# Measurement of Machine Effectiveness Using the Overall Equipment Effectiveness (OEE) Value Approach on the BX-75 Machine (A Case Study)

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**Abstract**

PT XYZ is a company engaged in the pipe industry with various types of HDPE pipe products according to consumer needs. PT XYZ has problems with the BX-75 engine because it has a high breakdown value and is obtained from historical production data. The high breakdown caused the production process of the BX-75 engine to be hampered and the daily production target was reduced. To determine the effectiveness of the BX-75 engine, measurements using the Overall Equipment Effectiveness (OEE) method are needed. The research was conducted using the OEE method to identify whether it is in accordance with world class standards, if the OEE value is still low, a Six Big Losses analysis will be carried out from the pareto chart which will determine what losses affect the low OEE value and analyze the details of the causes of each fishbone diagram. The average OEE value on BX-75 machines in November-December 2022 was 78.86%. The result is still below 85% so six big losses analysis is still needed. There are two types of losses that dominate, namely downtime losses and setup & adjustment losses. Downtime losses have an average loss of 13.50% and setup losses have an average of 9.53%.

**Keywords** Machine Effectiveness Measurement, Manufacturing Industry, Overall Equipment Effectiveness, Six Big Losses, Pareto Diagram, Fishbone Diagram.

## INTRODUCTION

The development of the manufacturing industry in increasing from year to year, this course makes competition in the manufacturing industry increasingly rapid. One of the success indicators of a manufacturing company is determined by the smooth production. The productivity of a company can be seen from the company's ability to run the run the production process effectively and efficiently (Arifianto, 2018). To support the manufacturing system, the performance of the equipment used must be considered so that it can be used optimally (Hermanto, n. 2016.). Machinery and equipment are one of the main forces of a company in mainting the continuity of the production process (Rifaldi et al., 2020).

Machies used in the production process require a system consisting of inputs, operating processes and ouputs to run optimally and efficiently. To maintain the condition of the machine so that there is no damage or disturbances that cause the production process to stop, good maintenance is needed so that the result can increase the effectiveness of the machine or equipment and damage can be avoided (Rahmadhani, n. 2014.). Therefore, to obtain maximum result, it is necessary to (Hermanto, 2016.)have a machine condition that is ready to operate in terms of capability, feasibility, accuracy and capacity. In the manufacturing industry engaged in piping there are various types of machines used.

PT XYZ is one of the companies engaged in the piping industry for underground water pipes with HDPE pipes product. PT XYZ has problems with production machines that are continuously and often trouble on the BX-75 machine. The biggest engine trouble occurs in engine breakdown which affects engine performance because it hinders the production process. One of the efforts made when machine problem occur is to analyze the level of effectiveness of machine performance can be done by measuring Overall Equipment Effectiveness (OEE).

Overall Equipment Effectiveness (OEE) as a measurement is very important to know which areas need to be improved productivity or efficiency of the machine or equipment and can also show bottleneck areas contained in the production trajectory(Stamatis, n.d.). OEE is also a measuring tool to evaluate and improve the right way to ensure increased productivity of machine or equipment use (Adesta et al., 2018). This OEE calculation considers parameters such as the length of time for production, machine work performance, the number of products produced and the quality of the products produced. Six Big Losses analysis is used to determine the types of losses that affect the magnitude of the OEE value which has an effect of the effectiveness of the machine (Nakajima et al, 1988). One of the problems that inhibit the production process is the constraint of the machine, it is caused by machine problem such as old machine, not done maintenance. Effort are made when machine problem occur by analyzing the level of effectiveness of a machine performance. Measurement of the effectiveness of machine performance can be done by measuring Overall Equipment Effectiveness. According to (Stamatis, 2010) The OEE method used to breakdown the performance of a manufacturing unit into 3 separate components and can be measured in the form of availability ratio, performance rate, and rate of quality. Decreased machine effectiveness is caused by Six Big Losses or Six loss factor grouped in the form of downtime losses, speed losses and defect losses. After result Six Big Losses become indicators and factors that cause OEE values to be below world class standard then provide suggestion for repairing the machine so that the effectiveness of the machine is normalized.

## LITERATURE REVIEW

Productivity is related to the effectiveness and efficiency of resource utilization in producing output where effectiveness is the degree achievement of the output production system while efficiency is measure that indicates the extent to which the resources us in the production process produce output according (Sumanth et al, 1984).

The purpose of this research is to measure the effectiveness of the BX-75 machine using the OEE method and to compare the actual OEE value of the BX-75 machine with international standard. In addition, looking for the value of the *Six Big Losses* factors that most dominantly affect the cause of low machine effectiveness and analyzing the causes using pareto diagram and fishbone diagram to provide suggestion for improvements so that the effectiveness of the machine is not low.

## METHODS

The research was conducted at PT XYZ which is engaged in the pipe industry. The object of research was carried out on the BX-75 production machine to determine the effectiveness of the machine in working. The research methods carried out are

1. Problem Identification

   Problem identification consist of observation, interviews, and literature studies from various relevant sources, as well as determining the research topic to be carried out.
2. Data Collection and Processing Data

   Data collection consist of primary data and secondary data. The secondary data used is the company's historical data from November to December 2022 which consist of machine actual machine time for production, number of produced, product reject data, product scrap data, ideal cycle time, machine working time and breakdown time. Data processing is carried out using the Overall Equipment Effectiveness (OEE) method on the BX-75 machine which will then be analyzed with the Six Big Losses.
3. Analysis and Conclusion

   The processed data is analyzed by comparing the result of calculations and making pareto diagram and analyzing the causes of problem using fishbone diagram. Preparing recommendation for improvement based on the root causes that have been obtained. After obtaining the analysis and discussion, the last step is to make conclusions from the result of data processing and suggestions for future research.

## RESULT AND DISCUSSION

1**.** Overall Equipment Effectiveness (OEE)

Three main factors are required in determining the OEE value, namely availability rate, performance rate, dan quality rate. OEE is obtained by multiplying these 3 factors. Next step is to determine the value of Six Big Losses factors that cause a decrease in machine effectiveness and find out the specific losses related to factors that are very influential in the low OEE value. The following are the results of the BX-75 machine data processing

1..1 Availability Ratio

Avaliablity as a ratio that shows the use of time available for machine operations that produce goods. In measuring the availability ratio, data is needed in the form of machine working time, planned downtime, which is useful for calculating loading time. In addition, the data needed is machine downtime as a variable to measure how much machine operation time.

The calculation of availability in November week 1 is a follows.

$$Availability = \frac{Operating\ Time}{Loading\ Time}\ x\ 100\% \quad (1)$$

$$Availability = \frac{123,6}{144} \, x \, 100\%$$
$$Availability = 85,83\%$$

**Table 1. Availability Ratio Results**

| Month | Week | *Operating Time* (Hour) | *Loading Time* (Hour) | *Availability Ratio* |
|---|---|---|---|---|
| November | 1 | 123,6 | 144,0 | 85,83% |
| | 2 | 146,1 | 168,0 | 86,96% |
| | 3 | 161 | 168,0 | 95,83% |
| | 4 | 124,8 | 168,0 | 74,29% |
| | 5 | 34,7 | 48,0 | 72,29% |
| Desember | 1 | 99,6 | 120,0 | 83,00% |
| | 2 | 167,4 | 168,0 | 99,64% |
| | 3 | 164 | 168,0 | 97,62% |
| | 4 | 60,7 | 73,0 | 83,15% |

The results of the calculation of the availability value of the BX-75 machine in Table 1. Availability value from November-December 2022 not ideal because is only November week 3, December week 4 and 5 which obtaine a value above JIPM. The average availability ratio value obtained is 86,51%. The value that has not met the JIPM standard is due to be high downtime value and the production process has not been optimized due to frequent breakdown that reduce production time. The graph of the result of the calculation of the availability ratio of the BX-75 machine can be seen in figure 1.

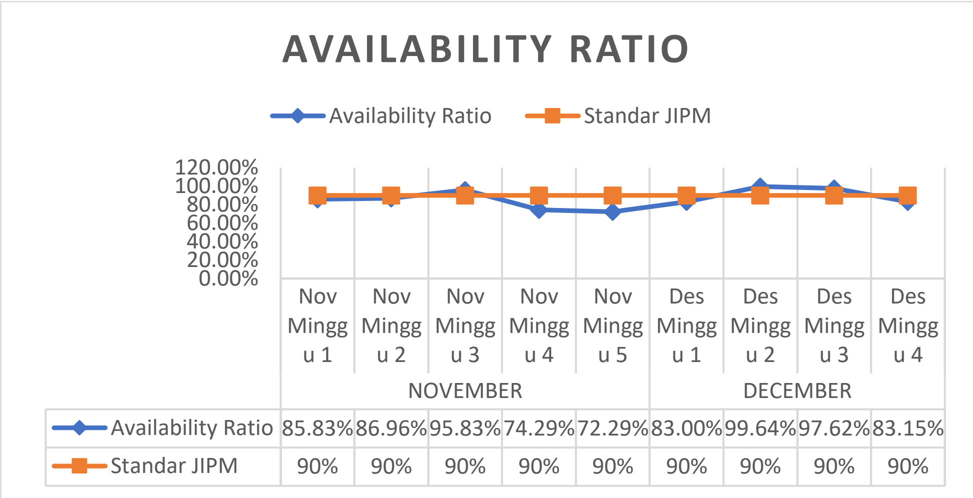


**Figure 1. Availability Ratio Graph**

1.2 Performance Effficiency

Performance efficiency is a ratio that describes the ability of equipment to produce goods. This ratio is the result of ideal cycle time and processed amount. The calculation of performance efficicency start with the calculation of ideal cycle time.

The calculation of performance efficiency in November week 2 is as follows.

$$Performance\ Efficiency = \frac{total\ production\ x\ Ideal\ Cycle\ Time}{Operation\ Time} \, x \, 100\% \quad (2)$$

$$Performance\ Efficiency = \frac{51.915 \, x \, 0,002572985}{146,1} \, x \, 100\%$$

$$Performance\ Efficiency = 97,75$$

**Table 2. Performance Efficiency Results**

| Month | Week | Total Production (KG) | *Operating Time* (Jam) | *Cycle Time Ideal* (jam) | *Performance Efficieny* |
|---|---|---|---|---|---|
| November | 1 | 46.729 | 123,6 | 0,002572985 | 97,28% |
| | 2 | 51.915 | 146,1 | 0,002750982 | 91,75% |
| | 3 | 67.159 | 161,0 | 0,002392764 | 99,81% |
| | 4 | 55.220 | 124,8 | 0,001989246 | 88,02% |
| | 5 | 16.918 | 34,7 | 0,001749752 | 85,31% |
| Desember | 1 | 37.333 | 99,6 | 0,002555961 | 95,80% |
| | 2 | 89.794 | 167,4 | 0,001864243 | 100,00% |
| | 3 | 83.430 | 164,0 | 0,00196455 | 99,94% |
| | 4 | 24.485 | 60,7 | 0,002377275 | 95,89% |

The result of the highest performance efficiency value can be seen in Table 2 in December Week 2, while the lowest value is in November Week 5. The average obtained from performance efficiency is 95,53%. For the whole performance efficiency value has reached and exceeded the JIPM standard but only November Week 4 and 5 did not reach the JIPM standard. The thing that the high and low value of performance efficiency is seen from the total amount of production, the higher the production produced, the higher the value of performance efficiency. The graph of the result of the calculation of performance efficiency can be seen in Figure 2.

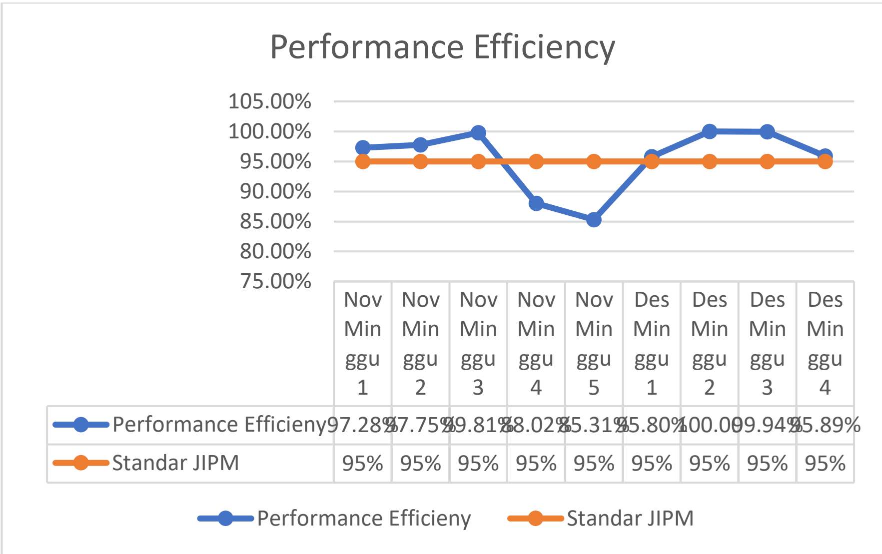


**Figure 2. Performance Efficiency Graph**

1.3 Rate of Quality

Rate of quality is a value that shows the ratio of a machines's ability to produce non-defective product. The calculation of the quality rate requires data on the total amount of production and reject data for each week.
The calculation of performance efficiency in November week 1 is a follows.

$$Rate\ of\ Quality = \frac{\text{processed amount} - \text{defect amount}}{Processed\ amount} \qquad (3)$$

$$Rate\ of\ Quality = \frac{46.729 - 2753}{46.729}$$

$$Rate\ of\ Quality = 94{,}11\%$$

**Table 3. Rate of Quality Result**

| Month | Week | Total Production Quantity (kg) | Total *Reject* (kg) | *Rate Of Quality* |
|---|---|---|---|---|
| November | 1 | 46.729 | 2753 | 94,11% |
| | 2 | 51.915 | 3644 | 93,05% |
| | 3 | 67.159 | 5431 | 91,91% |
| | 4 | 55.220 | 1258 | 97,72% |
| | 5 | 16.918 | 1236 | 92,69% |
| Desember | 1 | 37.333 | 1962 | 95,00% |
| | 2 | 89.794 | 1955 | 97,82% |
| | 3 | 83.430 | 2579 | 96,97% |
| | 4 | 24.485 | 1312,5 | 94,64% |

The results of the rate of quality values in Table 3. show the highest value in December Week 2 and the lowest value in November Week 3. However, the calculation of the rate of quality has not exceeded the predetermined JIPM standard, this is because the number of product rejects is quite large causing the value of the rate of quality to be low, the lower the reject, the higher the value of the rate of quality. The rate of quality calculation graph can be seen in Figure 3.

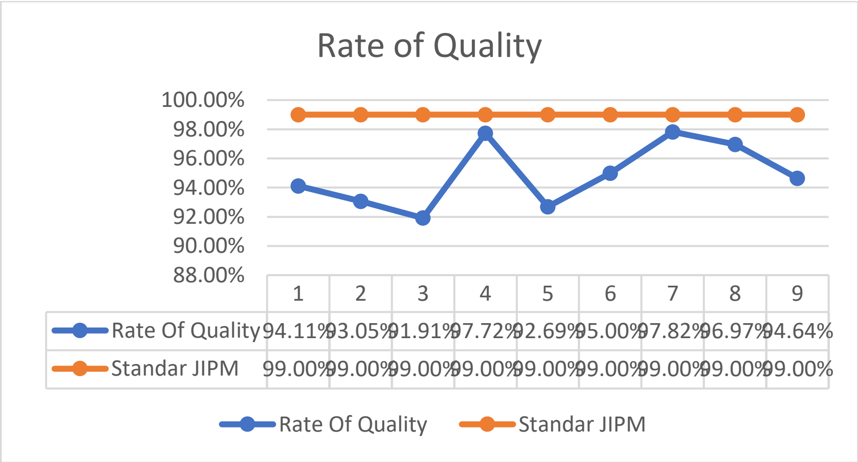


**Figure 3. Rate of Quality Graph**

1.4 Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) is obtained by taking ito availability, performance efficiency and rate of quality [4].

The calculation of OEE for November week 1 is as follows.

$$\text{OEE} = Availability\ x\ Performance\ x\ Quality \quad (4)$$

$$\text{OEE} = 85{,}85\%\ \text{x}\ 97{,}28\%\ \text{x}\ 94{,}11\%$$

$$\text{OEE} = 78{,}58\%$$

**Table 4 OEE Results**

| Month | Week | *Availability* | *Performance Efficieny* | *Rate Of Quality* | OEE |
|---|---|---|---|---|---|
| November | 1 | 85,83% | 97,28% | 94,11% | 78,58% |
| | 2 | 86,96% | 97,75% | 93,05% | 79,11% |
| | 3 | 95,83% | 99,81% | 91,91% | 87,92% |
| | 4 | 74,29% | 88,02% | 97,72% | 63,90% |
| | 5 | 72,29% | 85,31% | 92,69% | 57,17% |
| Desember | 1 | 83,00% | 95,80% | 95,00% | 75,54% |
| | 2 | 99,64% | 100,00% | 97,82% | 97,47% |
| | 3 | 97,62% | 99,94% | 96,97% | 94,61% |
| | 4 | 83,15% | 95,89% | 94,64% | 75,46% |

The results of the calculation of OEE values in table 4. produces acomparative OEE value of BX-75 machines every week and has different fluctuations every week. The highest value occurred in December Week 2 at 97.47% and the lowest value occurred in November Week 5 at 57.17%. The average OEE value on BX-75 machines in November-December 2022 was 78.86%, the OEE value factor that has not reached the JIPM target is due to the low availability ratio value and rate of quality value. This is due to the high value of downtime on the BX-75 engine that occurs in the production process, the number of products produced and the number of product rejections, and the speed of production. A graph of OEE calculation results can be seen in Figure 4.

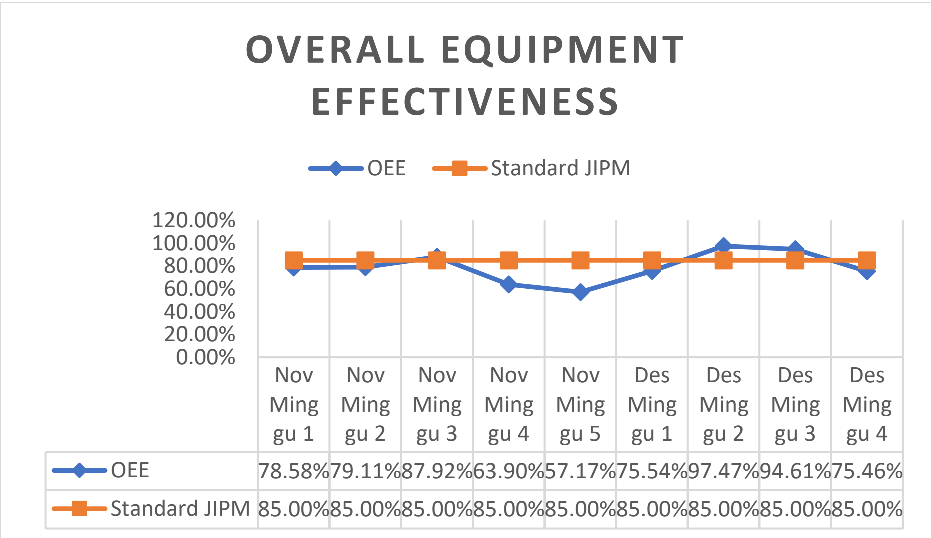


**Figure 4 Overall Equipment Effectiveness Graph**

2. Six Big Losses

From the six big losses data, the result of time losses can be caused by failure losses, setup and adjusment losses, idling losses, reducing speed losses, reprocessing, scrap can be seen the results of the calculation of the six sources of time losses in the following Table 5.

**Table 5. Six Big Losses of Machine BX-75**

| *Six Big Losses* | Average Losses | Percentage of *Losses* | Cumulative *Losses* |
|---|---|---|---|
| *Downtime Loss* | 13,50% | 39,12% | 39,12% |
| *Setup and adjusment* | 9,53% | 27,62% | 66,73% |
| *Defect Losses* | 4,25% | 12,32% | 79,05% |
| *Idling and minor stoppages Losses* | 3,44% | 9,97% | 89,02% |
| *Reduce Speed Losses* | 3,40% | 9,86% | 98,88% |
| *Scrap Losses* | 0,39% | 1,12% | 100,00% |
| TOTAL | 34,50% | 100,00% | 100,00% |

The results of the average time losses listed in Table 5. Explain that there are two types of losses that dominate, namely downtime losses and setup adjustment losses. Downtime losses have an average losses of 13,50% or equivalent to 39,12% of the overall losses that occur. Setup losses have an average of 9,53% or equivalent to 27,62% of the overall losses that occur. The large value of downtime is due to machine in the leaking waterbath section, dirty spray and unstable houloff lines.

3. Pareto Diagram

Pareto diagram is a bar chart that shows problem in order occurrence [14. The pareto principle is the 20:80 formula, 20% of quality problems cause losses of 80%. Result of Pareto Diagram in Figure 5.

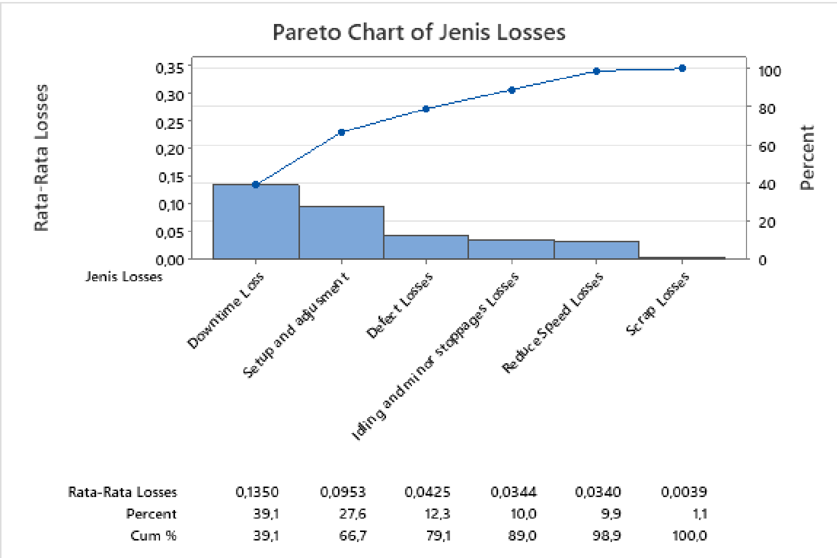


**Figure 5. Pareto Diagram Losses**

The results shown in Figure 5. Diagram pareto which uses the 80/20 principle where 80% of the low OEE value is caused by 20% of losses. Results were obtained that showed a percentage value of ≥ 20% or the most significant loss factor from the pareto analysis was *downtime losses* with a value of 39.1. This loss was chosen as a priority for improvement efforts to increase the effectiveness of the BX-75 engine.

4. Fishbone

The basic function of the fishbone diagram is to analyze and determine what factors are the cause of a problem that can later be taken corrective action [6]. After calculating and analyzing losses, the next step is to trace the root cause of the emergence by making a fishbone diagram in the figure below.

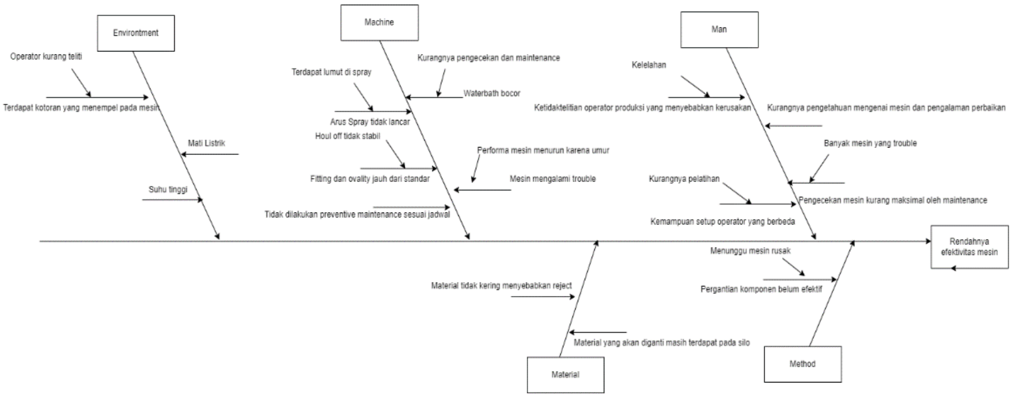


**Figure 6. Fishbone Diagram**

The results of the causal diagram / fishbone used to analyze the factors causing the problems that occur, show that there are 6 factors that cause the OEE value not to be achieved, namely machine, human, material, method and environmental factors. Among them are unstable speed houl off on the bx-75 engine, a leaking waterbath causes the shape of the pipe to be imperfect because the temperature inside the waterbath changes, then a dirty spray causes cooling from pipes is not perfect. Different operator setup capabilities due to different experiences, then repair activities are very dependent on the maintenance division so that the time needed is long and hampers the production process.

5. Reccomendations and Proposed Improvement

Recommendations and suggestions for improvement to increase the OEE value based on the results of the fishbone diagram analysis.

**Table 6. Recommendations and Proposed Improvement**

| Problems | Proposed Improvements Destination |
|---|---|
| Pipe production operators at PT XYZ are highly dependent on the maintenance division to carry out minor repairs so that time in the pipe production process is hampered and the lack of cleaning carried out after production can cause machine congestion. | Implement autonomous maintenance which will be carried out training and involve production operators in maintaining machines such as detecting deviations that occur on the machine and improving performance in cleaning product residues to reduce the risk of machine congestion. |
| There is no efficient method of calculating pin and bush changeover time. | Resetting the pin and bush cangevoer and created a standardized time measure for completion of the adjustment. |
| BX-75 engine houl off speed setting cannot be set to three decimal places | Resetting the houl off speed BX-75 machine and making improvements by maintenance and from the machine supplier to be able adjust the three decimal numbers of the machine so that the production output per pipe is faster |
| The process of picking up equipment and the movement of the setup process is hampered because there is no floor marking to guide the flow of equipment and the placement of equipment is not properly organized and there is no SOP for cahing or checking parts. | Organize equipment, make demarcation, standard for floor marking, mark the edge of the room to place boxes and make SOP. |

## CONCLUSION

Based on the results of the research that has been done it can be concluded that the measurement machine effectiveness with OEE method. Value of OEE on machine BX-75 has not reach world class standard. The result of availability ratio, rate of quality has not reached the standard due to the high downtime value and production process is not optimal because there are frequent breakdowns so that reduce production time and the number reject product is quite large causing the value of the rate of quality to be low. In addition, the low effectiveness of machinery or equipment that can cause losses to the company which is often caused by the use of ineffective and efficient equipment which is contained in six major loss factors. The most influential factor of machines on PT XYZ in *downtime* losses based on the pareto diagram is 80% low OEE value caused by 20% losses.

There are proposed improvements that can be made to improve the effectiveness of the machine such as implementing *autonomous maintenance* so that operators can repair themselves without hampering production time then make SOPs for changing or checking parts on the machine to minimize machine damage periodically and the machine can operate optimally. Advice that can be given Providing training that increases the insight of operators on how to maintain machines, machine SOPs must be carried out continuously so that damage can be minimized.

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