Jurnal E-Komtek
Vol. 10, No. 1. (2026) pp. 305-323
https://jurnal.politeknik-kebumen.ac.id/index.php/E-KOMTEK
p-ISSN : 2580-3719 e-ISSN : 2622-3066

Analysis Overall Equipment Effectiveness (OEE) Using Multiple Linear Regression on the Assembly Coil Line at PT. XYZ

Moh. Farhan Athoillah[1], Harry Ramza[2]

[1,2] Department of Electrical Engineering, Universitas Muhammadiyah Prof. Dr. Hamka, Indonesia, 13830

mfarhanathoillah@uhamka.ac.id

https://doi.org/10.37339/e-komtek.v10i1.3321

Published by Politeknik Piksi Ganesha Indonesia

Artikel Info
Submitted:
08-07-2026
Revised:
08-07-2026
Accepted:
09-07-2026
Online first :
09-07-2026

Abstract

Production efficiency is a critical factor in the increasingly competitive automotive manufacturing industry. This study analyzes the value of Overall Equipment Effectiveness (OEE) of the Assembly Coil Line at PT. XYZ during February 2026. OEE was evaluated using three main components Availability, Performance Efficiency, and Rate of Quality. Data were collected over 20 working days, with a Planned Production Time of 19,200 minutes and Planned Down Time of 2,880 minutes, resulting in 16,320 minutes of Effective Working Time. The Average OEE reached of 94.48%, comprising Availability of 95.31%, Performance Efficiency of 99.70%, and Rate of Quality of 99,42%, all exceeded the 85% world-class benchmark. Reduced Availability was primarily caused by 670 minutes of unplanned downtime, 36 machine failures, and an average MTBF of 432 minutes. The study recommends implementing Total Productive Maintenance (TPM) and Predictive Maintenance to sustain and further improve production performance.

Keywords: OEE, Performance Efficiency, Multiple Linear Regression, Availability, TPM, Quality

Abstrak

Efisiensi produksi merupakan faktor kritis dalam industri manufaktur otomotif yang semakin kompetitif. Penelitian ini bertujuan menganalisis nilai Overall Equipment Effectiveness (OEE) pada line Assembly Coil di PT. XYZ selama Februari 2026. Perhitungan OEE dilakukan berdasarkan tiga komponen utama, yaitu Availability, Performance Efficiency, dan Rate of Quality. Data diperoleh dari 20 hari kerja, dengan total Planned Production Time sebesar 19.200 menit dan total Planned Down Time sebesar 2.880 menit, sehingga Effective Working Time sebesar 16.320 menit. Hasil analisis menunjukkan rata-rata OEE sebesar 94,48%, dengan nilai Availability 95,31%, Performance Efficiency 99,70%, dan Rate of Quality 99,42%. Yang seluruhnya melampaui standar world-class OEE sebesar 85%. Penurunan Availability terutama disebabkan oleh unplanned Downtime mesin selama 670 menit dengan 36 kali kerusakan dan MTBF rata-rata 432 minutes. Penelitian merekomendasikan penerapan Total Productive Maintenance (TPM) dan Predictive Maintenance untuk mempertahankan serta meningkatkan performa produksi secara berkelanjutan.

***Kata-kata kunci**: OEE, Performance Efficiency, Regresi Linear Berganda, Availability, TPM, Quality*

1. Introduction

The automotive manufacturing industry in Indonesia is experiencing rapid growth in line with rising demand for motor vehicles. As one of the leading suppliers of automotive components, PT. XYZ is required to continuously improve the efficiency and productivity of its production lines in order to remain competitive in the global market.

Overall Equipment Effectiveness (OEE) is one of the techniques commonly used to measure and improve the effectiveness of production equipment [1]. OEE was first introduced by Seiichi Nakajima in 1988 as part of the Total Productive Maintenance (TPM) concept [2]. This method comprehensively integrates three key aspects: machine availability, performance efficiency, and product quality rate [3].

The Assembly Coil Line is one of the critical production lines in the Coil Assembly Department at PT. XYZ, responsible for assembling coil components for vehicle ignition systems. Overall Equipment Effectiveness (OEE) assessment has been applied by several researchers to evaluate machine performance and identify areas for improvement, particularly with regard to enhancing efficiency and reducing downtime. Previous research has shown that the application of OEE can provide important insights for improving production effectiveness on the assembly line, thereby optimising the overall manufacturing process [4] [5].

According to the production data of PT. XYZ's for February 2026, the Assembly Coil Line recorded 670 minutes of unplanned downtime and 36 machine breakdowns. These interruptions reduced the effective operating time of the equipment and may adversely affect production productivity if not addressed through continuous improvement efforts. Although the Overall Equipment Effectiveness (OEE) exceeded the world-class benchmark, identifying the key factors influencing OEE remains essential for developing effective strategies to enhance machine reliability and improve production efficiency [2][6].

Previous research has generally focused on measuring Overall Equipment Effectiveness (OEE). Most studies have stopped at the stage of evaluating OEE values or analysing the Six Big Losses, without statistically testing the operational factors that have the greatest influence on OEE. Furthermore, previous studies have been conducted on various types of machinery and in different manufacturing companies, meaning that the characteristics of the causes of OEE decline may not necessarily be the same as those at PT. XYZ's Assembly Coil Line. Therefore, this study not only calculates the OEE value but also integrates an analysis of Mean Time Between Failure (MTBF), product defects and downtime using the multiple linear regression method to identify the most dominant factors influencing OEE [5].

The implementation of OEE in the Coil Assembly Department at PT. XYZ is expected to reduce unplanned downtime and increase production speed, in line with the findings of previous research. Consequently, a continuous improvement strategy can be formulated to achieve a higher OEE value and meet industry standards. Disruptions on this line have the potential to hamper the company's entire internal supply chain. Against this background, the research aims to conduct an in-depth analysis of the OEE value on the Assembly Coil Line for the period February 2026, identify the factors influencing it, and recommend data-driven improvements [7].

The contribution of this research is to produce an analytical model that not only evaluates the level of line effectiveness through OEE, but also identifies the extent of the influence of MTBF, product defects and downtime on OEE using a statistical approach. The research findings are expected to form the basis for the development of data-driven machine maintenance strategies to improve production effectiveness on a sustainable basis [5] [8].

2. Method

This study aims to analyze the effectiveness of production equipment, identify the factors causing losses, and determine the influence of independent variables on the Overall Equipment Effectiveness (OEE) value [1] [9]. The analysis was conducted by calculating OEE, measuring MTBF, and applying Multiple Linear Regression (MLR) to identify the relationships among the variables under investigation. The research methodology is presented in the flowchart shown in **Figure 1.**

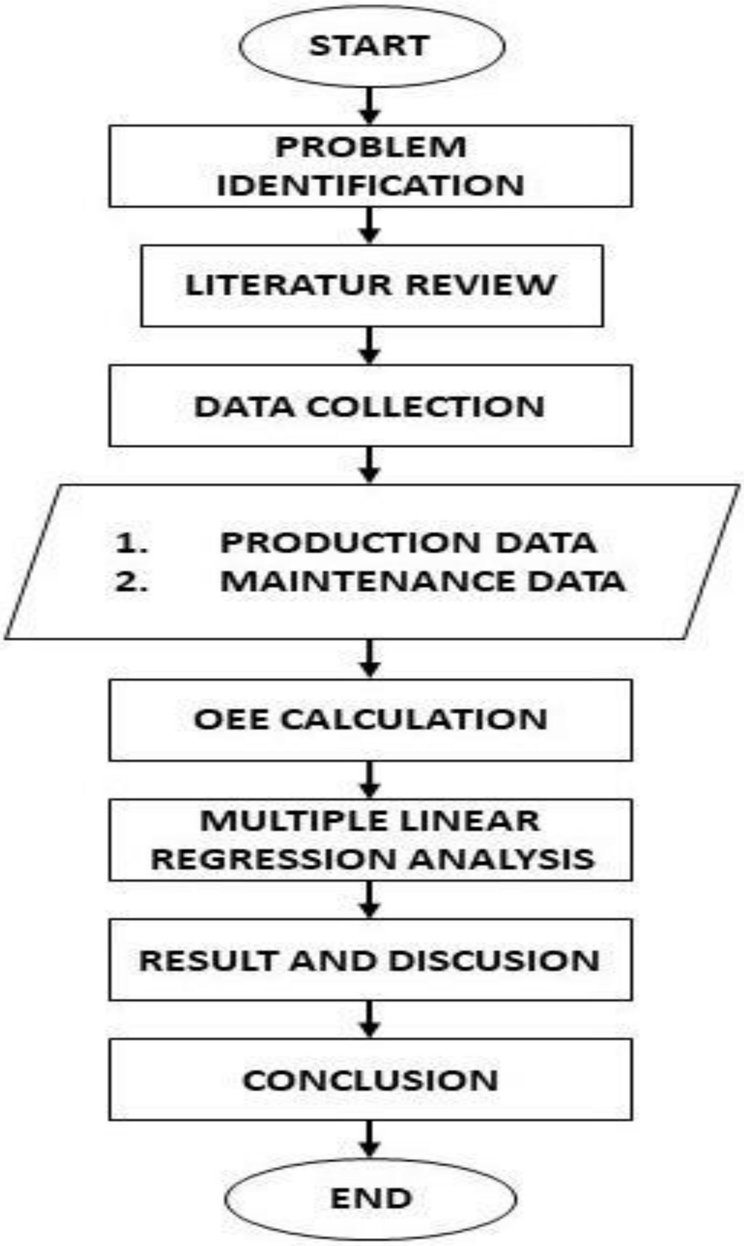

Figure 1. Research Flowchart

2.1 Overall Equipment Effectiveness (OEE)

The analysis conducted in this study employed the Overall Equipment Effectiveness (OEE) approach based on the guidelines established by the Japan Institute of Plant Maintenance (JIPM) [1]. OEE was used as a performance indicator to evaluate the operational effectiveness of production equipment through three key components, namely Availability, Performance and Quality [3]. This combination provides a comprehensive measure of the level of equipment utilization and performance in supporting the production process. The fundamental concept of OEE calculation, along with the classification of the Six Big Losses that affect production equipment effectiveness, is presented in **Figure 2.**

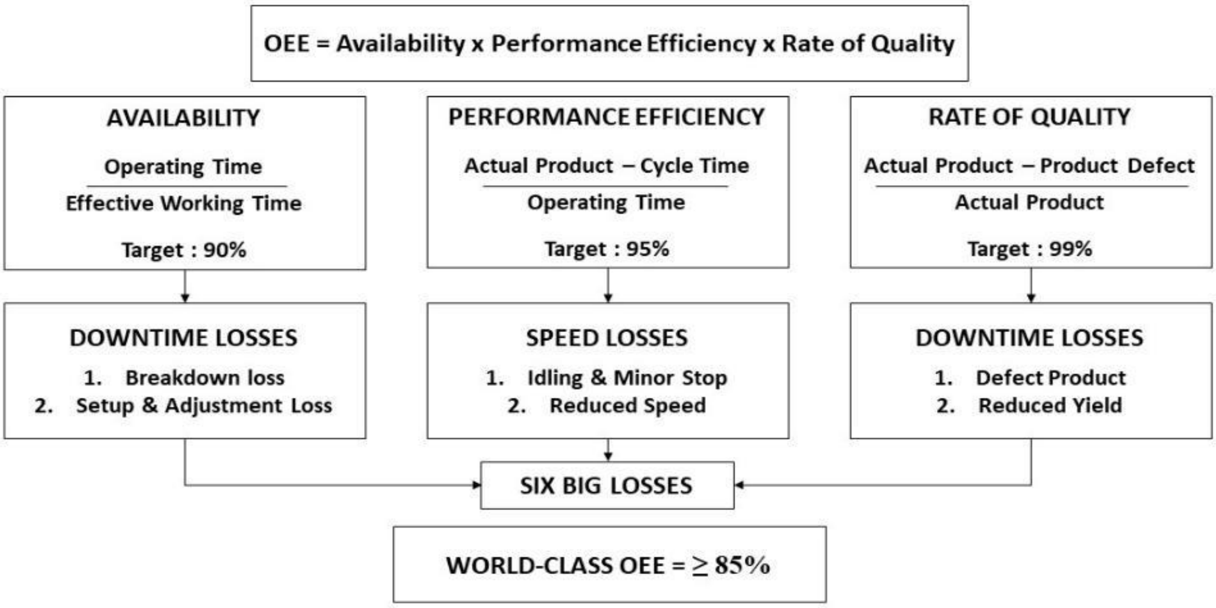

Figure 2. Fundamental Concept of OEE Calculation and the Classification of Six Big Losses [1].

a. Availability is the ratio of actual machine operating time to the planned operating time. It measures the amount of time that the equipment is available for production according to the scheduled operating time and is influenced by both planned downtime and unplanned downtime [3]. The equation used to calculate availability is **Equation (1).**

$$\text{Availability}(\%) = \left(\frac{\text{Operating Time}}{\text{Effective Working Time}}\right)\text{x}100\% \tag{1}$$

b. Performance Efficiency measures how fast the equipment operates compared with its ideal speed. This component reflects losses caused by reduced operating speed and micro-stoppages [3]. The equation used to calculate Performance Efficiency is presented in **Equation (2).**

$$\text{Performance Efficiency}(\%) = \left(\frac{\text{Actual Production} - \text{Theoretical Cycle Time}}{\text{Operating Time}}\right)\text{x}100 \tag{2}$$

c. Rate of Quality is the ratio of good products to the total number of products produced. This component represents losses resulting from defective products and rework during the production process [10]. The equation used to calculate the rate of Quality is presented in **Equation (3).**

$$\text{Rate of Quality}(\%) = \left(\frac{\text{Actual Production} - \text{Product Defect}}{\text{Actual Production}}\right) x100 \quad (3)$$

d. Overall Equipment Effectiveness (OEE) is obtained by multiplying the values of Availability, Performance Efficiency, and Rate of Quality (RoQ)[1][3]. The equation used to calculate the Overall Equipment Effectiveness (OEE) value is presented in **Equation (4).**

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

Subsequently, the calculated OEE values was compared with the world-class standards established by the Japan Institute of Plant Maintenance (JIPM) as a benchmark for evaluating production equipment effectiveness. According to this standard, the minimum acceptable OEE value is 85%, with component values of Availability ≥90%, Performance Efficiency of ≥95%, and a Rate of Quality of ≥99%. This evaluation was conducted to determine the level of effectiveness achieved by the production system under study.

2.2 Six Big Losses

Within the framework of Total Productive Maintenance (TPM), the Six Big Losses theory identifies six main sources of productivity losses that affect the effectiveness of production equipment. These six losses include machine breakdowns (breakdown losses), downtime due to set-up and adjustment (setup and adjustment losses), idling and minor stoppages s (idling and minor stoppage losses), reduced operating speed (reduced speed losses), in-process product defects (process defect losses), and reduced yield in the early stages of production (reduced yield losses) [5]. This concept forms the basis for measuring Overall Equipment Effectiveness (OEE), as each category of loss contributes directly to the components of Availability, Performance and Quality. Thus, the Six Big Losses provide a clear and systematic analytical framework for identifying factors that reduce productivity and serve as a reference for continuous improvement to enhance efficiency and the quality of production output **[3]**.

2.3 Multiple Linear Regression

Linear regression modelling is one of the analytical approaches used to determine the relationship between, and the influence of, several independent variables on a single dependent variable simultaneously **[11][12]**. This approach aims to identify changes in the dependent variable that are influenced by changes in the independent variables, either partially or simultaneously. In this study, multiple linear regression analysis was applied to examine the influence of Mean Time Between Failure (MTBF), Product Defects and Downtime on Overall Equipment Effectiveness (OEE) **[5]**. The application of Multiple Linear Regression in manufacturing research is crucial because the achievement of production equipment effectiveness is influenced not only by a single factor, but also by numerous operational factors that are interrelated. The MTBF value represents the level of machine reliability in operating without failure, Product Defects indicate the quality level of production output; whilst Downtime describes the time during which the machine is idle, which can reduce the effectiveness of the production process. Consequently, the application of multiple linear regression analysis can be utilised to analyse the factors that make the most significant contribution to the achievement of the OEE value. For the purposes of this study, the equation used in the Multiple Linear Regression equation used presented in **Equation (5).**

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 \tag{5}$$

In the Multiple Linear Regression equation, Y represents the dependent variable, namely Overall Equipment Effectiveness (OEE), while a denotes the regression constant, representing the OEE value when all independent variables are zero. The regression coefficients b_1, b_2 and b_3 indicate the magnitude of the change in the OEE value resulting from a one-unit change in each independent variable, assuming that all other variables remain constant. X_1 represents Mean Time Between Failure (MTBF), X_2 represents Product Defects, and X_3 represents Downtime, all of which serve as the independent variables in this study **[13]**. A positive coefficient indicates a positive relationship, meaning that an increase in the independent variable will increase the OEE value. Conversely, a negative coefficient indicates in inverse relationship, meaning that an increase in the independent variable results in decrease the OEE value. Classical assumption tests were conducted to ensure that the regression model satisfied the assumptions of the Best Linear Unbiased Estimator (BLUE), including multicollinearity and heteroscedasticity tests **[14]**. Subsequently, statistical analysis was conducted using the coefficient of determination (R^2) and Adjusted R^2 to assess the ability of the independent variables to explain the variation in OEE values. In addition, the F-test was performed to examine the simultaneous effect of the variables MTBF, Product Defects and Downtime on Overall Equipment Effectiveness (OEE) **[13]**. The results of these analyses were used to identify the factors influencing production equipment effectiveness and to support efforts aimed at improve production performance.

Several previous studies have applied Multiple Linear Regression to analyse the relationships among variables in the manufacturing sector, whereas studies on Overall Equipment Effectiveness (OEE) have generally focused on measuring OEE values **[15]**. However, these studies have not yet integrated OEE analysis with Multiple Linear Regression to examine the simultaneous effects of Mean Time Between Failure (MTBF), Product Defects, and Downtime on OEE values in an Assembly Coil Line. Therefore, this study aims to identify the dominant factors influencing OEE values in order to provide more targeted and data-driven recommendations for improvement **[6] [15]**.

2.4 Pearson's Correlation

To analyse the linear relationships among the independent variables namely, Mean Time Between Failure (MTBF) (X_1), Product Defects (X_2), and Downtime (X_3) the Pearson correlation method was employed. This statistical method was used to measure the strength and direction of the linear relationship between two variables. The Pearson correlation coefficient ranges from −1 to +1. A positive coefficient indicates a positive linear relationship between the variables, whereas a negative coefficient close to zero indicates little or no linear relationship between the variables. The equation for calculating the Pearson correlation coefficient is presented in **Equation (6).**

$$r_{X_iX_j} = \frac{\sum(X_i - \bar{X}_i)(X_j - \bar{X}_j)}{\sqrt{\sum(X_i - \bar{X}_i)^2 \cdot \sum(X_j - \bar{X}_j)^2}} \quad (6)$$

2.5 Research Variables

The research variables were defined based on technical indicators directly related to production equipment effectiveness. The independent variables include Mean Time Between Failure (MTBF), Product Defects and Downtime, which represent equipment reliability, production quality, and the level of operational disruption, respectively **[5] [8]**. Meanwhile, the dependent variable is OEE, which is calculated based on the components of Availability, Performance Efficiency and Rate of Quality. This variable structure was designed to provide a comprehensive understanding of the relationship between technical maintenance-related factors and production equipment effectiveness. The research variables are presented in **Table 1.**

Table 1. Research Variables

Variable	Variable Type	Description	Unit
X1	Independen	Mean Time Between Failure (MTBF)	Minutes
X2	Independen	Product Defect	Pcs
X3	Independen	Downtime	Minutes
Y	Dependen	Overall Equipment Effectiveness (OEE)	%

Source: OEE data analysis February, 2026

Table 1 shows that the independent variables were selected to measure the technical factors that directly influence the production equipment effectiveness **[10]**. MTBF represents the system's operational reliability, Product Defect indicates the quality level of the output, and Downtime reflects the amount of production time lost due to operational disruptions **[7]**. The dependent variable OEE was selected because it provides a comprehensive measure of production system effectiveness by integrating three core components of OEE. This variable structure is expected to provide a deeper understanding of the factor influencing production line effectiveness through the relationships between the independent and dependent variables**.**

3. Results and Discussion

3.1 Determination of Overall Equipment Effectiveness (OEE)

Based on production and maintenance data collected over 20 working days in February 2026, the daily Overall Equipment Effectiveness (OEE) values for the Assembly Coil Line were determined. The dataset includes technical variables such as Downtime, Product Defects and MTBF. In addition, it presents the three components of OEE, namely Availability, Performance Efficiency, Rate of Quality, as well as the corresponding daily OEE values. The presentation of these data provides a comprehensive overview of the day-to-day variation in production equipment effectiveness during the observation period. The dataset is presented in **Table 2.**

Table 2. Daily OEE Data for the Assembly Coil Line February 2026

Day	Downtime (min)	Prod. Defect (pcs)	MTBF (min)	A (%)	PE (%)	RoQ (%)	OEE (%)
1	50	120	766	93.87	99.70	97.91	91.63
2	55	77	376	92.03	99.68	98.63	90.48
3	0	16	816	100	9975	99.74	99.49
4	60	46	250	92.03	99.70	99.18	91.01
5	115	8	701	85.91	99.67	99.85	85.50
6	10	145	801	98.16	99.68	97.58	95.49
7	35	18	260	95.71	99.72	99.69	95.15
8	55	15	250	92.03	99.70	99.73	91.51
9	60	23	378	92.65	99.70	99.59	91.99
10	0	16	801	98.16	99.75	99.73	97.66
11	35	12	391	95.71	99.73	99.80	95.26
12	10	12	796	97.55	99.68	99.80	97.04
13	0	42	816	100	99.75	99.31	99.07
14	30	12	260	95.71	99.70	99.80	95.23

15	65	21	376	92.03	99.70	99.63	91.41
16	35	15	255	93.87	99.66	99.74	93.31
17	25	19	396	96.94	99.72	99.68	96.35
18	0	21	806	98.77	99.75	99.65	98.19
19	10	12	806	98.77	99.70	99.80	98.28
20	20	22	393	96.32	99.67	99.63	95.64
Total	670	672	10,694	95.31	99.70	99.42	94.48

Source: Production Data from the Assembly Coil Line at PT. XYZ, February 2026.
A: Availability
PE: Performance Efficiency
RoQ: Rate of Quality

Table 2 shows that the daily OEE values varied considerably throughut the observation period. The highest value was recorded on day 3, reaching 99.49%, whereas the lowest value was observed on day 5, at 85.50% primarily due to relatively high downtime (115 minutes). Over the 20 working days, total production reached 116.703 pcs. The calculated average values were 95.31% for Availability, 99.70% for Performance Efficiency, and 99.42% for Rate of Quality, resulting in an overall average OEE of 94.48%. The Performance Efficiency value indicates that the equipment operated close to its ideal cycle time (8 seconds), with minimal speed losses and minor stoppages, thereby ensuring efficient production operations. Similarly, the high Rate of Quality indicates that the production process consistently met quality standards with a very low defect rate (0.57%). These finding suggest that, although production performance and quality consistently exceed world-class standards, downtime remains the primary factor contributing to fluctuations in OEE value. Therefore, reducing and controlling downtime through a more structured maintenance strategy should be prioritized to maintain the consistent effectiveness of the production line.

3.2 Calculation of OEE Components

Once the values for Availability, Performance, and Efficiency have been obtained, the next step is to calculate Overall Equipment Effectiveness (OEE). The OEE value is calculated by multiplying these three components to obtain an indicator represents the overall effectiveness of the production equipment. Subsequently, the calculated OEE value is evaluated against the world-class OEE standards to assess the operational performance and equipment effectiveness of the production line under study. The calculated OEE values are presented in **Table 3**.

$$\text{OEE} = 95{,}31\% \times 99{,}70\% \times 99{,}42\% = 94{,}48\% \tag{7}$$

Table 3. Calculation of OEE Components

OEE Components	Value	Standar World-class	Status
Availability	95.31%	≥ 90%	Achieved
Performance Efficiency	99.70%	≥ 95%	Achieved
Rate of Quality	99.42%	≥ 99%	Achieved
OEE	94.48%	≥ 85%	Achieved

All OEE components exceeded the world-class standards.
Source: OEE data analysis February, 2026

a. The Average Availability of the Assembly Coil Line in February 2026 was 95.31%, exceeding the world-class standard of 90%. However, Availability was the lowest among the three OEE component, making it the primary factor contributing to the reduction in the overall OEE value. Over 20 working days, total unplanned downtime amounted to 670 minutes, with an average of 33.5 minutes per day. The highest downtime occurred on Day 5, reaching 115 minutes, which reduced the OEE value to 85,50%, the lowest recorded during the observation period. All recorded unplanned downtime resulted from machine breakdowns, whereas no downtime attributable to material storages or other factors was recorded.

b. The average Performance Efficiency of the Assembly Coil Line in February 2026 was 99.70%, consistently exceeding the world-class standard of 95% throughout the observation period. This result indicates that the production equipment operated very close to its ideal speed. The theoretical cycle time of 0.13 minutes per piece, with an actual total production of 116,703 pieces, the production line achieved a high level of operational performance. Furthermore, no significant speed losses or minor stoppages were observed during observation period.

c. The Average Rate of Quality of the Assembly Coil Line in February 2026 was 99.42%, exceeding the world-class standard of 99%. During the 20 working days, a total 672 defective units were recorded out of a total production of 116,703 units. The highest Rate of Quality was 99.85%, recorded on Day 5, whereas the lowest was 97.58%, recorded on Day 6, when145 defective units were produced. Despite these daily variations, the consistently high Rate of Quality indicates that the quality control process on the Assembly Coil Line operated effectively throughout the observation period.

d. The Mean Time Between Failure (MTBF) was calculated to determine the average time between machine failures of the Assembly Coil Line during the observation period. MTBF serves as an indicator of equipment reliability, with higher MTBF values indicating a lower frequency of machine failures, consequently, more stable production system performance. The Equation used to calculate MTBF is presented in **Equation (8)**, and the calculation are presented in **Table 4.**

$$\text{MTBF} = \frac{15{,}555}{36} = 432 \text{ Minutes} \tag{8}$$

Table 4. MTBF Calculation Results

Period	Failure Frequency	Operating Time (min)	MTBF
February 2026	36	15,555 minutes	432 minutes

Source: OEE data analysis February, 2026

Table 4 shows that the MTBF of the Assembly Coil Line in February 2026 was 432 minutes, based on total of 36 machine failures. these results indicate that, on average, the production equipment operated for 432 minutes between consecutives failures. This finding reflects a relatively high level of equipment reliability, as the intervals between failures relatively long. An increase in MTBF contributes directly to the Availability component of the OEE calculation. Therefore, a higher MTBF is associated with improved overall production equipment effectiveness.

3.3 Six Big Losses

In addition to the quantitative analysis based on OEE calculations, a more detailed analysis of the major sources of production losses was conducted. The Six Big Losses approach was employed to identify the distribution of losses across each loss category, thereby highlighting the dominant factors contributing to reduced production equipment effectiveness. This analysis provides a comprehensive understanding of operational loss patterns and serves as a basis for prioritizing improvement initiatives.

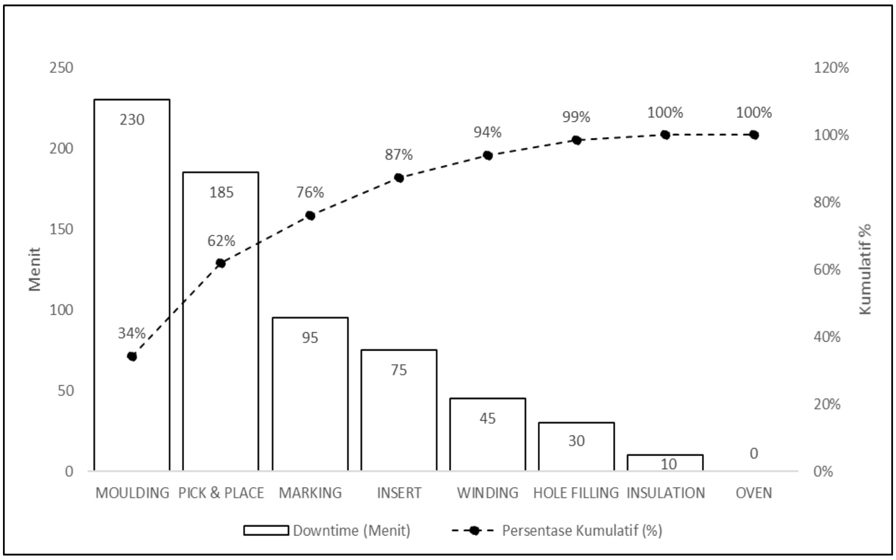

Figure 3. Six Big Losses chart

Figure 3 shows a graph of the 'Six Big Losses' from the downtime distribution for each process on the Assembly Coil line. The results indicate that the Moulding and Pick & Place processes ware the largest contributors to downtime, accounting for combined 62% of the total downtime. This finding suggests that the reduction in production equipment effectiveness was primarily attributable to these two processes. Other processes, such as Marking, Insert and Winding, have a relatively smaller impact, whereas Oven processes recorded no downtime during the observation period.

This distribution of downtime is directly related to the Availability component of the OEE calculation. Any increase in downtime reduces the actual operating time of the production equipment, thereby lowering the availability value. Although the average availability (95.31%) exceeded the world-class standard (90%), substantial downtime in the critical processes my reduce the consistency of overall OEE performance. Therefore, improvement efforts should focus on reducing downtime in the moulding and pick-and-place processes. The implementation of Total Productive Maintenance (TPM) and predictive maintenance strategies in these critical processes is expected to improve equipment reliability, enhance availability, and maintain OEE consistently above the world-class standard **[5][12].**

3.4 Multiple Linear Regression Analysis

This analysis was conducted to examine the effects of Mean Time Between Failure (MTBF), Product Defects, and Downtime on the Overall Equipment Effectiveness (OEE) in the Assembly Coil line during the observation period.

3.4.1 Pearson Correlation Matrix

This test was conducted to examine the strength and direction of the linear relationship among the independent variables, namely MTBF, Product Defects, and Downtime [6]. Pearson correlation analysis was performed as a preliminary step to identify the degree of association among the independent variables before conducting the Multiple Linear Regression analysis. The results provide an overview of the relationship among the independent and support the assessment of the suitability of the regression model. The Pearson correlation matrix is presented in **Table 5.**

Table 5. Pearson Correlation Matrix among Variable (N = 20)

Variable	MTBF (X1)	Product Defect (X2)	Downtime (X3)
MTBF (X1)	1,000	0,253	-0,450*
Product Defect (X2)	0,253	1,000	-0,023
Downtime (X3)	-0,450*	-0,023	1,000

Source: OEE data analysis February, 2026

The results presented in **Table 5** show that the Pearson correlation coefficient between MTBF and Downtime was −0.450. The absolute value of the calculated correlation coefficient (|r| = 0.450) exceeded the critical r value (0.444) at the 5% significance level for a sample size of N = 20, indicating a statistically significant negative correlation between MTBF and Downtime. In other words, higher MTBF values were associated with lower Downtime, suggesting that improved equipment reliability is related to fewer operational interruptions. Conversely, the correlation coefficient between MTBF and Product Defects was 0.253, whereas the coefficient between Product Defects and Downtime was −0.023. Both coefficients were smaller than the critical r value (0.444), indicating that these relationships were not statistically significant. These findings suggest that Product Defects were not significantly correlated with either MTBF or Downtime during the observation period. Overall, the Pearson correlation analysis indicates that only the relationship between MTBF and Downtime was statistically significant. Furthermore, no strong correlations ($r > 0.80$) were observed among the independent variables, suggesting that multicollinearity was unlikely. This assumption was subsequently confirmed through the multicollinearity test.

3.4.2 Classical Assumption Test

a. Heteroscedasticity Test

The heteroscedasticity test was conducted to determine whether the residuals in the regression model exhibited constant variance (homoscedasticity). The test was performed using the Glejser method with ABS_RES as the dependent variable [6][8]. The results of the heteroscedasticity test are presented in **Table 6.**

Table 6. Results of the Heteroscedasticity Test

Variable	B	Std. Error	Beta	t	Sig	Interpretation
Constant	0,889	0,205	-	4,334	0,001	-
MTBF	0,000	0,000	-0,110	-0,468	0,646	Homoscedasticity
Product Defect	-0,003	0,002	-0,413	-1,975	0,066	Homoscedasticity
Downtime	-0,005	0,002	-0,444	-1,959	0,068	Homoscedasticity

Dependent Variable: ABS_RES

Based on the Glejser test results presented in **Table 6**, all independent variables in the regression model namely, MTBF, Product Defects, and Downtime have significance values (p-values) greater than 0,05. These results indicate that no evidence of heteroscedasticity was detected, suggesting that the regression model satisfies the homoscedasticity assumptions. The absence of heteroscedasticity supports the reliability of the estimated regression coefficients. Consequently, the statistical inferences derived from the regression model, including the *t*-test and *F*-test, can be considered valid. These findings further support the suitability of the regression model for explaining the relationships between MTBF, Product Defects, Downtime, and Overall Equipment Effectiveness (OEE).

b. Multicollinearity Test

The multicollinearity test was performed to examine whether correlations existed among the independent variables. The regression model is considered to be free from multicollinearity if the Tolerance value is greater than 0.10 and the Variance Inflation Factor (VIF) Is less than 10 [6]. The results of the multicollinearity test are presented in Table 7.

Table 7. Results of Multicollinearity Test

Variable	Tolerance	VIF	Interpretation
(X1) MTBF	0.739	1.353	No multicollinearity
(X2) PRODUK DEFECT	0.926	1.080	No multicollinearity
(X3) DOWNTIME	0.789	1.267	No multicollinearity

a. **Dependent Variable: OEE**

Based on the multicollinearity test results presented in Table 7, the Tolerance values for MTBF (X_1), Product Defects (X_2), and Downtime (X_3) were 0.739, 0.926, and 0.789, respectively. All Tolerance values exceeded the minimum threshold of 0.10, indicating that no multicollinearity was detected. In addition, the Variance Inflation Factor (VIF) values for MTBF, Product Defects, and Downtime were 1.353, 1.080, and 1.267, respectively. Since all VIF values were below 10, the regression model was considered free from multicollinearity.

These findings indicate that the regression model satisfies the assumption of no multicollinearity. Consequently, the contribution of each independent variable to Overall Equipment Effectiveness (OEE) can be estimated reliably without substantial distortion caused by linear relationships among the predictor variables.

3.4.3 Multiple Linear Regression Analysis

This analysis was conducted to examine the simultaneous and partial effects of the independent variables, namely Mean Time Between Failure (MTBF) (X_1), Product Defects (X_2), and Downtime (X_3), on the dependent variable, Overall Equipment Effectiveness (OEE). Using this method, the contribution of each independent variable to production equipment effectiveness can be evaluated. Since the regression model satisfied the classical assumption tests, the estimated regression coefficients were considered valid and suitable for interpreting the relationships among the variables and supporting the development of appropriate equipment maintenance strategies. The results of the multiple linear regression analysis are presented in **Table 8.**

Table 8. Results of Multiple Linear Regression Analysis

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	98.492	0.544		181,130	0,000
MTBF	0.001	0.001	0,048	0,921	0,371
PRODUCT DEFECT	-0.016	0.004	-0,173	-3,680	0,002
DOWNTIME	-0.115	0,006	-0,952	-18,727	0,000

a. Dependent Variable: OEE

The regression coefficients presented in **Table 8** were then substituted into the multiple linear regression equation to describe the relationship between the dependent variable, Overall Equipment Effectiveness (OEE), and the independent variables, namely Mean Time Between Failure (MTBF), Product Defects, and Downtime, as shiwn in **Equation 9**.

$$Y = 98.492 + 0.001X1 - 0.016X2 - 0.115X3 \quad (9)$$

The interpretation of the regression coefficients explains how a one-unit increase or decrease in each independent variable affects the OEE value, assuming that the other independent variables remain constant.

1. MTBF: In theory, a higher MTBF is expected to improve OEE. However, in this study, the regression coefficient was very small (0.001), indicating that a one-unit increase in MTBF was associated with only a 0.001% increase in OEE. Furthermore, this effect was not statistically significant, suggesting that variations in MTBF did not have a significant influence on OEE.
2. Product Defects: A one-unit increase in Product Defects was associated with a 0.016% decrease in OEE. Conversely, a one-unit decrease in Product Defects was associated with a 0.016% increase in OEE. This effect was statistically significant.
3. Downtime: Downtime was the most influential variable in the regression model. A one-minute increase in Downtime was associated with a 0.115% decrease in OEE, whereas a one-minute decrease in Downtime was associated with a 0.115% increase in OEE. This

effect was statistically significant and is consistent with the principles of Total Productive Maintenance (TPM).

3.4.4 Simultaneous F-Test (ANOVA)

The simultaneous F-test (ANOVA) was performed to evaluate whether the independent variables collectively exerted a significant influence on the dependent variable. The analysis was conducted by comparing the p-value with the significant level of 5% ($\alpha = 0.05$). A p-value below 0.05 indicates that the independent variables have a statistically significant joint effect on the dependent variable. In contrast a p-value exceeding 0.05 suggest that the independent variables do not collectively as statistically significant effect on the dependent variable. The results of the simultaneous F-test are presented in **Table 9.**

Table 9. Results of the Simultaneous F-Test (ANOVA)

Model	Sum of Square	df	Mean Square	F	Sig.
Regression	233.277	3	77.759	158.244	0.000[b]
Residual	7.862	16	0.491		
Total	241.139	19			

a. Dependent Variable: OEE

b. Predictors: (Constant), DOWNTIME, PRODUCT DEFECT, MTBF

The results presented in **Table 9** show that the calculated F value was 158.244, with a significance value (*p*-value) of 0.000. With a sample size of 20 and three independent variables (MTBF, Product Defects, and Downtime), the regression degrees of freedom were $df_1 = 3$, and the residual degrees of freedom were $df_2 = 16$, resulting in a critical F value of 3.24 at $\alpha = 0.05$. Since the calculated F value (158.244) was greater than the critical F value (3.24) and the *p*-value was less than 0.05, the regression model was statistically significant. These findings indicate that MTBF, Product Defects, and Downtime jointly had a significant effect on Overall Equipment Effectiveness (OEE).

3.4.5 Coefficient of Determination (R^2) and Adjusted R^2

The coefficient of determination analysis was conducted to evaluate the ability of the independent variables to explain the variation in the dependent variable. The R^2 value represents the proportion of the variation in Overall Equipment Effectiveness (OEE) explained by the regression model [7]. A higher R^2 value indicates that the independent variables account for a greater proportion of the variation in the dependent variable. Therefore, R^2 serves as an important indicator of the model's goodness of fit. The results of the coefficient of determination analysis are presented in **Table 10**.

Table 10. Results of the Coefficient of Determination Analysis

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.984	0.967	0.961	0.70099

a. Predictors: (Constant), DOWNTIME, PRODUCT DEFECT, MTBF

Table 10 shows that the regression model produced an R^2 value of 0.967 and an Adjusted R^2 value of 0.961. These results indicate that 96.1% of the variation in Overall Equipment Effectiveness (OEE) can be explained by MTBF, Product Defects, and Downtime, whereas the remaining 3.9% is attributable to other factors not included in the model. The high Adjusted R^2 value indicates that the regression model remains robust after adjusting for the number of independent variables. Overall, these findings demonstrate that the proposed regression model provides an excellent fit to the observed data.

4. Conclusion

The results of this study on the Assembly Coil Line at PT. XYZ during February 2026 showed that the average Overall Equipment Effectiveness (OEE) was 94.48%, with Availability, Performance Efficiency, and Rate of Quality values of 95.31%, 99.70%, and 99.42%, respectively. All OEE components exceeded the world-class benchmark (≥85%). However, Availability recorded the lowest value among the three components, primarily due to 670 minutes of unplanned Downtime resulting from 36 machine failures. The average Mean Time Between Failure (MTBF) was 432 minutes, indicating a relatively good level of equipment reliability.

The multiple linear regression analysis showed that Downtime was the most significant factor affecting OEE, with a regression coefficient of −0.115. Product Defects also had a statistically significant negative effect on OEE, with a regression coefficient of −0.016, whereas MTBF did not have a statistically significant effect. Furthermore, the simultaneous F-test indicated that MTBF, Product Defects, and Downtime jointly had a significant effect on OEE ($F = 158.244$, $p < 0.001$).

The coefficient of determination analysis produced an R^2 value of 0.967 and an Adjusted R^2 value of 0.961, indicating that 96.1% of the variation in OEE could be explained by MTBF, Product Defects, and Downtime, while the remaining 3.9% was attributable to other factors not included in the model. Overall, the findings indicate that the effectiveness of the Assembly Coil Line has reached the world-class level. Nevertheless, further improvements can be achieved by increasing Availability, particularly through reducing Downtime and minimizing the frequency of machine failures.

References

[1] M. Asbari, "Systematic Literature Review : Implementasi Overall Equipment Effectiveness (OEE) terhadap Kinerja Industri Manufaktur di Indonesia," vol. 1, no. 1, pp. 67–88, 2026.
[2] A. B. Sulistyo and S. M. Wirawati, "Analisis Penerapan Total Productive Maintenance (TPM) dengan Perhitungan Overall Equipment Effectiveness (OEE) pada Mesin Sewing di PT Parkland World Indonesia," vol. 24, no. 2, pp. 278–288, 2024.
[3] I. H. Nugroho, X. Salahudin, and F. Hilmy, "Optimasi Produktivitas Mesin Microfeed melalui Pendekatan Overall Equipment Effectiveness (OEE): Studi Kasus di Industri Manufaktur," vol. 4, no. 1, pp. 63–68, 2025.
[4] H. Ariyah, "Penerapan Metode Overall Equipment Effectiveness (OEE) Dalam Peningkatan Efisiensi Mesin Batching Plant (Studi Kasus : PT . Lutvindo Wijaya Perkasa)," vol. 1, no. 2, pp. 70–77, 2022.
[5] A. T. Kirana *et al.*, "Analisis Perhitungan Overall Equipment Effectiveness (OEE) untuk Meningkatkan Efisiensi Mesin Haloong (Studi Kasus : PT Benteng Api Technic , Gresik)," vol. 7, no. 1, pp. 59–68, 2024.
[6] M. Oee, D. I. Pt, and M. Jaya, "Jurnal Taguchi," pp. 220–228, 2024.
[7] W. A. Ramadhanus, R. R. Padmakusumah, and R. Vanditta, "Analisis Pengaruh Implementasi Lean & Six Sigma Terhadap Kinerja Operasional Pada Perusahaan Manufaktur XYZ," vol. 6, no. 4, pp. 2267–2274, 2025.
[8] A. S. Purba, N. F. P. Leksonowati, N. Pamungkas, N. Yuniarsih, N. H. Batubara, and D. Prasetyo, "Studi Pengaruh Nilai Availability Mesin Stamping Terhadap Jumlah Hasil Produksi," *J. Integr.*, vol. 16, no. 2, pp. 98–103, 2024, doi: 10.30871/ji.v16i2.8536.
[9] M. N. Rafliadi, B. B. Ramadhan, A. Danar, and Y. Prastyo, "Menganalisis Produktivitas Kerja Menggunakan Metode Total Productive Maintenance (TPM) dan Overall Equipment Effectivness (OEE) Pada Mesin Moulding," vol. 2, no. 1, pp. 24–32, 2025.
[10] G. Primula and M. I. Hamdy, "Evaluasi Efektivitas Mesin Ripple Mill Melalui Pendekatan Overall Equipment Effectiveness (OEE)," vol. 2, no. 4, pp. 301–309, 2023.
[11] F. Suwanto and I. Pradesan, "Implementasi Data Mining Regresi Linear Berganda Pada Sistem Prediksi Penjualan Obat Pada Apotek XYZ," vol. 5, no. 1, pp. 83–94, 2026.
[12] I. J. Matondang, E. Budianita, F. Syafria, and I. Afrianty, "BULLETIN OF COMPUTER SCIENCE RESEARCH Sistem Prediksi Produksi Kelapa Sawit Berbasis Gradio Menggunakan Algoritma Regresi Linear Berganda," vol. 6, no. 2, pp. 664–672, 2026, doi: 10.47065/bulletincsr.v6i2.994.
[13] S. Kasus, A. Demin, and P. Pt, "Analisa Penerapan Konsep Kaizen 5S Terhadap Efektivitas Kerja Menggunakan Uji Regresi Linier Berganda," vol. 11, no. 2, pp. 139–146, 2023.
[14] D. Ruhiat and F. Azis, "Regresi Nonparametrik Spline Multivariabel untuk Pemodelan Pengaruh Unit Usaha , Tenaga Kerja dan Nilai Investasi pada Usaha Mikro terhadap Pertumbuhan PDRB di Provinsi Jawa Barat," vol. 3, no. 2, pp. 120–133, 2023.
[15] Y. Rokhayati and N. S. Utomo, "Jurnal Sustainable : Jurnal Hasil Penelitian dan Industri Terapan Prediksi Kelayakan Operasional Mesin Rivet Menggunakan Regresi Linear Berganda," vol. 10, no. 01, pp. 10–15, 2021.