# Analysis of Centrifugal Pump Machine Performance Using the Overall Equipment Effectiveness (OEE) Method (Case Study: PT. XYZ)

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Received: 2023-05-11 Received in revised from: 2023-06-02 Accepted: 2023-06-05

***Abstract***

Improving performance in a company is a key factor in increasing efficiency and productivity. However, often the improvement efforts made are ineffective because they do not address the root cause of the problem. The Total Productive Maintenance (TPM) concept with its components can clearly identify the root cause of the problem and its contributing factors, allowing improvements to be focused on the appropriate aspects. One method of measuring machine performance used is Overall Equipment Effectiveness (OEE), which calculates factors such as availability, performance efficiency, and quality level. In a case study at PT.XYZ, OEE was used to analyze the performance of distribution pump machines. During the period of August 2022, the OEE value for each pump machine reached 99%, which exceeded the world-class OEE of 85%. However, the analysis showed that Idling Minor Stop Losses was the main cause of losses that affected machine effectiveness, with a percentage of losses reaching 82%.

***Keywords:*** *Total Productive Maintenance (TPM), Overall Equipment Effectiveness (OEE), Idling Minor Stop Losses, Performance Improvement, pump machine performance analysis.*

## 1. Introduction

The efforts to improve the performance of a company is an important factor that must be considered. But in reality, these efforts are often ineffective because it only deals with symptoms without addressing the root cause. Companies have difficulty finding the factors that cause problems due to the lack of available data. Therefore, it is necessary to have a method that can clearly identify the problems that focus on correcting the real root cause [1]. Total Productive Maintenance (TPM) consists of three components, namely total approach, productive action, and maintenance which can identify root causes and causal factors for improvement. Through Overall Equipment Effectiveness (OEE), which is a method of measuring the level of effectiveness in the use of an equipment or system by including several points of view in the calculation process. This measurement method consists of three main factors that are interconnected, namely availability, performance, and quality [2]-[4].

PT. XYZ is a company that provides clean water service in the city of Surabaya and its surroundings, as a company that serves the provision of clean water in the city of Surabaya, of course PT. XYZ strives to optimize the operational performance of city distribution pumps to improve a better service so that the supply of clean water to customers can be distributed smoothly and meet customers' clean water needs.

The operational level of the pump machine at PT. XYZ is so high that within a week operational pump is replaced to anticipate damage to the distribution pumps. The existence of an old pump machine can lead to longer machine maintenance and search for spare parts that are already scarce, resulting in high machine downtime and the machine being unable to be used for a long time[5][6]. Damage to the machine or machine components can cause a decrease in performance, resulting in the water discharge coming out of the pump machine does not match the standard stated on the machine's nameplate, and the availability of the pump machine will also decrease to distribute clean water to consumers.

## 2. Method

The research methodology will outline each step of the process, from start to finish. This phase consists of a series of steps to gather information to be used for research to address a problem, enabling the researcher to proceed methodically and with clear objectives. The following are research steps shown in the figure below:

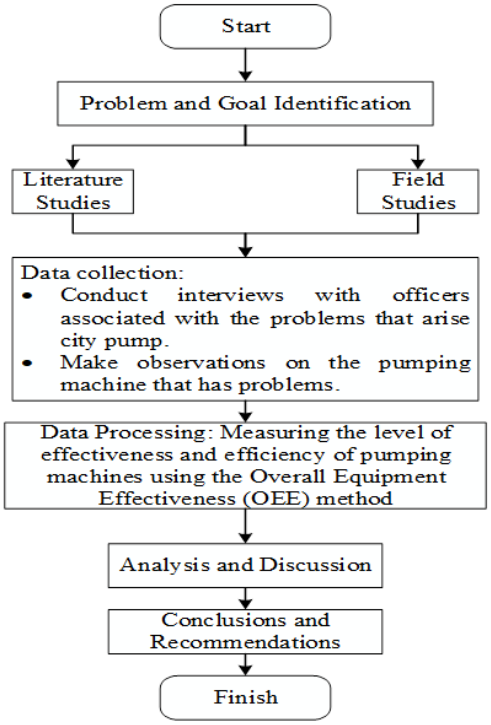


Figure 1. Research Method Flowchart

## 3. Results and Discussion

### Data Collection and Processing

Production data from PT. XYZ that has been collected:

Table 1. Production Results ($m^3$) for December 2022

| Distribution Pump Machine *Production* Data ($m^3$) | | |
|---|---|---|
| No | Pump | $m^3$ |
| 1 | South distribution pump No. 1 | 380.634 |
| 2 | South distribution pump No. 2 | 156.146 |
| 3 | South distribution pump No. 3 | 136.516 |
| Total | | 673.295 |

### Planned Downtime and Setup and Adjustment Data of Pumping Machines

Table 2. South Distribution Pump *Planned Downtime* Data for December 2022

| *Planned Downtime* of Pump Machines Data (Hours) | | |
|---|---|---|
| No | Pump | Hours |
| 1 | South distribution pump No. 1 | 336 |
| 2 | South distribution pump No. 2 | 168 |
| 3 | South distribution pump No. 3 | 168 |

Table 3. South Distribution Pump *Setup and Adjustment* Data for December 2022

| Pump Machine *Setup and Adjustment* Data (Hours) | | |
|---|---|---|
| No | Pump | Hours |
| 1 | South distribution pump No. 1 | 8 |
| 2 | South distribution pump No. 2 | 5 |
| 3 | South distribution pump No. 3 | 3 |

**Total Breakdown Data of Pump Machines**

From the results of observations on the pump machines in the south distribution pump house, total breakdown data on the pump machines were obtained

Table 4. South Distribution Pump *Total Breakdown* Data for December 2022

| Pump *Total Breakdown* Data (Hours) | | |
|---|---|---|
| No | Pump | Hours |
| 1 | South distribution pump No. 1 | 0 |
| 2 | South distribution pump No. 2 | 0 |
| 3 | South distribution pump No. 3 | 0 |

***Total Downtime* Data of Pump Machines**

From the results of observations on the pump machines in the south distribution pump house, there are Total Downtime data obtained from the following formula [7]:

$$Total\ downtime = Total\ Breakdown \pm\ \ Setup\ and\ Adjustment\ Time$$

After the *Planned Downtime* and *Setup Adjustment* times are totaled, the following is the result of the Total Downtime of the pump machines using the formula above:

Table 5. South Distribution Pump *Total Downtime* Data for December 2022

| Data *Total Downtime* Mesin Pompa (Hours) | | |
|---|---|---|
| No | Pump | Hours |
| 1 | South distribution pump No. 1 | 8 |
| 2 | South distribution pump No. 2 | 5 |
| 3 | South distribution pump No. 3 | 3 |

**Overall Equipment Effectiveness Analysis (OEE)**

The results of the calculation of *Overall Equipment Effectiveness* (OEE) which is the result of multiplying the *Availability Ratio*, *Performance Efficiency*, and *Quality Rate* Products on the three pump machines [8].

Tabel 6. South Distribution Pump OEE Result Data for December 2022

| Pump Machine Overall Equipment Effectiveness (OEE) data | | | | | | |
|---|---|---|---|---|---|---|
| No | Pump | *Availibility Rate* | *Performance Rate* | *Rate of Quality* | OEE | JIPM |
| 1 | South distribution pump No. 1 | 98% | 100% | 100% | 99% | 85% |
| 2 | South distribution pump No. 2 | 99% | 100% | 100% | 99% | 85% |
| 3 | South distribution pump No. 3 | 99% | 100% | 100% | 100% | 85% |
| Rata-Rata | | | | | 99% | |

The *Overal Equipment Effectiveness* (OEE) values were obtained at around 99%, the results of the machines' *Availability ratio* were between 98% and 99%, the results of the *Performance Efficiency ratio* are around 100% for the three pump machines and the results of the *Quality ratio* are around 100% for each machine pumps in the south distribution pump house. These results have exceeded the results of *World Class* OEE by 85% [9][10].

### ***Six Big Losses*** **Calculation Analysis**

The depiction of Pareto diagram in data processing can be seen that the *Idling Minor Stop Losses* factor has the largest percentage of the six factors that cause losses that affect the effectiveness of the machine. The analysis is done by looking at the cumulative percentage of the *Six Big Losses* factors, and we can see in the Figure 2,3 and 4:

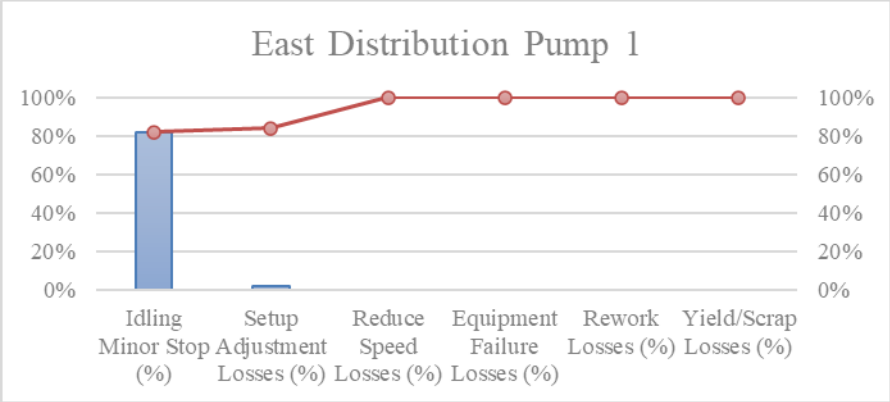


Figure 2. Pareto Diagram of *Six Big Losses* Percentage of Distribution Pump Machine 1

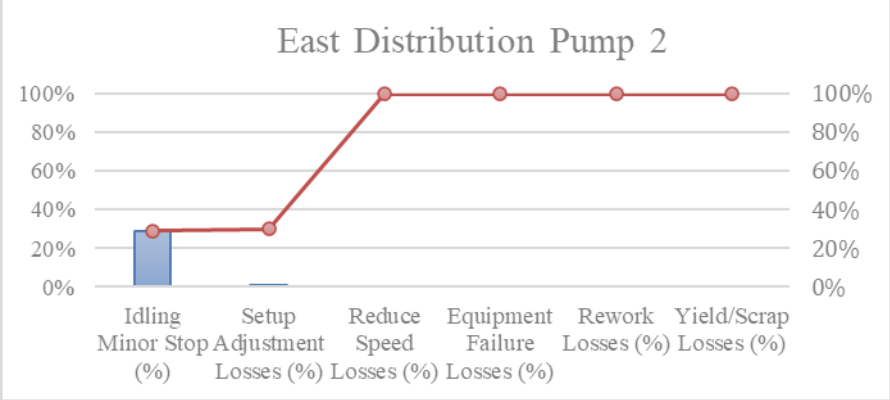


Figure 3. Pareto Diagram of *Six Big Losses* Percentage of Distribution Pump Machine 2

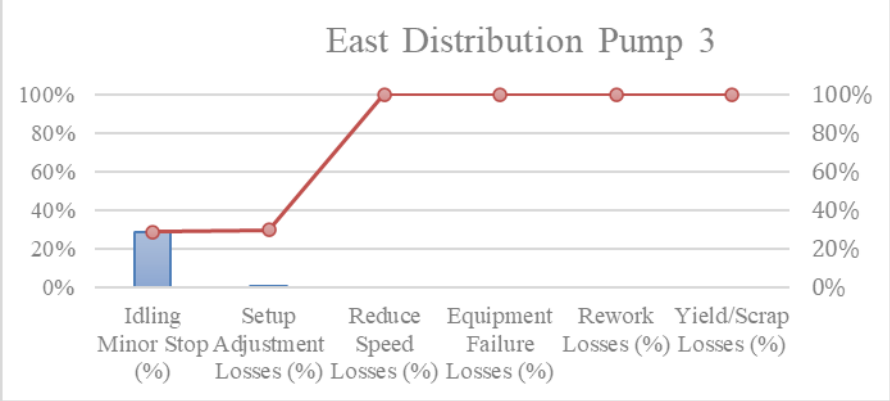


Figure 4. Pareto Diagram of *Six Big Losses* Percentage of Distribution Pump Machine 3

From the pareto diagram above it can be seen that the factor that has the largest percentage of the six factors is *Idling Minor Stop Losses*, amounting to 82% for distribution pump 1, and 29% for pumps 2 and 3.

***Fishbone* Chart**

Through the Pareto diagram, it can be seen that the factor that contributes the most to the six big losses is the *Idling Minor Stop Losses* by 82% for the distribution pump machine 1, 29% for the distribution pump machine 2, and 29% for the distribution pump machine 3. According to the Pareto Rule (rule of 80%) then the cumulative percentage value that is close to or equal to 80% is the priority for the formulation of the problem which will be discussed next. Therefore, the main trigger factor for *idling minor stop losses* will be analyzed using a *cause-and-effect* diagram which can be seen in the red circle in the Figure 5.

From the analysis of the cause-and-effect diagram for the *Idling Minor Stoppages Losses* factor, a *Fishbone* chart analysis is obtained for the south distribution pump machine:

*Material*

1. Ordering spare parts takes a long time.
2. Spare parts that are not original have different component material strengths, which can affect pump performance.

*Machine*

1. There are damaged or worn-out pump engine components so the weekly pump change becomes longer.
2. There are components in the pump engine that are old, which can affect pump performance.

*Method*

1. Production employees as pump operators do not follow the weekly pump change SOP steps correctly. So that it can cause cavitation in the engine.

*Man*

1. Production employees as pump operators are not careful about the presence of cavitation on the machine during the weekly pump change and tend to rush. Which can result in the pump not working optimally.

*Environment*

1. The pump room has a high machinery noise level. due to the old age of the pump and electromotor components it can cause a very noisy sound in the pump housing.
2. The pump room has a humid environment. Due to the old age of the pump, there is a condition where the pump seal is leaking, resulting in water coming out between the pump engine seals.

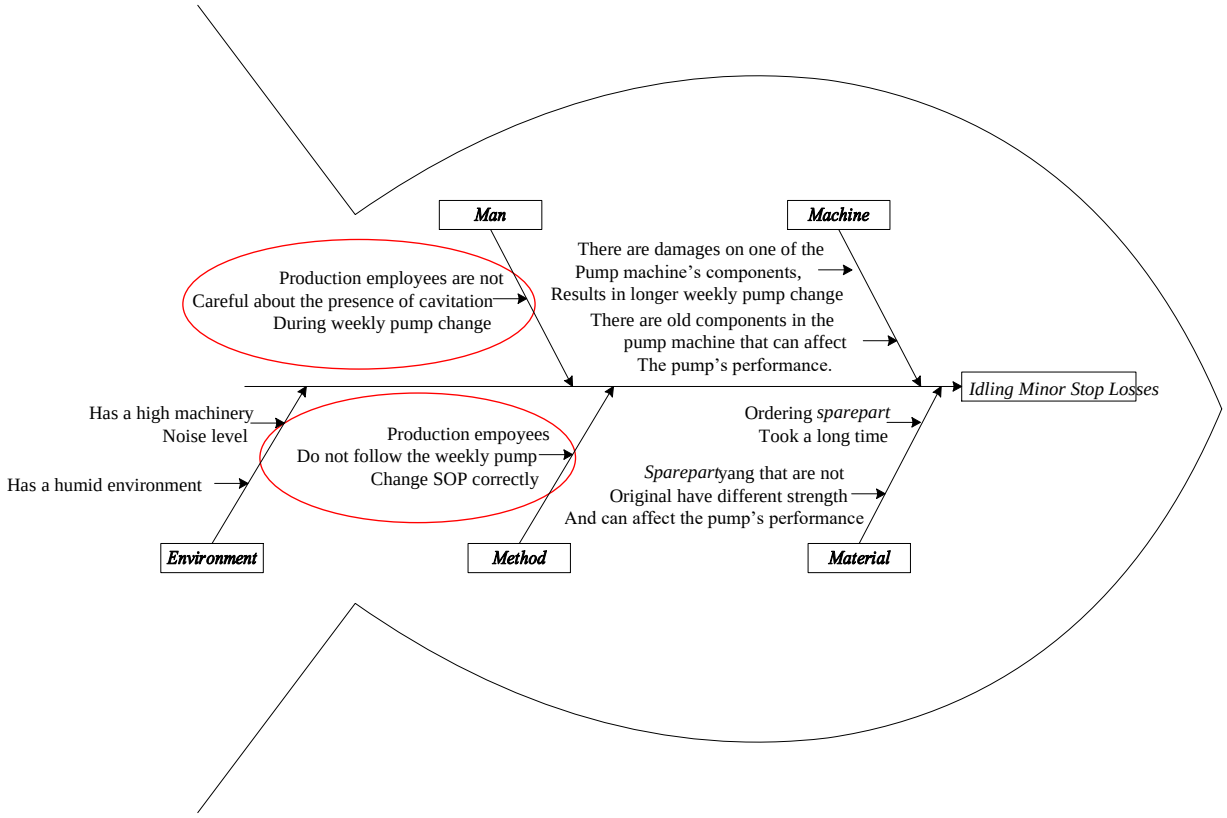


Figure 5. *Fishbone* chart on Distribution Pump Machine

## Suggested Improvements

Based on the percentage of the Pareto diagram of all the Six Big Losses factors, it can be seen that the percentage of the Idling Minor Stoppages Losses factor has the largest percentage and is a factor that greatly influences the effectiveness of the machine. Therefore, it is necessary to propose improvements to deal with this:

1. Suggested improvements on engine factors

   The availability of production machines that are ready to be used in production activities is very important, the machines used should not be damaged for a long time because it will disrupt the course of production and affect the level of productivity. The steps for solving machine-related problems are:

   a) By increasing maintenance on the machine, either weekly or monthly. Check the grease on the electromotor shaft coupling bearing to the pump engine. Check if there is a leak in the engine seal. Check for loose engine bolts. Perform replacement of worn or aged engine components.

2. Suggested improvements on labor factor

   The labor factor gets more attention because humans are part of a working system that plays the role of the operator of the machine, with various characteristics and abilities that can have a major influence on business success and increase machine effectiveness. Steps to overcome labor-related problems are:

   a) Providing more effective training for new workers or old workers, with the aim of the training is to increase the skills of production employees in operating the pump machines.

b) Implementing stricter sanctions against workers who do not follow the SOP steps in operating pump machines.

## 4. Conclussion

The *Overal Equipment Effectiveness* (OEE) values were obtained at around 99% for each pump machine in the south distribution pump house, with the result of the *availability ratio* of pump machines at 98% for distribution pump machine 1 and 99% for distribution pump machine 2 and 3, the *Performance Efficiency ratio* is around 100% for each pump machine and the *Quality Ratio* is around 100% for each pump machine. The OEE results for each pump in the south distribution pump house have exceeded the *world-class* OEE results by 85%. In data processing, it can be seen that the *Idling Minor Stop Losses* factor which has the largest percentage of the six factors on the *man* and *method* factors causes losses that affect the effectiveness of the machine, with a loss percentage of 82%.

The following are the results of the six big losses analysis on the pump machine:

*Material*

1. Ordering spare parts takes a long time.
2. Spare parts that are not original have different component material strengths, which can affect pump performance.

*Machine*

1. There are damaged or worn-out pump engine components so the weekly pump change becomes longer.
2. There are components in the pump engine that are old, which can affect pump performance.

*Method*

1. Production employees as pump operators do not follow the weekly pump change SOP steps correctly. So that it can cause cavitation in the engine.

*Man*

1. Production employees as pump operators are not careful about the presence of cavitation on the machine during the weekly pump change and tend to rush. Which can result in the pump not working optimally.

*Environment*

1. The pump room has a high machinery noise level. due to the old age of the pump and electromotor components it can cause a very noisy sound in the pump housing.
2. The pump room has a humid environment. Due to the old age of the pump, there is a condition where the pump seal is leaking, resulting in water coming out between the pump engine seals.

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