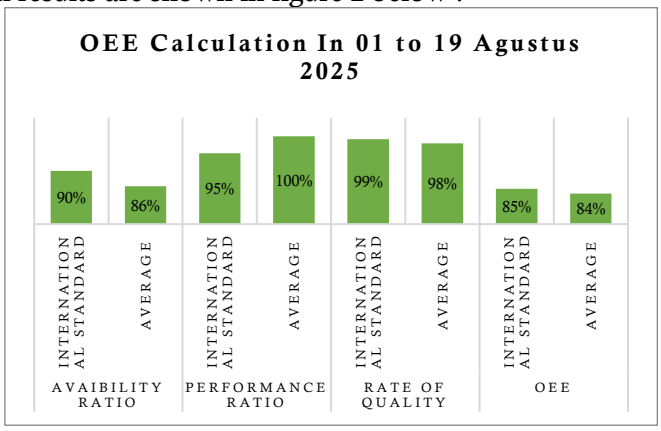

Figure 3. Comparison of OEE for P670 Pump Machines

Based on figure 2 above, it shows the OEE calculation from August 1 to 19. The calculation results are Availability Ratio of 86%, Performance Ratio of 100%, and Rate of Quality of 98%. This results in an OEE value of 84%, which does not meet the international standard of 85%.

Six Big Losses

Based on the OEE value of the P670 pump machine compared to the ideal OEE value standard, the company needs to take corrective action to improve the OEE value of the machine. Therefore, it is necessary to calculate the six big losses with the results shown in table 7 below :

Table 7. Percentage Six Big Losses

Six Big Losses	Percentage (%)
Equipment Failure Losses	14,44%
Setup & Adjusment Losses	1,81%
Idling & Minor Stoppages Losses	43,80%
Reduce Speed Losses	27,46%
Quality Defect Losses	2,02%
Yield Losses	2,02%

Table 7 shows the average percentage of six major losses, from which it can be concluded that there are six factors affecting machine performance, namely Equipment Failure Losses, Setup & Adjustment Losses, Idling & Minor Stoppages Losses, Reduce Speed Losses, Quality Defect Losses, and Yield Losses. The highest percentage in this calculation is Idling & Minor Stoppages Losses at 43,80%, and the lowest is Setup & Adjustment Losses at 1,81%. It can be concluded that based on the percentage for the Idling & Minor Stoppages Losses category, which hinders the productivity of the P670 pump machine due to idling and losses when not in operation, this is an important issue that must be addressed to achieve a significant increase in OEE.

Fishbone Diagram

Fishbone Diagrams are used to find the causes of failure. These failure factors are illustrated in figure 3. The fishbone data processing results in 5 factors causing defects.

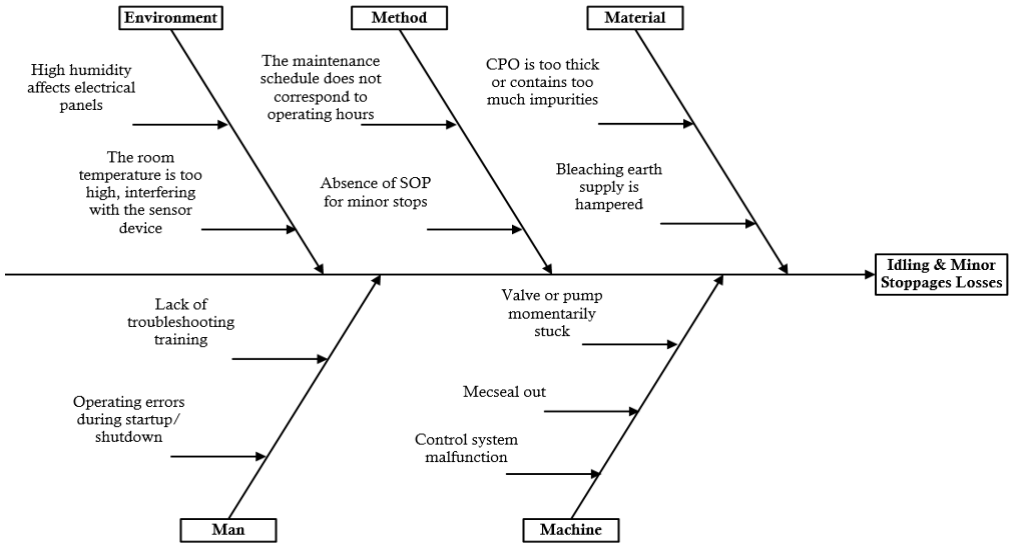

Figure 4. Fishbone Diagram

Therefore, the results of the fishbone diagram above need to be improved to address the issues of Idling & Minor Stoppages Losses. The following are improvements for the causes of Idling & Minor Stoppages Losses :

Table 8. Suggested Improvements

Type of Failure	Failure Factors	Causes of Failure	Suggested Improvements
Idling & Minor Stoppages Losses	Environment	An unclean, damp, and dirty environment makes the surrounding area less efficient in the production process, which affects the P670 pump machine	It is advisable to schedule regular cleaning during each shift
	Method	Insufficient monitoring, flow, or temperature resulted in pressure on the overhead of the P670 pump machine	An alarm is triggered on the room control when the temperature is about to exceed the standard, reaching the overhead limit
	Material	Liquids with high solid content that will cause erosion, resulting in rust on several parts of the P670 pump	Cleaning and replacement of rusted parts and replacement of materials
	Man	Operator error in monitoring or setting parameters resulted in the pump machine breaking down due to overload flow	Held more in-depth training for operators on operation
	Machine	A leaking seal causes fluid to leak from the pump	Performed daily, weekly, and annual maintenance

From the results in table 8 above, improvements can be seen in Idling & Minor Stoppages Losses. This means that the company can reduce the impact of factors such as unemployment and losses during non-operation, which hinder the productivity of the P670 pump machine.

Analysis Total Productive Maintenance (TPM)

The following is a TPM analysis based on factors affecting the effectiveness of the P670 pump machine :

1. **Autonomous Maintenance**
   In this aspect, operator errors were found in monitoring or setting parameters, which caused the pump to break down. This finding directly indicates the need to improve operator skills and knowledge. With proper training, operators can detect deviations early on, prevent errors, and perform minor maintenance independently.
2. **Preventive and PM**
   In this regard, a leaking seal was found, causing fluid to leak from the pump, high solid content causing erosion, and rust on parts of the pump. Both of these findings are problems that can be prevented with an effective maintenance routine. Preventive maintenance will identify worn seals or the impact of fluid materials before they cause major damage or downtime.
3. **Focused and Individual**
   In this regard, there was a lack of monitoring of flow, temperature, or pressure, which led to excessive pressure (overhead). This problem requires in-depth analysis to find the root cause, which can then be addressed with focused solutions, such as installing sensors or automatic warning systems.
4. **Occupational Safety and Environment**
   In this regard, the area around the machine was found to be unclean, damp, and dirty. A poor environment not only affects work safety, but also the effectiveness and service life of the machine. These findings emphasize the importance of maintaining cleanliness as an integral part of maintenance.
5. **Early Equipment Management**
   In this regard, operator errors, leaks, erosion, and environmental issues are important data that must be recorded and analyzed. Although these findings come from existing machines, the data is invaluable. The design team must use this information to ensure that future P670 pump models or other new equipment are designed with features that can prevent these problems from the outset.
6. **Quality Maintenance**
   In this aspect, there is a lack of monitoring of flow, temperature, or pressure that can affect the operational quality of the machine. Although this issue is recorded as Idling & Minor Stoppages, failure to control process parameters can cause variations in output quality. Therefore, improvements in this factor also have a positive impact on quality maintenance.

CONCLUSION

Based on research on the P670 pump machine using the OEE method, the Availability Ratio was 86%, the Performance Ratio was 100%, and the Rate of Quality was 98%, with an OEE value of 84%, which is still below the international standard of 85%. It was identified that the highest failure rate was in Idling & Minor Stoppages Losses. After the results were known, improvements were made, including a cleaning schedule, adding alarm control sensors, machine maintenance, and operator training. In order to implement these improvements effectively, the company must form a special team consisting of management representatives, technicians, and operators to oversee the implementation of improvements, conduct periodic evaluations by comparing OEE values before and after implementation, provide training every 2 weeks or once a month, assign work area coordinators to ensure that everything runs smoothly, develop a structured maintenance schedule, and establish a routine cleaning schedule. For future research, the OEE and TPM methods can be applied to other machines in this company or others that have not previously implemented these methods to improve machine performance and effectiveness.

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