

Effectiveness Analysis of NPK 2 Bagging Operations Using Oee, Six Big Losses, and Fmea: A Case Study at PT XYZ

Moch Diva Widya Prasetya¹, Muhammad Zainuddin Fathoni^{2*}, Mega Rahayu Hardiyanti³

^{1, 2, 3}Industrial Engineering Study Program, Faculty of Engineering, University of Muhammadiyah Gresik, Indonesia

*Corresponding Author:

Email: zainuddin@umg.ac.id

Abstract.

This study was conducted to evaluate the level of effectiveness of the NPK 2 Bagging facility at PT XYZ through the application of the Overall Equipment Effectiveness (OEE), Six Big Losses, and Failure Mode and Effect Analysis (FMEA) methods. The data taken is facility data during the January-July 2026 period. OEE is used to measure effectiveness based on availability, performance, and quality, while Six Big Losses is used to identify dominant losses. Furthermore, FMEA is used to determine the priority of failure modes based on Severity (S), Occurrence (O), and Detection (D) through the calculation of Risk Priority Number (RPN). Based on the results of data processing, the average effectiveness of the facility is shown by an availability value of 80.19%, performance of 85.21%, and quality of 99.48%, with an average OEE value of 67.23%. Meanwhile, the evaluation using the Six Big Losses method showed that Equipment Failure Loss and Reduced Speed Loss were the losses with the highest percentage, 12.67% and 12.58%, respectively, and Setup and Adjustment Loss of 7.14%. The three losses were then analyzed using FMEA to determine the failure mode with the highest risk priority as the basis for the preparation of repair proposals. Improvement proposals were focused on improving facility maintenance, controlling the weighing system and operating speed, as well as reducing setup time and facility adjustment.

Keywords: Overall Equipment Effectiveness (OEE), Six Big Losses, Risk Priority Number (RPN), Failure Mode and Effect Analysis (FMEA) and Bagging NPK.

I. INTRODUCTION

The fertilizer industry plays an important role in supporting the agricultural sector because fertilizers are used to meet the nutritional needs of plants [1]. In addition to the production process, packaging is an important stage to ensure that products that have met quality standards are ready to be stored and distributed. The effectiveness of packaging facilities also affects the company's ability to achieve production targets [2].

PT XYZ is a manufacturer of a single fertilizer, compound fertilizer. This research focuses on the Bagging Department, especially the NPK 2 Bagging facility which is used to package NPK fertilizer products after obtaining quality approval. The bagging process includes the flow of products from the cooling bay to the hopper, then through the feeding conveyor, elevator, and tripper conveyor to the bagging silo before packaging. Based on company data for the January until July 2026 period, NPK 2 Bagging production has fluctuated, with the lowest production in June at 5,024 tons and the highest in July at 17,961 tons. The achievement of production targets also varies between 27.91%–96.56%, indicating that the performance of the facility is still unstable.

To analyze these conditions, this study uses Overall Equipment Effectiveness (OEE) to measure the effectiveness of facilities based on Availability, Performance, and Quality [3]. Furthermore, Six Big Losses is used to identify and determine the most dominant losses, while Failure Mode and Effect Analysis (FMEA) is used to identify failure modes and determine risk priorities based on Severity, Occurrence, and Detection through the Risk Priority Number (RPN) value [4]. The combination of these three methods provides a gradual analysis starting from measuring effectiveness, identifying dominant losses, to determining the priority of failure modes as the basis for the preparation of improvement proposals [5]. Based on the above conditions, this study was used to determine the effectiveness of the NPK 2 Bagging facility based on OEE, analyze the Six Big Losses, determine three dominant losses, and determine the failure mode with the highest risk priority in each dominant loss using FMEA as the basis for the improvement proposal.

II. METHODS

This study uses a quantitative approach combined with qualitative assessment to analyze the effectiveness of the NPK 2 Bagging facility at PT XYZ. The quantitative approach is used to calculate Overall Equipment Effectiveness (OEE) which includes Availability, Performance, and Quality [6], and Six Big Losses to identify and determine the dominant losses. Furthermore, qualitative assessment is used in Failure Mode and Effect Analysis (FMEA) to identify failure modes and determine risk priorities based on

Severity (S), Occurrence (O), and Detection (D) through Risk Priority Number (RPN) values [4]. The data used is operational data and production of facilities during the January-July 2026 period.

The object of the study is the NPK 2 Bagging facility used to package NPK fertilizer products. Production facilities that experience disruption or damage can experience downtime that affects the smooth running of the production process, so the condition and reliability of the facility need to be considered in the effectiveness analysis [7]. The process begins after the product is finished and meets the requirements as a final product, then temporarily placed in a cooling bay until the product temperature is below 40°C and obtains nutrient content approval from Quality Control (QC). The approved product is then moved using a wheel loader to the hopper and flows through the feeding conveyor, elevator, and tripper conveyor to one of the two bagging silos alternately. Next, the product is packaged at the NPK 2 Bagging facility and the sack is closed using a sewing machine before proceeding to the next stage.

The research stages were carried out sequentially, starting from data collection, OEE calculation, Six Big Losses analysis, to FMEA analysis. The OEE calculation was used to determine the level of facility effectiveness based on three main indicators. The results of the Six Big Losses analysis were used to determine the three dominant losses that contributed the greatest to the decline in facility effectiveness [8]. The three losses are then the basis for identifying the relevant failure modes to be analyzed using FMEA. Each failure mode is assessed based on S, O, and D, and then RPN is calculated to determine one failure mode with the highest risk priority on each dominant loss [9]. The results of the analysis are then used as the basis for the preparation of improvement proposals to increase the effectiveness of the NPK 2 Bagging facility.

Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) is used to measure the level of effectiveness of the NPK 2 Bagging facility based on three main components, namely Availability, Performance, and Quality and has an ideal value in table 1[10]. The three components describe the facility's ability to utilize the available time, produce products according to ideal capabilities, and produce products that meet quality requirements. The OEE value is calculated by multiplying the three components as in formula 1.

$$OEE = (Availability \times Performance \times Quality) \times 100\% \quad (1)$$

Table 1. Ideal value on OEE

Factor OEE	OEE Processed
Availability	90%
Performance	95%
Quality	99%
Overall Equipment Effectiveness (OEE)	85%

The aspects that make up the OEE are as follows:

a. Availability

Availability is a comparison between the actual operating time and the loading time. Loading time is the time available for production activities after deducting planned downtime[11]. The calculation of Availability is carried out with the equation as in formula 2.

$$Availability = \frac{Loading\ Time - Downtime}{Loading\ Time} \times 100\% \quad (2)$$

Loading time is obtained from working time after deducting planned downtime in formula 3.

$$Loading\ Time = Working\ Time - Planned\ Downtime \quad (3)$$

Furthermore, the operating time is obtained by subtracting downtime from the loading time in formula 4.

$$Operating\ Time = Loading\ Time - Downtime \quad (4)$$

In this study, downtime is used to describe the time when facilities are unable to carry out production processes due to disruptions or damage recorded in the company's operational data.

b. Performance

Performance is used to determine the actual ability of a facility to produce products compared to its ideal capabilities[12]. Performance calculation uses Ideal Cycle Time obtained from data or company standards. The Performance equation is in formula 5.

$$Performance = \frac{Ideal\ Cycle\ Time \times Total\ Production}{Operating\ Time} \times 100\% \quad (5)$$

c. Quality

Quality is used to determine the level of products that meet quality requirements compared to total production [13]. Products that experience defects or reprocesses are considered as products that do not meet the category of good products. Quality calculation is carried out by equation in formula 6.

$$Quality = \frac{Good\ Product}{Total\ Production} \times 100\% \quad (6)$$

Good Product is obtained from total production minus defective products in formula 7.

$$Good\ Product = Total\ Production - Defect\ Product \quad (7)$$

The results of the Availability, Performance, and Quality calculation are then used to obtain the OEE value of the NPK 2 Bagging facility.

Six Big Losses

In addition to the measurement of Overall Equipment Effectiveness (OEE), the effectiveness of production facilities can be further analyzed using Six Big Losses to identify the types of losses that cause reduced effectiveness. The Six Big Losses include Equipment Failure Losses, Setup and Adjustment Losses, Idling and Minor Stoppage Losses, Reduced Speed Losses, Process Defect Losses, and Reduced Yield Losses as seen in formulas 8 - 13. This analysis is used to determine the contribution of each loss and determine the most dominant losses in the NPK 2 Bagging facility as the basis for further analysis using the Failure Mode and Effect Analysis (FMEA) method [14].

a. Equipment Failure Loss

$$Equipment\ Failure\ Loss = \frac{Breakdown\ Time}{Loading\ Time} \times 100\% \quad (8)$$

b. Setup and Adjustment Loss

$$Setup\ and\ Adjustment\ Loss = \frac{Setup\ and\ Adjustment\ Time}{Loading\ Time} \times 100\% \quad (9)$$

c. Idling and Minor Stoppage Loss

$$Idling\ and\ Minor\ Stoppage\ Loss = \frac{Minor\ Stoppage\ Time}{Loading\ Time} \times 100\% \quad (10)$$

d. Reduced Speed Loss

$$Reduce\ Speed\ Loss = \frac{Operating\ Time - (Ideal\ Cycle\ Time \times Total\ Production)}{Loading\ Time} \times 100\% \quad (11)$$

e. Process Defect Loss

$$Process\ Defect\ Loss = \frac{Ideal\ Cycle\ Time \times Defect\ Product}{Loading\ Time} \times 100\% \quad (12)$$

f. Reduced Yield Loss

$$Reduce\ Yield\ Losses = \frac{Ideal\ Cycle\ Time \times Loss/Gain}{Loading\ Time} \times 100\% \quad (13)$$

Failure Mode and Effect Analysis (FMEA)

Furthermore, Failure Mode and Effect Analysis (FMEA) is used to identify failure modes, causes, and impacts of failures and determine risk priorities based on Severity, Occurrence, and Detection through the Risk Priority Number (RPN) value [15]. FMEA was conducted after the analysis of the Six Big Losses to identify and determine the priority of the failure mode at the NPK 2 Bagging facility. The identification of failure modes was carried out based on the results of observations and interviews with personnel related to the operation and maintenance of the facility. Furthermore, each failure mode was assessed by the respondents based on three parameters, namely on a scale of 1–10. Severity (S) indicates the severity, Occurrence (O) indicates the level of occurrence, while Detection (D) indicates the ability to detect failure. The results of the respondents' assessment were recapitulated to obtain S, O, and D values used in the calculation of the Risk Priority Number (RPN) in table 2.

Table 2. S O D Assessment Criteria

Scales	Severity (S)	Occurrence (O)	Detection (D)
1	Very small impact	Almost never happens	Very easy to detect
2–3	Low impact	Rare	Easy to detect

4–5	Medium impact	Sometimes it happens	Quite easy to detect
6–7	The impact is quite high	Quite often	Difficult to detect
8–9	High impact	Frequent	Very difficult to detect
10	The impact is very serious	Very common	Almost undetectable

The values of the three parameters are used to calculate the Risk Priority Number (RPN) with equation 14.

$$RPN = S \times O \times D \quad (14)$$

The results of the RPN are then sorted to determine the failure mode with the highest risk priority as the basis for the preparation of improvement recommendations.

III. RESULT AND DISCUSSION

Data Collection

This study uses data related to the operation of the NPK 2 Bagging facility in the form of primary data obtained from reports on the results of interviews with various parties, related to the number of working days, working hours, the number of bagging production results, defective products, and good products. The data analyzed covers the period from January to July 2026, which includes information about facility downtime, the amount of production output, and products that require reprocessing. The results of the data collection are further presented as follows:

- a. Data on the number of days and hours worked

Table 3. Data on Number of Days and Hours of Work

Month	Number of Days	Shift	Total (Hours)	Work Hours
Jan-26	31	3	46.5	744
Feb-26	28	3	42	672
Mar-26	31	3	46.5	744
Apr-26	30	3	45	720
May-26	31	3	46.5	744
Jun-26	30	3	45	720
Jul-26	31	3	46.5	744

Source: Company Data January 2026 - July 2026

- b. Data of Downtime Bagging NPK 2

Table 4. Data Downtime Bagging Npk 2

Category	Time (minutes)
Electrical & Instrument	3333
Production	15347,5
Heavy Equipment	1040
Mechanical	3040
Operational	7910
Utility	270
Others	2765
Shutdown Program	79020

Source: Company Data January 2026 - July 2026

- c. NPK 2 Bagging Results Data

Table 5. Npk 2 Bagging Results Data

Month	Number of Targets /Month (Kg)	Production Yield/Month(kg)	Target Achievement (%)
Jan-26	18.600.000	13.383.100	71,95%
Feb-26	16.800.000	13.856.950	82,48%

Mar-26	18.600.000	12.290.050	66,08%
Apr-26	18.000.000	16.248.650	90,27%
May-26	18.600.000	7.068.000	38,00%
Jun-26	18.000.000	5.024.450	27,91%
Jul-26	18.600.000	17.961.200	96,57%

Source: Company Data January 2026 - July 2026

d. Data product reprocess Bagging NPK 2

Table 6. Data product Reprocess

Month	Bagging Yield Quantity/Month (Tons)	Number of Production Defects (Tons)	Number of Good products (tons)
Jan-26	13.383	68	13.316
Feb-26	13.857	81	13.776
Mar-26	12.290	50	12.241
Apr-26	16.249	108	16.141
May-26	7.068	32	7.037
Jun-26	5.024	18	5.006
Jul-26	17.961	126	17.835

Source: Company Data January 2026 - July 2026

The quantitative data collected was used in the OEE analysis, with assessments based on three main ratios, namely availability, performance efficiency, and quality level. In addition, qualitative data were used in the FMEA analysis with assessments based on aspects of severity, incidence, and detection, which was then continued in the calculation of the Risk Priority Score (RPN).

OEE Calculation Results

Overall Equipment Effectiveness (OEE) is a calculation method used to assess the level of effectiveness of an equipment [16]. The stages in calculating the OEE value include the following steps:

a. Availability

Availability of uptime using the following calculations

$$\text{Operating Time} = \text{Loading time} - \text{Downtime}$$

$$\text{Loading Time} = \text{Weekdays} - \text{Planned Downtime}$$

For example, the calculation of Availability in January 2026 is carried out as follows

$$\text{Loading Time} = 744 - 93 = 651 \text{ hours}$$

$$\text{Operating Time} = \text{Loading Time} - \text{Downtime} = 651 - 165.88 = 485.13 \text{ hours}$$

$$\text{Availability} = (\text{Operating Time} / \text{Loading Time}) \times 100\% = (485.13 / 651) \times 100\% = 74,52 \%$$

With the same calculation, the Availability value of the Bagging NPK 2 facility until July 2026, can be seen in Table 7.

Table 7. The Value of Availability

Month	Work Hours	Setup & Adjustme nt (Hours)	Planned Downti me	Breakdo wn Time	Downtim e	Loading Time (Hours)	Operatin g Time (Hours)	Available Time
Jan-26	744	46.5	93	119.38	165.88	651	485.13	74.52%
Feb-26	672	42	84	104.47	146.47	588	441.53	75.09%
Mar-26	744	46.5	93	77.25	123.75	651	527.25	80.99%
Apr-26	720	45	90	81.83	126.83	630	503.17	79.87%
May-26	744	46.5	93	64.50	111.00	651	540.00	82.95%
Jun-26	720	45	90	47.58	92.58	630	537.42	85.30%
Jul-26	744	46.5	93	66.75	113.25	651	537.75	82.60%
Average								80%

Source : Data Processing

b. Performance Efficiency

For example, the calculation of Availability in January 2026 is carried out as follows

$$\text{Performance Efficiency} = (\text{Total Production} \times \text{Ideal Cycle Time}) / \text{Operating Time} \times 100\% \\ = (13.383 \text{ kg} \times 0.035 \text{ hours/kg}) / 485.13 \text{ hours} \times 100\% = 97\%$$

With the same calculation, the Availability value of the Bagging npk 2 facility until July 2026, can be seen in Table 8.

Table 8. Calculation of Performance Efficiency Bagging Npk 2

Month	Production Quantity/Month (Ton)	Ideal Cycle Time (Month/Ton)	Operating Time	OR (%)
Jan-26	13.383	0.035	485.13	97%
Feb-26	13.857	0.035	441.53	110%
Mar-26	12.290	0.035	527.25	82%
Apr-26	16.249	0.035	503.17	113%
May-26	7.068	0.035	540.00	46%
Jun-26	5.024	0.035	537.42	33%
Jul-26	17.961	0.035	537.75	117%
Friendly				85.21%

Source : Data Processing

c. Rate of Quality Product

$$\text{Quality Ratio} = (\text{Total Production} - \text{Defect}) / \text{Total Production} \times 100\%$$

For example, the calculation of the Quality Ratio in January 2026 is carried out as follows:

$$\text{Quality Ratio} = (13.383 - 68) / 13.383 \times 100\% = 99.5\%$$

The same calculation for the value of the rate of quality product at the NPK 2 bagging facility until July 2026 can be seen in Table 9.

Table 9. Perhitungan Rate Of Quality Bagging Npk 2

Month	Production Quantity/ Month (tons)	Production Reprocessing Quantity (tons)	Number of Good products (tons)	QR
Jan-26	13.383	68	13.316	99.5%
Feb-26	13.857	81	13.776	99.4%
Mar-26	12.290	50	12.241	99.6%
Apr-26	16.249	108	16.141	99.3%
May-26	7.068	32	7.037	99.6%
Jun-26	5.024	18	5.006	99.6%
Jul-26	17.961	126	17.835	99.3%
Friendly				99.5%

Source : Data Processing

Based on the calculation of the OEE of the Bagging NPK 2 facility for the period January-July 2026 in table 10. obtained an average Availability of 80.19%, Performance of 85.21%, and Quality of 99.48%, resulting in an average OEE of 67.23%. The Availability value shows that there is still a loss of operating time due to downtime and breakdown, while Performance shows that the facility's ability to maintain production speed is still fluctuating, especially in May and June. Meanwhile, the Quality value of 99.48% indicates that the quality of the product is very good. The average OEE of 67.23% indicates that the effectiveness of the NPK 2 Bagging facility is still not optimal, so an analysis of the Six Big Losses was carried out to identify the dominant losses as the basis for determining the focus of improvement. The results

of the Six Big Losses analysis are then the basis for identifying the failure mode through FMEA and determining the order of corrective actions by referring to the Risk Priority Number (RPN) value [17].

Table 10. Calculation Results of OEE Bagging NPK 2 for the Period January-July 2026

Month	Availability (%)	Performance (%)	Quality (%)	OEE (%)
January	74.52%	96.55%	99.50%	71.59%
February	75.09%	109.84%	99.42%	82.00%
March	80.99%	81.58%	99.60%	65.81%
April	79.87%	113.02%	99.34%	89.67%
May	82.95%	45.81%	99.55%	37.83%
June	85.30%	32.72%	99.64%	27.81%
July	82.60%	116.90%	99.30%	95.89%
Average	80%	85%	99%	67.23%

Source: Calculation Data January 2026 - July 2026

Analysis Results of the Six Big Losses

Based on Table 11, Equipment Failure Loss is the highest loss of 12.67%, for example in January 2026 with the calculation formula (Breakdown time/Loading Time), Equipment Failure Mode = $119.38/651 = 18.34\%$ and the same calculation is carried out until July 2026 which produces an average of 12.67%,

followed by Setup and Adjustment Loss having an average value of 7.14%. For example, in January 2026 a calculation was made by comparing Setup Time to Loading Time using the formula Setup and Adjustment Loss = $(\text{Setup Time}/\text{Loading Time}) \times 100\%$, so that Setup and Adjustment Loss = $(46.50/651) \times 100\% = 7.14\%$ was obtained. The same calculation was carried out from February to July 2026, so that an average Setup and Adjustment Loss of 7.14% was obtained.

Furthermore, Idling and Minor Stoppage Loss has an average value of 2.43%. For example, in January 2026, a calculation was made by comparing Minor Stoppage time to Loading Time using the formula Idling and Minor Stoppage Loss = $(\text{Minor Stoppage Time}/\text{Loading Time}) \times 100\%$, so that Idling and Minor Stoppage Loss = $(18/651) \times 100\% = 2.76\%$. The same calculation was carried out from February to July 2026, with Minor Stoppage values of 16.50 hours, 15 hours, 17 hours, 13.50 hours, 12 hours, and 16 hours, respectively. The results of the calculation resulted in an Idling and Minor Stoppage Loss value of 2.81%, 2.30%, 2.70%, 2.07%, 1.90%, and 2.46%, respectively, resulting in an average Idling and Minor Stoppage Loss of 2.43%.

Reduced Speed Loss has an average value of 12.58%. For example, in January 2026, a calculation was made by comparing the actual operating time with the ideal production time to the Loading Time using the formula Reduced Speed Loss = $[(\text{Operating Time} - (\text{Ideal Cycle Time} \times \text{Production Amount}))/\text{Loading Time}] \times 100\%$, so that the Reduced Speed Loss = $[(485.125 - (0.035 \times 13,383.1))/651] \times 100\% = 2.57\%$. The same calculation was carried out from February to July 2026, resulting in an average Reduced Speed Loss of 12.58%.

Process Defect Loss has an average value of 0.38%. For example, in January 2026, a calculation was made by comparing the time lost due to defective products to Loading Time using the formula Process Defect Loss = $(\text{Ideal Cycle Time} \times \text{Number of Production Defects})/\text{Loading Time} \times 100\%$, so that Process Defect Loss = $(0.035 \times 67.5)/651 \times 100\% = 0.36\%$. The same calculation was carried out from February to July 2026, so that an average Process Defect Loss of 0.38% was obtained.

Reduced Yield Loss has an average value of 0.17%. For example, in January 2026, a calculation was made by comparing the time lost due to Reduced Yield to Loading Time using the formula Reduced Yield Loss = $(\text{Ideal Cycle Time} \times \text{Loss/Gain})/\text{Loading Time} \times 100\%$, so that Reduced Yield Loss = $(0.035 \times 32.5)/651 \times 100\% = 0.17\%$. The same calculation was carried out from February to July 2026, so that an average Reduced Yield Loss of 0.17% was obtained.

These results show that losses that need to be prioritized are Equipment Failure Loss, Reduced Speed Loss, and Setup and Adjustment Loss, which serve as the basis for identifying failure modes and prioritizing risk using FMEA.

Table 11. Six Big Losses Analysis

Types of Losses	Average (%)	Rank
Equipment Failure Loss	12.67%	1
Reduce Speed Loss	12.58%	2
Setup and Adjustment Loss	7.14%	3
Idling and Minor Stoppage Loss	2.43%	4
Process Defect Loss	0.38%	5
Reduce Yield Loss	0.17%	6

Source: Data Processing

Dominant Losses Analysis

Based on table 12, the three highest losses were obtained at the NPK 2 Bagging facility, namely Equipment Failure Loss valued at 12.67%, Reduced Speed Loss valued at 12.58%, and Setup and Adjustment Loss at 7.14%. Equipment Failure Loss is related to failure modes in the form of obstacles in the sewing machine, damage to drive components, and sensor interference that can cause the facility to stop or experience disruptions. Reduced Speed Loss is related to disruption of the weighing process and operating speed under ideal conditions that can reduce production speed. Meanwhile, Setup and Adjustment Loss is related to setup/adjustment that lasts a long time so as to reduce effective production time. These three losses are then the basis for FMEA analysis to assess failure modes based on Severity (S), Occurrence (O), and Detection (D), after which determining risk priorities using RPN values as the basic object for making recommendations for improvement.

Table 12. The Most Important Losers

Losses	Average	Rank
Equipment Failure Loss	12,67%	1
Reduced Speed Loss	12,58%	2
Setup and Adjustment Loss	7,14%	3

Source: Data Processing

FMEA Analysis

FMEA was carried out as an advanced stage after the analysis of the Six Big Losses to identify and determine the priority of the failure mode at the NPK 2 Bagging facility. This analysis focused on three dominant losses, namely Equipment Failure Loss, Reduced Speed Loss, and Setup and Adjustment Loss. Each loss was then traced so that it provided a failure mode that had the potential to affect the effectiveness of the bagging process. For example, the failure mode of sewing machine damage had a value of Severity (S) of 9, Occurrence (O) of 6, and Detection (D) of 5. The value of the Risk Priority Number (RPN) was calculated using the formula $RPN = S \times O \times D$, so that $RPN = 9 \times 6 \times 5 = 270$ was obtained. The calculation of S, O, D, and RPN was then carried out on all failure modes that had been identified in table 13. [18].

Table 13. FMEA Analysis on NPK 2 Bagging Facility

No	Related Losses	Failure Mode	S	O	D	RPN
1	Equipment Failure Loss	Sewing machine malfunction	9	6	5	270
2	Equipment Failure Loss	Sensor malfunction	8	5	5	200
3	Equipment Failure Loss	Damage to drive components	9	5	5	225
4	Reduced Speed Loss	Disruption of the weighing process	8	6	5	240
5	Reduced Speed Loss	Operating speed under ideal conditions	8	5	5	200
6	Reduced Speed Loss	Unstable material flow	7	6	5	210
7	Setup and Adjustment Loss	Facility setup takes a long time	7	6	5	210
8	Setup and Adjustment Loss	Adjustment of old machine parameters	6	5	5	150
9	Setup and Adjustment Loss	Repetitive component adjustments	6	5	4	120

Source: Data Processing

For the failure mode, which is assessed based on three parameters, namely Severity (S) which indicates the severity for the impact of failure, Occurrence (O) which provides the level of probability of failure, and Detection (D) which is the ability to detect failure. From the results of the assessment, the Risk

Priority Number (RPN) value is then obtained by multiplying the levels of Severity (S), Occurrence (O), and Detection (D), which is formulated as $RPN = S \times O \times D$.

With the results of the calculation above, the failure modes with the highest RPN in each dominant loss are sewing machine damage in Equipment Failure Loss with RPN 270, weighing process disruption in Reduced Speed Loss with RPN 240, and facility setup lasting for a long time in Setup and Adjustment Loss with RPN 210. The failure mode is set as a repair priority because it has a high RPN value in each dominant loss and subsequently becomes the basis for the preparation of proposals for improvement.

Proposed Improvements

From the findings of the OEE, Six Big Losses, and FMEA analysis, it is focused on the failure mode with the highest risk priority [19]. From Equipment Failure Loss, repairs are carried out through regular checking of the condition of the sewing machine, lubrication, and replacement of worn components. In Reduced Speed Loss, periodic checks and calibration of the weighing system as well as monitoring of material flow and actual speed to keep the process running at optimal conditions.

In Setup and Adjustment Loss, the improvement is focused on reducing setup time and facility adjustment by preparing equipment and components before the process starts and establishing a clear work sequence. The implementation of these improvements is expected to reduce dominant losses and failure modes that have high risk priority so that the effectiveness of the NPK 2 Bagging facility can increase [20].

IV. CONCLUSION

Based on the results of the study, the effectiveness of the NPK 2 Bagging facility during the January-July 2026 period resulted in an average OEE of 67.23%, with Availability of 80.19%, Performance of 85.21%, and Quality of 99.48%. The results of the Six Big Losses analysis showed three dominant losses, namely Equipment Failure Loss of 12.67%, Reduced Speed Loss of 12.58%, and Setup and Adjustment Loss of 7.14%. Based on the FMEA analysis, the priority failure mode for each loss was determined based on the highest RPN value, namely sewing machine damage in Equipment Failure Loss with RPN 270, weighing process disruption in Reduced Speed Loss with RPN 240, and long-lasting facility setup in Setup and Adjustment Loss with RPN 210. These results are the basis for proposed improvements in the form of increasing preventive maintenance on sewing machines, controlling the weighing system and operating speed, as well as reducing setup time to reduce losses and increase the effectiveness of the NPK 2 Bagging facility [21].

V. ACKNOWLEDGMENTS

The author expressed his appreciation to PT XYZ for the permission and support provided during the observation process and the provision of data needed in the research. Gratitude was also expressed to the Industrial Engineering Study Program, Faculty of Engineering, University of Muhammadiyah Gresik, and the supervisor for the guidance, direction, and support provided until this research could be completed.

REFERENCES

- [1] Maslani, Hartoyo, R. Syarief, and Harianto, "A Model to Increase the Competitiveness of SOEs of Fertilizer Producers in Indonesia," Rest. IPB, 2023, [Online]. Available: <https://repository.ipb.ac.id/handle/123456789/133546>
- [2] A. J. Ramadhan and M. Jufriyanto, "Performance Analysis of Mobile Bagging Unit (MBU) Machines Using OEE (Overall Equipment Effectiveness) and FMEA (Failure Mode and Effect Analysis) *Methods, J. Technology. and Management. Ind. Application.*, vol. 5, no. 1, 2026, doi:10.55826/jtmit.v5i1.1510.
- [3] G. S. Siahaan and H. Suliantoro, "Analysis of the Value of Overall Equipment Effectiveness (OEE) to Improve the Performance of Pan Filter 1 Machine at Phosphoric Acid Plant (Case Study: PT Petrokimia Gresik)," Ind. Eng. Online J., vol. 13, no. 4, 2024, [Online]. Available: <https://ejournal3.undip.ac.id/index.php/ieoj/article/view/47618>
- [4] D. Apriansyah, Yusnawati, and M. Zeki, "Analysis of the Effectiveness of Maxtree Extruder Machine as a Basis for Maintenance to Improve Machine *Performance*," *J. Ind. Samudra*, vol. 5, no. 1, Apr. 2024, doi:

<https://doi.org/10.55377/jis.v5i1.10176>.

- [5] R. Priambodo and others, "Implementation of Six Big Losses-Based Overall Equipment Effectiveness Method to Evaluate the Effectiveness of Cement Packing Machines," *J. Serambi Eng.*, 2022, doi: 10.32672/jse.v7i2.3497.
- [6] G. Sirait and H. Banjarnahor, "Application of the Overall Equipment Effectiveness Method to Measure the Effectiveness of Press Machines," *JURSIMA*, vol. 12, no. 2, pp. 63–69, 2025, doi: 10.47024/js.v13i1.988.
- [7] R. W. Manto, S. S. Dahda, and M. Z. Fathoni, "Analysis of Engine Condition Proportions and Reliability in Hanger Shot Blast Machine by Markov Method (Case Study: PT. Barata Indonesia (Persero))," *Matric J. Manaj. and Tek. Ind. Production*, vol. 19, no. 1, pp. 23–35, 2018, doi: 10.30587/matrik.v19i1.521.
- [8] A. N. Laili, A. N. Rachmat, and P. A. Setiawan, "Performance Analysis of Roll Stand Machines Using the Overall Equipment Effectiveness Method in Steel Manufacturing Companies," *J. Safety, Heal. Environ. Eng.*, vol. 3, no. 1, pp. 74–80, 2025, doi: 10.35991/jshee.v3i1.46.
- [9] S. N. Fadilah and Y. Helianty, "Priority Order of Failure Repair Based on Failure Mode Effect Analysis Method," e-Proceeding FTI, Dec. 2024, [Online]. Available: <https://eproceeding.itenas.ac.id/index.php/fti/article/view/3442>
- [10] Samosir, "Evaluation of Effectiveness in Coke Production Using the Overall Equipment Effectiveness (OEE) Method Case Study: Coke Oven Plant PT Krakatau Steel (Persero) Tbk," *Ind. Eng. Online J.*, vol. 13, no. 2, 2024, [Online]. Available: <https://ejournal3.undip.ac.id/index.php/ieoj/article/view/43861>
- [11] I. Anwar and F. Achmadi, "Scheduling Strategy for Mold Dies Press Machine Set Up Using Overall Equipment Effectiveness (OEE) and Reliability Centered Maintenance (RCM) *Methods*," *Journal*, vol. 4, no. 2, 2023, doi: <https://doi.org/10.54471/idarotuna.v4i2.65>.
- [12] R. A. Hutapea and others, "Analisis Overall Equipment Effectiveness (OEE)," *Talent. Conf. Ser. Energy Eng.*, vol. 8, 2025, [Online]. Available: <https://talentaconfseries.usu.ac.id/ee/article/download/2658/2237/>
- [13] S. Dhuha, W. Wahyudin, and S. S. S. P. Sitorus, "Application of Overall Equipment Effectiveness Method in Measuring the Effectiveness of Kennedy Ken-503-9470k Press Machine at *PT. ABC*," *J. Serambi Eng.*, vol. 8, no. 3, 2023, doi: 10.32672/jse.v8i3.6142.
- [14] São Paulo et al., "Evaluation of OEE and Six Big Losses on CNC Cutting Machines in the Construction Industry Manufacturing CV Main Works of Engineering," *Matric J. Manaj. and Tek. Ind. Production*, vol. 26, no. 2, pp. 211–222, 2026, doi: 10.30587/matrik.v26i2.11326.
- [15] A. Dahlan, E. B. Leksono, and M. Z. Fathoni, "Identification and Analysis of Operational Risks in the Production Division of Tire Vulcanizing Companies Using Risk Management Methods with FMEA and FTA Approaches," *JUSTI (Journal of Sist. and Tek. Ind.)*, vol. 2, no. 1, pp. 44–61, 2021, doi: 10.30587/justicb.v2i1.3183.
- [16] I. Manaldi, "Analysis of Equipment Effectiveness Measurement Using the Overall Equipment Effectiveness *Method*," *J. Teknol.*, vol. 14, no. 2, pp. 56–63, 2024, doi: 10.35134/jitekin.v14i2.112.
- [17] A. G. Husna and A. I. S. Tjaja, "Efforts to Increase the Effectiveness of CNC Milling Machines Using Failure Mode and Effect Analysis," *E-Proceeding FTI*, vol. 1, no. 1, 2022, [Online]. Available: <https://eproceeding.itenas.ac.id/index.php/fti/article/view/633>
- [18] F. Wamar and L. Herdiman, "Analysis of the Effectiveness of CNC Profiling Jobs Linx 30 Machine with a Total Productive Maintenance Approach Using the OEE, Six Big Losses and FMEA Method at PT Dirgantara Indonesia," *Talent. Conf. Ser. Energy Eng.*, vol. 9, no. 2, 2026, doi: 10.32734/ee.v9i2.2802.
- [19] M. Wahyudi and W. Soedarmadji, "Analysis of the Effectiveness of Palletizer Machines with OEE and FMEA Methods," *At that time, Ilm. J. Penelit.*, vol. 7, no. 2, 2025, doi: 10.56630/tolis.v7i2.1165.
- [20] Fitriadi, "Integration of Overall Equipment Effectiveness (OEE) and Failure Mode and Effect Analysis (FMEA) to Increase the Effectiveness of Screw Press Machines at PT. Beurata Subur Persada, Nagan Raya Regency," *J. Optim.*, vol. 10, no. 2, 2024, doi: <https://doi.org/10.35308/jopt.v4i2.1524>.
- [21] D. N. Manalu, W. R. A. Pakpahan, E. R. S. B. Barus, and J. Tampubolon, "Preparation of Preventive Maintenance Schedule for Ripple Mill Machine with FMEA (Failure Mode and Effect Analysis) and OEE (Overall Equipment Effectiveness) Approaches at *PT XYZ*," *INTECOMS J. Inf. Technol. Comput. Sci.*, 2026, doi: 10.31539/r1xexr61.