G-Tech : Jurnal Teknologi Terapan
Vol. 9, No. 4, October 2025, p. 2322-2334
E-ISSN: 2623-064X | P-ISSN: 2580-8737

Aggregate Analysis of Packaging Machine Effectiveness Using the OEE Method at PT. XYZ

Siti Rahayu[1✉], **Satria Bagus Aji**[2], **Adi Fitra**[3], **Syarah Rizkia Feriaty**[4], **Tri Ngudi Wiyatno**[5]

[1, 2, 3, 4, 5] Department of Industrial Engineering, Faculty of Engineering, Universitas Pelita Bangsa, Indonesia

✉ **Corresponding Author :** Siti Rahayu (e-mail: siti.rahayu@pelitabangsa.ac.id)

Article Information

Article History

Received : October 16, 2025
Revised : October 25, 2025
Published : October 31, 2025

***Keywords*:**

Aggregate OEE;
OEE;
Lean Manufacturing;

ABSTRACT

In today's competitive manufacturing industry, maintaining high production efficiency and minimizing machine downtime are critical challenges, particularly in the food sector. This study aims to analyze the effectiveness of ten CBP product packaging machines at PT. XYZ using the Overall Equipment Effectiveness (OEE) method. The research employs a quantitative approach based on primary data collected through direct observation and interviews. The OEE method measures machine performance through three indicators: Availability, Performance, and Quality. The results show that the average OEE value from October to December 2023 is 94%, exceeding the world-class standard of 85%. The dominant loss affecting effectiveness was Equipment Failure Losses (50%), followed by Rework and Defect Losses (22% each). These losses are primarily caused by machine wear, material issues, and operator handling errors. The findings indicate that the OEE method serves as an effective tool for monitoring production efficiency and planning preventive maintenance. Regular operator evaluations and standardized maintenance procedures are recommended to sustain high equipment performance levels.

INTRODUCTION

Merely calculating the performance value obtained from a production process is not sufficient to determine how effectively and efficiently a machine operates in managing resources. Therefore, this issue becomes one of the challenges for manufacturing companies in the food industry, such as PT. XYZ. One of the company's strategies to manage resources more effectively and efficiently is by implementing the Total Productive Maintenance (TPM) system with the calculation method of Overall Equipment Effectiveness (OEE). OEE indicates how efficiently a company utilizes its assets, such as equipment, labor, high error rates, and its ability to meet customer quality requirements (Singh et al., 2021).

Nakajima introduced OEE in 1988 as part of Total Productive Maintenance (TPM), specifically for equipment or machinery (De Ron & Rooda, 2006). Initially introduced by Dr. Deming, he implemented statistical analysis and used the results to control quality during the production process, which later became the foundation of Total Quality Management (TQM) (Virk et al., 2020). However, some common concepts of TQM do not work well in maintenance environments. As we know, achieving maximum quality control also requires continuous maintenance of production equipment. The increasing need for preventive maintenance was quickly addressed by companies committed to TQM.

This maintenance philosophy was then adopted and developed in the manufacturing world, forming the foundation of Total Productive Maintenance (TPM). With TPM, the maintenance of production equipment becomes more feasible, allowing production processes to run effectively and efficiently (Mulyati et al., 2022). The implementation of TPM has been proven to bring positive changes to companies in the form of increased productivity, improved quality, cost control, accuracy in product delivery to consumers, workplace safety, and enthusiasm in creating a conducive factory operation environment (Purwanto & Jaqin, 2021).

Previous studies have widely applied the Overall Equipment Effectiveness (OEE) method to evaluate machine performance in various manufacturing sectors, including automotive and plastic injection industries. However, only a few studies have analyzed the aggregate OEE performance across multiple packaging machines within the food manufacturing industry, where machine variation and production scheduling complexity are relatively high. This situation highlights a research gap in understanding how aggregated OEE results can represent overall equipment performance and guide improvement priorities in such environments.

Aggregate OEE analysis is the process of combining OEE data from multiple machines to provide an overall picture of equipment effectiveness within a production system. This method involves collecting data related to operating time, downtime, actual output, ideal output, and the number of defective products from each machine and then consolidating the data to calculate total availability, performance, and quality metrics (Yan & Zhao, 2013). According to (Cigolini & Grando, 2009) combining OEE data allows companies to obtain a single indicator value that reflects the overall performance of multiple machines, which is highly useful for strategic decision-making and identifying areas that require improvement. This facilitates the monitoring of production process performance, especially with multiple machines operating simultaneously (Rahayu & Miftahuddin, 2025).

One of the performance measurement methods that can be used to address issues related to production equipment is Overall Equipment Effectiveness (OEE). This method is a key component of the maintenance system widely adopted by Japanese manufacturing companies, known as TPM. One example of research related to the use of OEE in measuring production performance is a study conducted by (Soltanali et al., 2020) titled "Measuring the production performance indicators for the food processing industry." The study found that after applying the OEE method, the new OEE index increased by approximately 4% due to maintenance improvements. Within this index, availability, performance efficiency, and quality rate increased by 3%, 2%, and 5%, respectively. Currently, PT. XYZ produces 25 different types of products using 56 machines for its packaging process, with varying efficiency levels across its products, as shown in Figure 1 below, which presents the machine efficiency performance data:

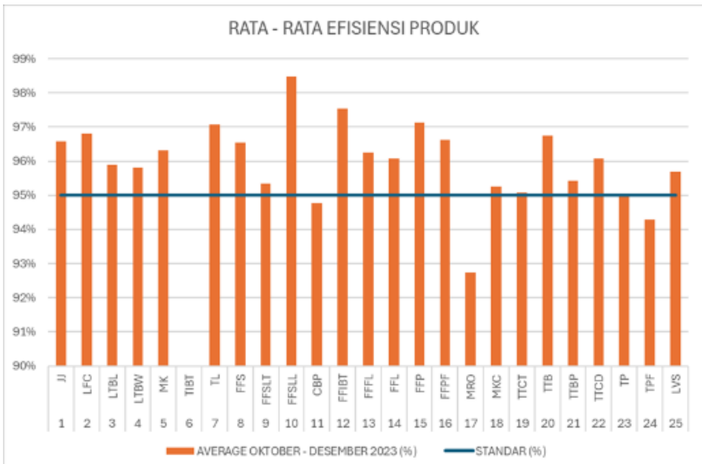

Figure 1. Machine Efficiency Performance Data

From the table data above, there are four products whose efficiency levels are still below the company's management standard of 95%. The TIBT product has an efficiency rate of 0% because it was not produced at all during the three-month period from October to December 2023. The CBP product is also below the standard at 94.77%, while the MRO product is at 92.75%. However, the MRO product is in the rationalization phase or is no longer in production, meaning it will undergo further analysis. The last product with an efficiency rate below the standard is TPF at 94.29%. However, since TPF is a slow-moving product with an irregular production schedule, it is only manufactured a few times per month.

Therefore, in this analysis, the most suitable data to use is from the CBP product because it is produced daily, yet its efficiency level remains below the standard set by management. Based on these findings, the CBP product line was selected for further analysis, as it is produced daily yet consistently falls below the company's efficiency standard of 95%. PT. XYZ operates more than 50 packaging machines but has not yet implemented OEE-based performance monitoring; its current evaluation relies solely on simple efficiency calculations. Therefore, this study focuses on applying the OEE method to assess the effectiveness of CBP packaging machines and identify key factors contributing to performance losses.

Therefore, this study aims to assist the production team and management of PT. XYZ in gaining a deeper understanding of the effectiveness of the CBP product packaging machines by analyzing the achieved values of Availability, Performance, and Quality, as well as identifying potential improvements that the production team can implement.

RESEARCH METHOD

Type of Research

This study employs a quantitative research approach, as it relies on documented data. The use of a quantitative research method aims to present detailed results, specific procedures, and clearly formulated hypotheses.

Data Collection Method

This study uses primary data obtained directly through observation and interviews. The nature of the data is quantitative, meaning it consists of numerical values.

The data used in this study were obtained directly from PT. XYZ's production department and cross-checked with machine operation records to ensure accuracy and consistency. Observation results were validated through interviews with production supervisors and maintenance personnel to confirm the causes of downtime and defects. Reliability was maintained by collecting data for three consecutive months (October–December 2023)

Methodology

The research method is a process composed of stages that are systematically interrelated with one another. The research flowchart can be seen in Figure 2.

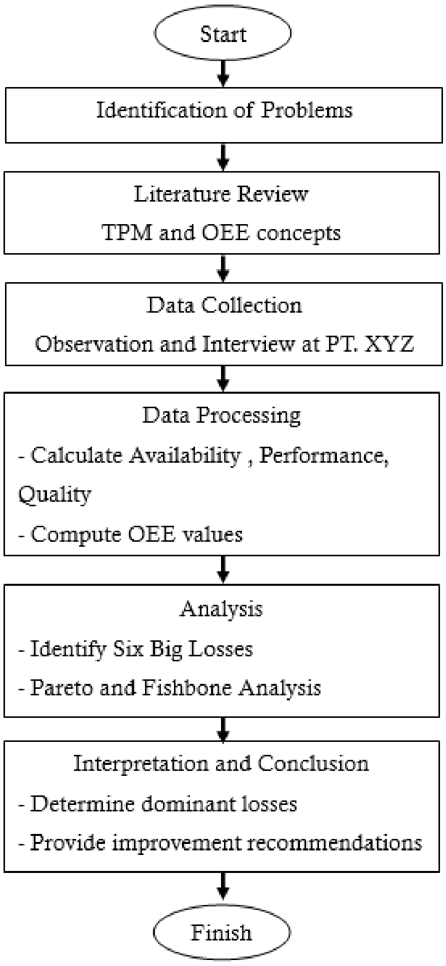

Figure 2. Research Flow Diagram

Overall Equipment Effectiveness (OEE) Method

According to (Farichi & Murnawan, 2023) OEE is a comprehensive indicator of a factory's condition, encompassing performance, operating time, and quality. This metric can be used to measure a factory's efficiency in adding value. OEE functions to identify and track losses by measuring how effectively equipment is utilized, identifying constraints, and assessing their impact on OEE (Wiyatno & Kurnia, 2022). OEE is calculated using three contributing factors: Availability, Performance, and Quality. The OEE value is obtained by multiplying these three variables.

$$\text{OEE} = Availability \times Performance \times Quality \tag{1}$$

Availability Rate

Availability Rate represents the ratio of utilized time available for machine and equipment operation (Supriyati et al., 2021). The variables influencing the availability rate are loading time and downtime losses. The formula for calculating availability rate is as follows:

$$Availability\ Rate = \frac{Loading\ Time - Downtime}{Loading\ Time} \times 100\% \tag{2}$$

Where:

1. Downtime = machine downtime during production stoppage
2. Loading Time = total available time – planned downtime

Performance Rate

Performance Rate represents the ratio describing a machine's capability to produce goods. Variables used to calculate performance rate include production output, ideal cycle time, and operating time (Supriyati & Wiyatno, 2025). The formula for calculating performance rate is:

$$Performance\ Rate = \frac{Output\ produced\ based\ on\ actual\ time}{Ideal\ Output\ produced\ based\ on\ actual\ time} \times 100\% \tag{3}$$

Where:

$$Ideal\ Output = \frac{Speed\ Machine \times \text{Number of Machines} \times \text{Actual Time}}{Pieces\ per\ Box} \tag{4}$$

Quality Rate

Quality rate represents the ratio describing the number of standard-compliant products produced by the machine. The variables affecting the quality rate include production output and the number of non-conforming (NG) products produced within one operational cycle. The formula for calculating the quality rate is:

$$Quality\ Rate = \frac{Production\ Output - Total\ Defect}{Production\ Output} \times 100\% \tag{5}$$

Where:

1. Production Output = total output from the production process
2. Total Defect = number of defective products

Equipment Failure Losses

To calculate equipment failure losses, data on downtime and loading time during the production process is required. The formula used to calculate equipment failure losses is as follows:

$$Equipment\ Failure\ Losses = \frac{Downtime}{Loading\ Time} \times 100\% \tag{6}$$

Setup and Adjustment Losses

Setup and Adjustment Losses refer to losses that occur due to the machine loading time used to prepare the equipment but has not yet produced output. To calculate setup and adjustment losses, data on setup time and loading time during the production process is required.

$$Setup\ \text{and}\ Adjusment\ Losses = \frac{Setup\ Time}{Loading\ Time} \times 100\% \tag{7}$$

Reduces Speed Losses

Reduced Speed Losses refer to losses in machine loading time due to a reduction in cycle time or standard time, which can occur as a result of various factors.

Formula for Reduced Speed Losses adjusted for the Piece-Rate Production System:

$$Reduced\ Speed\ Losses = \frac{Ideal\ Output\ \text{in}\ Pieces - Real\ Output\ \text{in}\ Pieces}{Ideal\ Output\ \text{in Pieces}} \times 100\% \tag{8}$$

Idling and Minor Stopages Losses

Idling and minor stopages losses refer to losses caused by events such as brief machine stoppages, machine idle time, and similar occurrences. To calculate these losses, the target value is subtracted from the output, which is then multiplied by the ideal machine speed to produce one unit. The formula used to calculate idling and minor stoppages is as follows:

$$Iddling\ \text{and}\ Minor\ Stopages\ Losses = \frac{Plan - Output \times Ideal\ Cycle\ Time}{Loading\ Time} \times 100\% \tag{9}$$

Defect Losses

Defect Losses reflect the amount of available machine loading time that is absorbed by producing defective products. The calculation is performed by multiplying the total number of defective products by the actual cycle time and dividing it by the machine loading time. The formula used to calculate defect losses is as follows:

$$Defect\ Losses = \frac{Waste \times Ideal\ Cycle\ Time}{Loading\ Time} \times 100\% \quad (10)$$

Rework Losses

Rework Losses refer to losses caused by defective products or rework activities, which result in the loss of production time and may also lead to material waste. To calculate the losses caused by rework, the following formula is used:

$$Rework\ Losses = \frac{Waste \times Ideal\ Cycle\ Time}{Loading\ Time} \times 100\% \quad (11)$$

Pareto Diagram

The Pareto diagram is a method used to determine the order of the most significant problems based on frequency data obtained from a check sheet (Permono et al., 2022). An example of a Pareto diagram can be seen in Figure 2, which illustrates a sample Pareto diagram.

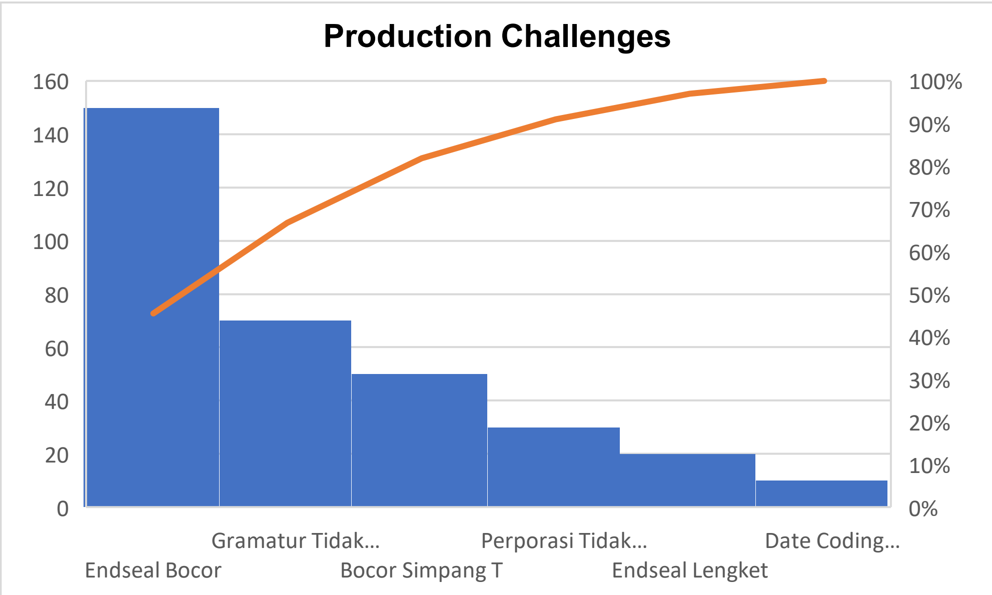

Figure 3. Example of a Pareto Diagram

Fishbone Diagram

One of the Seven Tools used to analyze the root causes of major problems is the Fishbone Diagram, as defined by (Permono et al., 2022). This diagram helps identify various contributing factors to an issue by categorizing them into different branches. An example of a fishbone diagram can be seen in Figure 3 below:

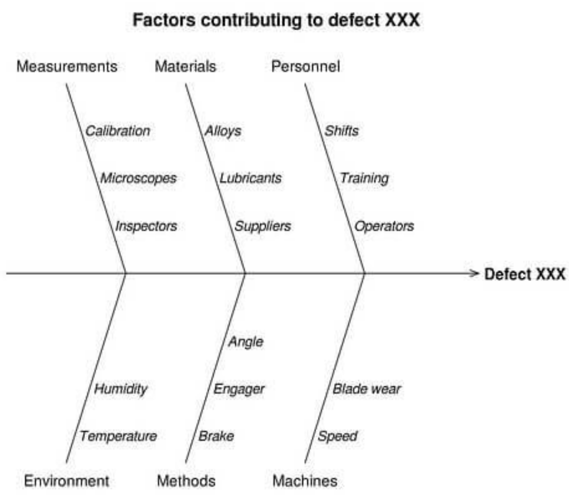

Figure 4. Example of a Fishbone Diagram

Loading Time

Loading time can be defined as the actual production time. It is calculated by subtracting planned downtime (scheduled preventive maintenance time) from the machine working time (normal production time). Since the machines operate continuously without scheduled daily planned downtime, in this study, loading time is considered equal to machine working time.

Table 1. Aggregate of Loading Time

Months	Minutes
October 2023	174.957
Nopember 2023	139.212
December 2023	143.250

Planned Downtime

Planned Downtime refers to the time allocated for conducting preventive maintenance or other scheduled maintenance activities to ensure that machines and other production equipment remain in good condition, supporting the production department in meeting its production schedule (Wiyatno & Kurnia, 2022).

Since the packaging machines operate continuously, planned downtime is typically scheduled when the machines stop operating at the end of the week.

For example, on Sunday, October 8, 2023, no packaging process was conducted on that day, meaning the planned downtime was 1,440 minutes per machine, or a total of 14,400 minutes for 10 machines used in the CBP product packaging process.

Downtime Losses

Downtime Losses, also known as Failure and Repair Time, refer to the time lost due to machine breakdowns, during which no output is produced.

In data collection, downtime losses are recorded from the moment the machine stops for repairs until it resumes operation (Wibowo, 2023). When a machine breaks down, the operator records the issue and the duration of the problem on a downtime check sheet. The technician then evaluates whether the packaging machine can be repaired while running or if it requires a complete stop.

Table 2. Aggregate of Downtime Losses

Months	Minutes
October 2023	17.172
Nopember 2023	11.774
December 2023	11.464

Number of Defects

At PT. XYZ, the number of defects is commonly referred to as Bad Stock (BS). Bad Stock occurs when packaged products do not meet the quality standards set by the quality team.

Table 3. Aggregate of Number of Defects

Months	Minutes
October 2023	11.688
Nopember 2023	7.708
December 2023	7.583

Output

Output refers to the total production output from the machines. The output from 10 production machines used for the CBP product packaging process is presented in Table 4.

The aggregate production output from October to December 2023 is measured in cartons (dus) and then converted into pieces by multiplying each carton by 40 pieces

Table 4. Aggregate of Output

Months	Dus	Minutes
October 2023	258.729	10.349.160
Nopember 2023	210.036	8.401.440
December 2023	213.446	8.537.840

Ideal Cycle Time

Ideal Cycle Time is secondary data that has been documented by the production process department for each machine used in this study. It can also be referred to as the production plan, as ideal cycle time is typically used for production scheduling.

The target quantity (quantity target) is also known as the production plan, which represents the maximum achievable target within the available operating time.

Table 5. Aggregate of Ideal Cycle Time

Months	Dus	Minutes
October 2023	262.436	10.497.440
Nopember 2023	208.818	8.352.720
December 2023	214.875	8.595.000

Operating Time

Operating Time is calculated as Loading Time minus Downtime Losses, or in other words, it represents the actual amount of time the machines are in operation.

Table 6. Aggregate of Operating Time

Months	Minutes
October 2023	157.785
Nopember 2023	127.438
December 2023	131.786

RESULTS AND DISCUSSION

Measurement of Aggregate OEE Value

In Table 7, the Aggregate OEE values for the 10 packaging machines for CBP products from October to December 2023 are displayed:

Table 7. The Aggregate OEE Values

Months	Availability (%)	Performance (%)	Quality (%)	OEE (%)
October 2023	90%	94%	95%	93%
Nopember 2023	92%	95%	96%	94%
December 2023	92%	95%	96%	94%
		Average		94%

From the data in the table above, a graph illustrating the achievement percentage of the OEE value can be depicted, as shown in Figure 4 The Trend of Aggregate OEE from October to December 2023 is presented below:

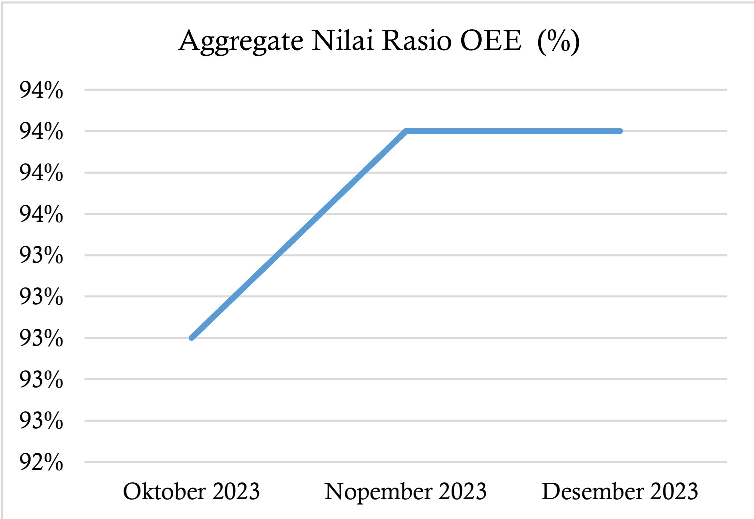

Figure 5. Trend of Aggregate OEE Values

The obtained OEE value of 94% indicates that the machine utilization at PT. XYZ is above the world-class standard of 85% (Nakajima, 1988). However, as stated by (Singh et al., 2021), a high OEE does not always reflect optimal maintenance performance, since dominant losses such as equipment failure can still cause production instability. This finding suggests that despite achieving an excellent overall OEE value, PT. XYZ still faces challenges in maintaining consistent machine reliability, indicating the need for stronger preventive maintenance and operator-level monitoring to sustain long-term efficiency.

Accumulative Value of Six Big Losses

The updated values for the Six Big Losses from 10 packaging machines for CBP products from October to December 2023 show a detailed breakdown of these losses.

Table 8. Six Big Losses

Type of Losses	Downtime (Minutes)	Cumulative Downtime (Minutes)	Six Big Losses (%)	Cumulative Six Big Losses (%)
Equipment Failure Losses	20.205	20.205	50%	50%
Rework Losses	8.890	29.095	22%	72%
Defect Losses	8.890	37.985	22%	94%
Setup and Adjusments Losses	2.425	40.410	6%	100%
Reduced Speed Losses	0	40.410	0%	100%
Idling and Minor Stopages Losses	0	40.410	0%	100%
Total	40.410	-	100%	-

From the updated table above, a Pareto diagram has been created as follows:

Figure 6. Pareto Diagram of Six Big Losses

The dominance of equipment failure losses (50%) reflects weaknesses in preventive maintenance practices. According to (Mulyati et al., 2022), consistent implementation of Total Productive Maintenance (TPM) can significantly reduce equipment-related breakdowns and increase machine availability. Therefore, the high proportion of equipment failure losses at PT. XYZ indicates that TPM activities, such as autonomous maintenance and routine inspection, need to be strengthened. The occurrence of rework and defect losses (22%) also supports the findings of (Purwanto & Jaqin, 2021), who emphasized that inadequate operator discipline and equipment calibration often lead to repeated product defects.

Overall, the findings of this study support the theoretical framework of OEE introduced by (Nakajima, 1988) and further discussed by (De Ron & Rooda, 2006), which emphasize the importance of balancing availability, performance, and quality to achieve overall equipment effectiveness. The results also confirm that equipment failure is still a major source of inefficiency in packaging operations, consistent with previous studies in the food manufacturing sector (Soltanali et al., 2020). Therefore, PT. XYZ needs to focus on preventive maintenance and operator training as key strategies to sustain high OEE performance in the long term.

Fishbone Diagram

To immediately implement improvements, it is necessary to analyze the factors that cause the OEE value to be ineffective. An analysis of the factors hindering the production process can be carried out using a Fishbone diagram.

It has been determined that the factor contributing the largest loss, which also appears to be a major hindrance to the production process, is Equipment Failure Losses. Therefore, this particular loss will be the focus of the problem to be addressed first. As a result, the analysis of this loss will be conducted using a Fishbone diagram to identify the root causes.

The Fishbone Diagram for Equipment Failure can be seen in Figure 6 below:

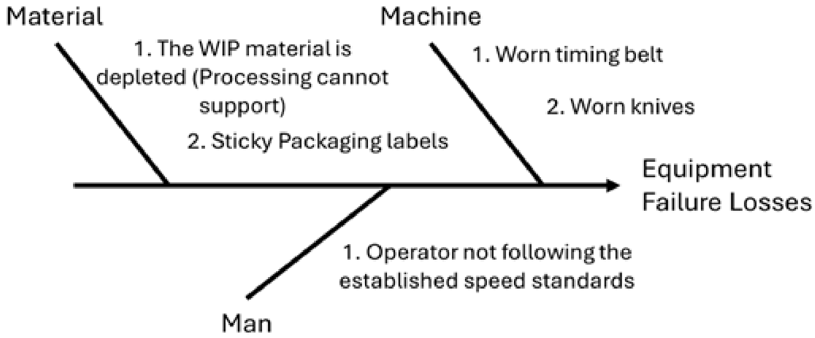

Figure 7. Fishbone Diagram for Equipment Failure Losses

From the diagram above, it can be concluded that there are three main categories influencing the OEE ratio, which are as follows:

Material: PT. XYZ often encounters issues caused by sticky labels, such as jammed labels, labels being too short or too long, and labels getting caught. These problems have caused downtime from October to December 2023, with a total downtime of 6448 minutes and a frequency of 1595 occurrences.

Machine: PT. XYZ frequently experiences machine issues, such as imprecise timing belts, improper timing belt fit, and broken timing belts. The root cause of these issues is the wear and tear of the timing belts during production. These issues contribute to downtime with a total of 5663 minutes and a frequency of 1171 occurrences. Additionally, issues with worn knives due to prolonged use, such as broken, misaligned, or jammed knives, have caused downtime for the machines, contributing 1462 minutes of downtime and 131 occurrences.

Man: The final factor influencing downtime, as identified in the Fishbone diagram, is the human factor. Human errors significantly affect the largest downtime issues in production. For example, errors in the bucket or RCU of the scale often occur because operators adjust the machine speed too quickly, violating the established standards. This problem results in various machine stoppages, including bucket errors, RCU errors, and thermocouple cable failures caused by overheating, leading to seal leaks. These issues have contributed a total of 19,425 minutes of downtime with 4524 occurrences from October to December 2023.

The purpose of this study was to identify the effectiveness of CBP packaging machines through OEE analysis. The results confirm that machine effectiveness is generally high; however, major losses caused by equipment failure indicate that preventive maintenance procedures need further improvement.

CONCLUSION

The research results show that the average Overall Equipment Effectiveness (OEE) value of the ten CBP product packaging machines at PT. XYZ from October to December 2023 is 94%, which exceeds the world-class standard of 85%. The Availability ratio averaged 91%, the Performance ratio 94.77%, and the Quality ratio 95%. The dominant loss affecting machine effectiveness is Equipment Failure Losses, contributing 50% of total downtime, followed by

Rework Losses and Defect Losses at 22% each. These results indicate that the packaging machines operate efficiently, but there is still room for improvement in maintenance practices to reduce equipment-related downtime.

To maintain and improve machine performance, PT. XYZ is advised to strengthen preventive maintenance programs and conduct regular evaluations of operator practices. Developing standardized operating procedures (SOPs) for handling common machine issues—such as worn knives and timing belts—can also help minimize future failures. Future research is recommended to apply other improvement methods such as Failure Mode and Effect Analysis (FMEA) or Reliability Centered Maintenance (RCM) to further enhance machine reliability and operational stability.

REFERENCES

Cigolini, R., & Grando, A. (2009). Modelling capacity and productivity of multi-machine systems. *Production Planning and Control*, *20*(1), 30–39. https://doi.org/10.1080/09537280802627969

De Ron, A. J., & Rooda, J. E. (2006). OEE and equipment effectiveness: An evaluation. *International Journal of Production Research*, *44*(23), 4987–5003. https://doi.org/10.1080/00207540600573402

Farichi, M. K., & Murnawan, H. (2023). Analisis Pengukuran Efektifitas Mesin Packing Di Unit 2 Menggunakan Overall Equipment Effectiveness (Oee) Dengan Pendekatan Total Productive Maintenance. *Teknika* , *1*(1), 66–80.

Mulyati, F. S., Septiadi, M. T., & Fauzi, M. (2022). Analisis Penerapan Total Productive Maintanance (Tpm) Dengan Menggunakan Metode Overall Equipment Effectiveness (Oee) Di Pt Xyz. *Jurnal Bayesian : Jurnal Ilmiah Statistika Dan Ekonometrika*, *2*(1), 75–81. https://doi.org/10.46306/bay.v2i1.30

Permono, L., Salmia, L. A., & Septiari, R. (2022). Penerapan Metode Seven Tools Dan New Seven Tools Untuk Pengendalian Kualitas Produk (Studi Kasus Pabrik Gula Kebon Agung Malang). *Jurnal Valtech*, *5*(1), 58–65.

Purwanto, C., & Jaqin, C. (2021). Improving curing process productivity in the tire industry using OEE, TPM and FMEA methods. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, *Figure 1*, 6709–6715. https://doi.org/10.46254/an11.20211152

Rahayu, S., & Miftahuddin, A. L. (2025). *Journal of Optimization System and Ergonomy Implementation Analisis Total Productive Maintenance Menggunakan Metode Overall Equipment Effectivenes (OEE) dan Six Big Losses Pada Mesin Curing Tire Press di PT . XYZ*. *3*(01), 62–70.

Singh, S., Khamba, J. S., & Singh, D. (2021). Analysis and directions of OEE and its integration with different strategic tools. *Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering*, *235*(2), 594–605. https://doi.org/10.1177/0954408920952624

Soltanali, H., Mehdi, K., & Jose, T. F. (2020). *Measuring the production performance indicators for food processing industry*. Measurement. https://doi.org///doi.org/10.1016/j.measurement.2020.108394.

Supriyati, S., & Wiyatno, T. N. (2025). Improving press machine efficiency using a TPM approach and Six Big Losses analysis. *Journal Industrial Servicess*, *10*(2), 347. https://doi.org/10.62870/jiss.v10i2.28344

Supriyati, S., Wiyatno, T. N., & Darmawan, H. (2021). Peningkatan Produksi Plastik Injection dengan Analisis Overall Equipment Effectiveness dan Single Minute Exchange of Dies.

Operations Excellence Journal of Applied Industrial Engineering, *13*(3), 394. https://doi.org/10.22441/oe.2021.v13.i3.036

Virk, S. I., Khan, M. A., & Indher, A. A. (2020). *Review of Total Productive Maintenance (TPM) & Overall Equipment Effectiveness (OEE) Practices in Manufacturing Sectors*.

Wibowo, D. R. (2023). Upaya Peningkatan Efektivitas Mesin Menggunakan Metode Overall Equipment Effectiveness (Oee) Dan Failure Mode and Effect Analysis (Fmea) Mesin Toyo T235 Grinding. *Jurnal Ilmiah Teknik Dan Manajemen Industri*, 1–75.

Wiyatno, T. N., & Kurnia, H. (2022). Increasing Overall Equipment Effectiveness in the Computer Numerical Control Lathe Machines Using the Total Productive Maintenance Approach Peningkatan Overall Equipment Effectiveness pada Mesin Bubut Computer Numerical Control dengan Menggunakan Pendekat. *Jurnal Bayesian: Jurnal Ilmiah Statistika Dan Ekonometrika*, *2*(1), 1–8. https://doi.org/10.31315/opsi.v15i2.7284

Yan, C. B., & Zhao, Q. (2013). A unified effective method for aggregating multi-machine stages in production systems. *IEEE Transactions on Automatic Control*, *58*(7), 1674–1687. https://doi.org/10.1109/TAC.2013.2240111