

# **Productivity Improvement of Cement Production Process Using Objective Matrix (OMAX) Method: A Case Study**

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## **Abstract**

Increasing productivity is crucial for businesses to sustain their performance and efficiency in an increasingly competitive industrial environment. This study focuses on enhancing the productivity of the cement production process at PT XYZ, one of Indonesia's largest cement manufacturers, using the Objective Matrix (OMAX) method. Data was collected from the company's historical production records in 2023 which encompass actual production outputs, machine downtime, working hours, raw material, and energy consumption. Four critical performance criteria were identified: machine efficiency, energy consumption efficiency, raw material usage efficiency, and machine effectiveness. We found that the company's productivity index fluctuated frequently, and poor productivity was identified for several months. Analysis of the company's productivity index shows that the highest increase occurred in August, which increased by 144% from July, and the highest decrease occurred in February, which decreased by 58% from January. Key findings indicate that machine-related factors significantly influence production productivity, which leads to recommendations for a predictive maintenance strategy to replace the current preventive maintenance approach.

## **Keywords**

Objective Matrix, Productivity Measurement, Predictive Maintenance.

## **Introduction**

Along with technological developments, competition in the industrial world is becoming increasingly fierce. High competition between industries puts tremendous pressure on companies to improve their performance and efficiency to maintain their position. In maintaining its position, various factors can influence a company's position in the industrial competition, including productivity (Prayoga and Suseno 2023). In light of market dynamics, the study of productivity improvement is becoming more important since it allows the company to maintain their competitiveness and strengthens the social component of societal growth (Mhlanga and Pradhan 2020). Measuring the productivity of

a company's production line can be a reference point in evaluating and controlling company performance (Sirait et al. 2020).

PT XYZ is a company operating in the cement industry and one of Indonesia's largest cement producers. As the dominant player in the cement industry, PT XYZ not only exports domestically but also abroad, one of which is Bangladesh and Brunei Darussalam. PT XYZ produces many types of cement, one of which is Ordinary Portland Cement (OPC). OPC cement is a high-quality cement suitable for various construction applications, so it is often in demand by the public. All cement products produced by PT XYZ have met national and international standards. The production process plays a vital role in maintaining product quality. The production process is also essential to maintaining operational continuity and company competitiveness and requires monitoring its production performance.

Performance measurement is the process of identifying, defining, and employing indicators to monitor the performance of an organization (Sutopo, et al. 2022). There are several methods to measure the productivity performance of the production process, such as the American Productivity Center (APC), Objective Matrix (OMAX), Craig-Harris Model, and Marvin E. Mundel. In several previous studies, the American Productivity Center (APC) is used to analyze the productivity for optimization related to profitability and price recovery in shipping companies (Rosyandaru et al. 2022), the Craig-harris model is used to analyze productivity that focused on profits in a plantation sector (Sari et al. 2016), and the Marvin e. mundel model is used to measure productivity that focuses on production costs in shoes manufacturing industry (Ningtyas and Lukmandono 2019).

Meanwhile, the Objective Matrix (OMAX) is a method that can be used to measure performance levels using achievement indicators and a procedure to determine the overall productivity index (Suseno and Sitorus 2022). We chose the OMAX method because it combines several performance values from various performance factors or criteria into one single performance value, allowing for a more precise overall performance picture (Fajrianto et al. 2017). Several studies have employed the OMAX method to measure the productivity levels of various objects in several industrial sectors, such as furnace company (Sajiwo and Hariastuti 2021), milk processing industry (Avianda et al. 2014), and beverage bottle company (Ramayanti et al. 2020). Another research used the OMAX method to measure real-estate companies' supply chain performance systems (Zeke and Ariyanti 2022). Research by Mubin (2016) stated that the OMAX method can measure and evaluate the industry's sustainability performance.

Another research study by Pratama and Henny (2018) stated that the OMAX method can measure company productivity regarding occupational safety and health. Ramadhani et al. (2022) also showed that the OMAX method can identify factors affecting car detailing productivity. The OMAX method can identify factors that can affect productivity. The ratio results in this method can be used as an indicator of success that has been achieved and an indicator in planning to achieve productivity levels in the future (Supriyadi and Suryadiredja 2020). Faced with constantly changing market developments and increasing competitiveness, measuring productivity is crucial in identifying potential improvements, managing resources more efficiently, and optimizing production processes. Therefore, it is necessary to measure productivity on the PT XYZ production line so that the company can compete with its competitors. This research aims to measure production line productivity, identify problems that affect production productivity, and provide suggestions for improvements to increase company productivity.

## **2. Literature Review**

Productivity is the relationship between actual and physical results (goods and services) and actual input or a comparison between output and input (output and input). Production increases, but productivity does not increase or even decrease because productivity is related to achieving that production level (Muliadi 2019). Measuring productivity is the initial stage in the productivity cycle to determine the company's current level of productivity (Wahyuni and Setiawan 2017). The OMAX (Objective Matrix) measurement method was developed by James L. Riggs, a professor at the Department of Industrial Engineering at Oregon State University in the 1980s in the United States. Objective matrix (OMAX) is a measurement method for productivity analysis developed to determine the level of productivity in each part of the company by using productivity criteria that fit the company's condition (Sukanta et al. 2018). In the OMAX model, productivity performance measurement is carried out on an objective matrix of performance targets (Supriyadi and Suryadiredja 2020). The structure of the Objective Matrix model consists of several parts, namely as follows (Riggs 1987):

1. Productivity criteria: activities and factors that support the productivity of the work unit whose productivity is being measured are expressed in comparison (ratio).
2. Level-of-achievement: Measurements are carried out to monitor each criterion's magnitude of performance achievement.
3. Matrix scale cells: Before determining the matrix cells, first determine standard level 3 (average), level 0 (worst performance), and level 10 (target to be achieved).
4. Score: results from achieving the performance ratio in relation to whether the achievement results are above (according to target achievement), below, or on the standard scale.
5. Weight: Each criterion that has been determined has a different influence on the measured productivity level. For this reason, it is necessary to carry out weights that express the degree of importance (in %) and show the relative influence of these criteria on the productivity of the measured work unit. The sum of all criteria weights is 100%.
6. Value: The value of the achievements obtained for each period is obtained by multiplying the score on a specific criterion by the weight of that criterion.
7. Indicators: performance over a certain period. The total value of each criterion is recorded in the performance indicator box.

Figure 1 shows an example of a productivity assessment table using the objective matrix method.

CRITERIA		Criteria-1	Criteria-2	Criteria-3	Criteria-n	Information
Performance						
Level	10					Good
	9					
	8					
	7					
	6					Fair
	5					
	4					
	3					Poor
	2					
	1					
	0					
Score						
Weight						
Value						
Total						

Figure 1. Objective Matrix Table

Predictive maintenance (PdM) is a recent preventive maintenance approach that aims to prolong equipment life and maintain sustainable operational management in order to improve manufacturing process performance and efficiency (Achouch et al. 2022). Predictive maintenance uses prediction tools to determine when maintenance should be performed (Lourensius et al. 2023). Predictive maintenance allows early detection of failures by using predictive tools such as historical data (using machine learning), integrity factors (visual aspects, wear, and color differences from the original), inferential statistical methods, and engineering approaches (Carvalho et al. 2019). Predictive maintenance methods optimize machine availability and lowering maintenance costs. (Ali et al. 2024).

### 3. Methods

Measuring the productivity of the production process is carried out using the objective matrix (OMAX) method. This OMAX method combines productivity criteria into an integrated form and relates them to each other (Pratama and Henny, 2018). Determining productivity criteria is done by directly interviewing the head of production and one production staff at PT XYZ. The criteria measured in this research are machine efficiency (criteria 1), efficiency of energy consumption (criteria 2), efficiency of raw material usage (criteria 3), and machine effectiveness (criteria 4). The data used in measuring production productivity is obtained from the company's historical data in 2023, which consists of actual production numbers, machine downtime, machine working hours, raw material usage, and electrical energy consumption. Measuring productivity using the OMAX method consists of several stages.

- Define the criteria.
- Find the ratio for each criterion.
- Determine targets and intervals.

Determining targets and intervals is carried out in several stages. The following are the stages of determining targets and intervals:

- a. Determines the level 3 value

The level 3 value is determined by finding the average value of the ratio values for each criterion. The following is the equation used to find level 3 values:

$$\mu = \frac{\sum_{i=1}^{12} x_i}{12} \quad (1)$$

With :

$\mu$  = Average ratio value for each criterion measured

n = Number of data

$x_i$  = Ratio of the i-th criterion

- b. Determine the values for level 0 and level 10

Determining level 0 (lowest productivity value) is done by calculating the lower control limit (LCL), and determining level 10 (highest productivity value) is done by calculating the upper control limit (UCL). The following is the equation used to calculate the level 0 and level 10 values:

$$LCL = \mu - k\sigma \quad (2)$$

$$UCL = \mu + k\sigma \quad (3)$$

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{n}} \quad (4)$$

$$DA = \frac{\sigma}{\mu} \times 100\% \quad (5)$$

$$CL = 100\% - DA \quad (6)$$

With :

UCL = Upper Control Limit

LCL = Lower Control Limit

$\mu$  = Average ratio value for each criteria

$\sigma$  = Standard deviation

n = Number of data

k = Constant

DA = Degree of Accuracy

CL = Confidence Level

- c. Determines the intervals of level 1-2 and level 4-9

Interval values for levels 1-2 and levels 4-9 are obtained from interpolation results using the equation:

$$Interval (1 - 2) = \frac{Level\ 3 - level\ 0}{3 - 0} \quad (7)$$

$$Interval (4 - 9) = \frac{Level\ 10 - level\ 3}{10 - 3} \quad (8)$$

### Determine scores, weights, and values.

Score is a value that shows the existence of the performance ratio value for that month. Weight is the magnitude of the importance of a productivity criterion to total productivity. The amount of weight is determined by processing the weighting data using the analytical hierarchy process (AHP) with the pairwise comparison method. The Analytical Hierarchy Process (AHP) basic concept uses a pairwise comparison matrix to produce relative weight values between criteria and alternatives (Hamdani et al. 2014). Meanwhile, value is the value resulting from multiplying the weight and the score on the measured criteria.

### Calculate performance productivity indicators and index.

Calculating productivity indicators is carried out by adding all the values of all criteria for that period to obtain the productivity value for that period. After obtaining the company's productivity value in that period, the productivity index (PI) will be calculated using the following equation:

$$PI = \frac{\text{Total Value (t)} - \text{Total Value (t-1)}}{\text{Total Value (t-1)}} \times 100\% \quad (9)$$

With :

t = current period

#### 4. Data Collection

The data collection process was carried out in two ways: direct observation and literature study.

Direct observation

Observations were carried out by observing the production process directly in the field and conducting discussions and interviews with several company authorities in the production process, such as the head of the production department and production department staff.

Literature Study

Literature studies were carried out to collect information related to the company through previous publications.

### 5. Results and Discussion

#### 5.1 Performance Criteria

Performance criteria measure productivity in the department to be evaluated. The ratio of each criterion is calculated to determine the ratio of performance criteria. Table 1 shows the ratio of performance criteria used in this research.

Table 1. Performance Ratio Productivity Criteria

Month	Machine efficiency (ton/hours)	Energy Consumption (ton/kWh)	Raw Materials Usage (ton/ton)	Machine Effectiveness (hours/hours)
January	166,7455	2,0611	0,98044	0,7151
February	168,3437	2,0808	0,96446	4,0431
March	169,3695	2,0935	0,97982	3,9769
April	161,5894	1,9973	0,98390	4,0864
May	152,7476	1,8880	0,97104	3,3319
June	165,7303	2,0485	0,95276	8,8257
July	163,4912	2,0208	0,96220	4,7938
August	167,3777	2,0689	0,98212	1,7663
September	146,6731	1,8129	0,98053	1,4205
October	154,4615	1,9092	0,98374	0,7755
November	145,8067	1,8022	0,97052	1,6449
December	168,1745	2,0787	0,98239	0,8324

Criteria 1 shows the ratio between the actual production amount (production output) and machine working hours (hours) each month. This ratio shows the efficiency of machine use relative to the number of products produced. Criteria 2 shows the ratio between the actual production (production output) and the use of electrical energy (kWh) each month. This ratio shows the efficiency of electrical energy consumption to the amount of production output. Criteria 3 compares the actual production amount (output) and raw materials (tons) used monthly. This ratio shows the efficiency of using raw materials to the number of products produced. Criteria 4 compares total machine downtime (hours) and machine working hours (hours). This ratio shows the amount of machine downtime relative to the effectiveness of machine use each month.

#### 5.2 Determination of Performance Scale

Determining the productivity level value is the stage of deciding the level 0, level 3, and level 10 values used as initial data for calculating the productivity level value. Table 2. presents the productivity scale values for levels 0, 3, and 10 for each productivity criterion.

Table 2. Performance Scale Productivity Criteria

	Criteria 1	Criteria 2	Criteria 3	Criteria 4
$\mu$ (level 3)	160,8759	1,9885	0,9745	3,0177
UCL ( Level 10)	177,4573	2,1935	1,0000	0,5721
LCL (Level 0)	144,2944	1,7835	0,9452	8,8257

Table 3. presents the recapitulation values for the levels of each productivity criterion. The performance scale value for level 1-2 intervals and level 4-9 intervals for each productivity criterion are calculated using equations (7) and (8).

Table 3. Recapitulation of Levels for Each Criteria

Level	Criteria 1	Criteria 2	Criteria 3	Criteria 4
10	177,4573	2,1935	1,0000	0,5721
9	175,0886	2,1642	0,9996	0,9215
8	172,7198	2,1349	0,9954	1,2709
7	170,3510	2,1056	0,9912	1,6202
6	167,9822	2,0763	0,9871	1,9696
5	165,6134	2,0471	0,9829	2,3190
4	163,2447	2,0178	0,9787	2,6683
3	160,8759	1,9885	0,9745	3,0177
2	155,3487	1,9202	0,9647	4,9537
1	149,8216	1,8519	0,9549	6,8897
0	144,2944	1,7835	0,9452	8,8257

### 5.3 Calculation of Weight, Score, and Values

The weight calculation is carried out using the pairwise comparison method. At this stage, values for each matrix column, normalization matrix, eigenvector values, and matrix consistency tests are calculated. The matrix is considered consistent if the CR value is <0.1. Table 4 summarizes the weights for each criterion from the consistency test calculation.

Table 4. Weight for Each Criteria

	Weight	Weight (%)
Criteria 1	0,263	26%
Criteria 2	0,057	6%
Criteria 3	0,122	12%
Criteria 4	0,558	56%

Next, the objective matrix table determines the productivity value each month. The score is obtained by looking at the performance measurement data and determining which performance measurement is currently at the level that is closest to the number at level 0 – level 10. The score is determined based on the difference between the performance ratio and the level value. The score is then multiplied by the weight to obtain a value for each criterion. Then, the values for each criterion are added to get that month's productivity value. Figure 2. shows an example of calculation results using the objective matrix method for February 2023.

February						
CRITERIA	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Information	
Performance	<b>168,34369</b>	<b>2,08081</b>	<b>0,96446</b>	<b>4,04306</b>		
Level	10	177,45734	2,19345	1,00000	0,57211	Good
	9	175,08856	2,16418	0,99963	0,92148	
	8	172,71978	2,13490	0,99544	1,27086	
	7	170,35101	2,10562	0,99125	1,62023	
	6	167,98223	2,07634	0,98706	1,96960	Fair
	5	165,61345	2,04706	0,98287	2,31897	
	4	163,24467	2,01778	0,97868	2,66834	
	3	160,87589	1,98850	0,97449	3,01771	
	2	155,34874	1,92018	0,96472	4,95370	Poor
	1	149,82159	1,85186	0,95495	6,88969	
0	144,29444	1,78355	0,94517	8,82568		
Score	6	6	2	2		
Weight	0,26335	0,05689	0,12187	0,55789		
Value	1,58007	0,34134	0,24375	1,11578		
Total	3,28094					

Figure 2. Productivity Value for February

The blue color in each criterion column shows each criterion's achievement level for that month. Based on calculations, the productivity value obtained in February was 3.28094. To determine each criterion's performance per month in 2023, a recapitulation and level classification was carried out into three categories: poor (level 0-2, red), fair (level 3-6, yellow), and good (level 7-10, green).

Period	Criteria 1	Criteria 2	Criteria 3	Criteria 4
January	5	6	5	10
February	6	6	2	2
March	7	7	4	3
April	3	3	5	2
May	2	2	3	3
June	5	5	1	0
July	4	4	2	2
August	6	6	5	7
September	0	0	4	7
October	2	2	5	9
November	0	0	3	7
December	6	6	5	9

Figure 3. Criteria Level Recapitulation

### 5.4 Productivity Index

The aim of calculating the productivity index is to determine whether there has been an increase or decrease in productivity during the period used in the measurement. The productivity index value is obtained through calculations using equation (9). Table 5. shows the productivity index values for the period January – December 2023.

Table 5. Productivity Index

Month	Productivity Value	Productivity Index
Jan	7,8464	--
Feb	3,2809	-58%
Mar	4,4028	34%
Apr	2,6859	-39%
May	2,6798	-0,2%
Jun	1,7230	-36%
Jul	2,6405	53%
Aug	6,4360	144%
Sep	4,9506	-23%
Oct	6,2709	27%
Nov	4,2709	-32%
Des	7,5518	77%

Based on Table 5, there was an increase in productivity in several months, such as March, July, August, October, and December. The highest productivity growth occurred in August, with a productivity value of 6.4360 and an increase in the productivity index of 144% from July. Meanwhile, during this period, productivity decreased in several months, such as February, April, May, June, September, and November.

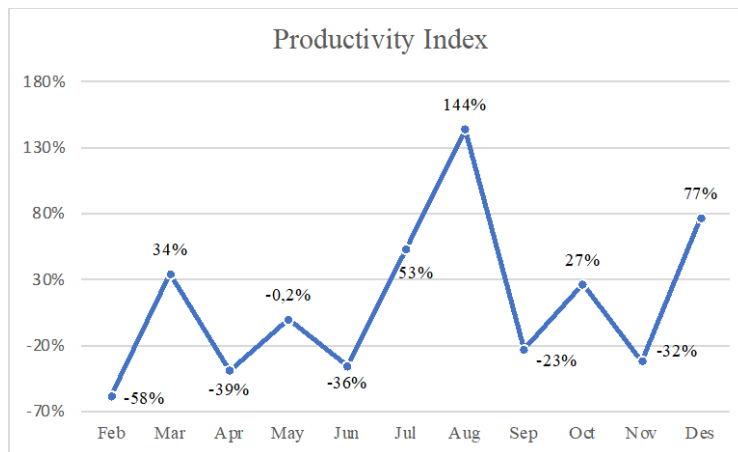


Figure 4. Graph of Productivity Index

The highest reduction in productivity occurred in February, with a productivity value of 3.2809 and a decrease in the productivity index of 58% from January.

### 5.5 Proposed Improvements

Table 5 shows that the company's productivity index fluctuated, and there have been several months of poor productivity. Therefore, factors that affect production productivity are identified to provide appropriate improvement proposals. To find out the causes of decreased productivity accurately, interviews with the production staff were conducted. Direct observations are also carried out to see the production process and identify issues that may not have been identified from the interview process. Based on the results of observations and interviews, the data obtained was then mapped into a fishbone diagram to assist visualization and further analysis.

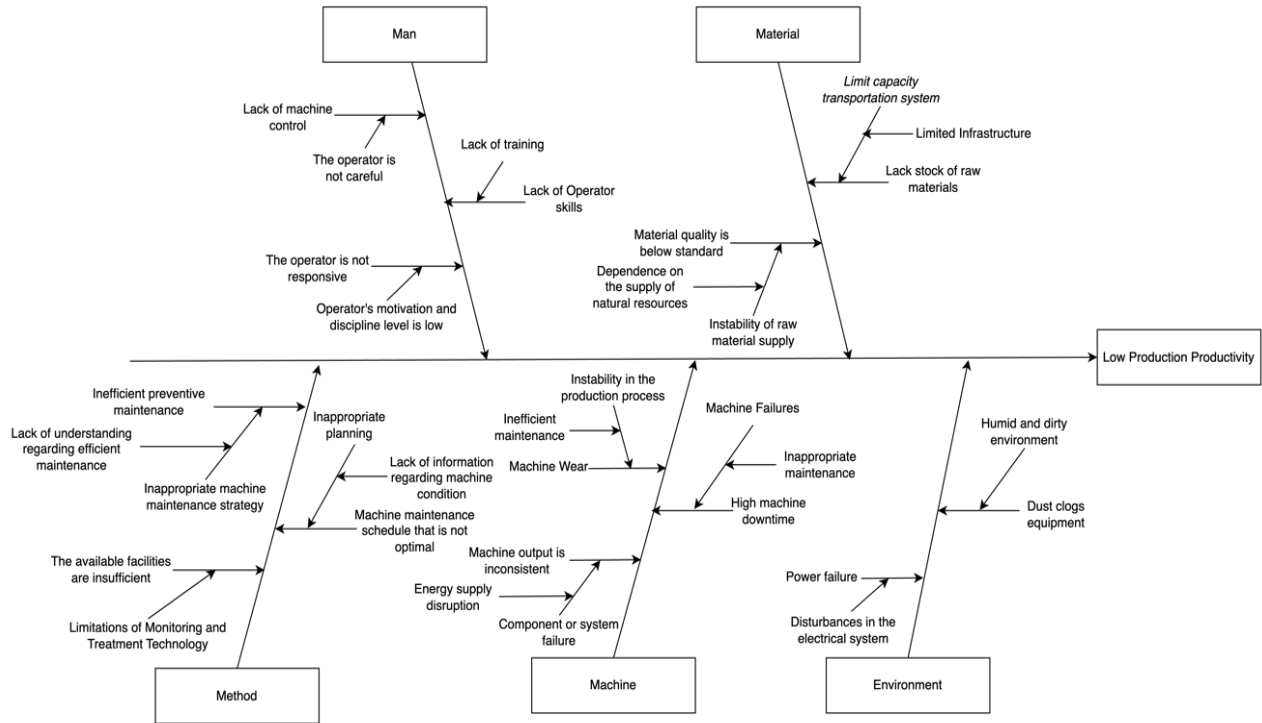


Figure 5. Fishbone Diagram

Based on the analysis of the factors causing low productivity, we proposed recommendations to improve the issues affecting the productivity performance (see Table 6).

Table 6. Proposed Improvements ( Presented in APPENDIX-A)

Based on Figure 5 and Table 6, machine-related factors have a dominant influence on production productivity. We suggest implementing a new predictive maintenance strategy to improve machine operational performance. So far, the company's maintenance team has only relied on preventive maintenance with a regularly determined schedule without considering the actual condition of the machine. Even though preventive maintenance is essential in maintaining the machine's condition, it may need to be more efficient in detecting problems or potential damage that can occur and appear suddenly.

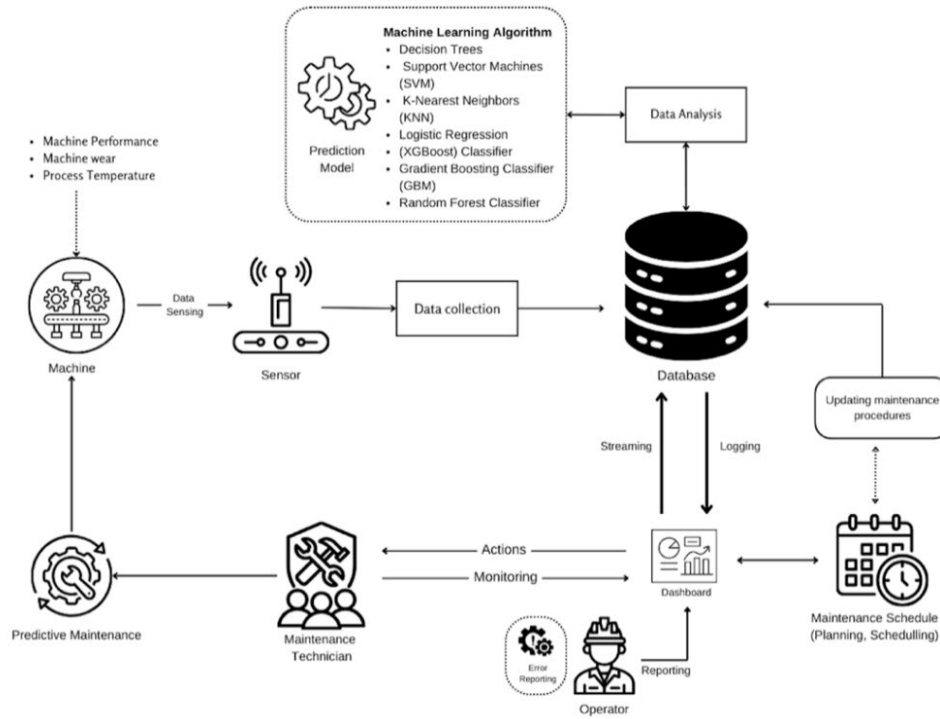


Figure 6. Implementation of Predictive Maintenance (Modified from Nazara 2022)

Implementing Predictive Maintenance involves systematic steps that can monitor, analyze, and respond proactively to machine conditions. Companies can utilize sensor technology and data analysis to monitor real-time machine conditions by adopting a predictive maintenance strategy. The sensors will collect data that includes the actual condition of the machine, such as component wear levels, engine performance, and potential problems or failures. The company will be able to detect potential damage or wear early, provide early warning to maintenance teams, and take preventative action before unexpected machine failures occur. In addition, based on condition monitoring data, machine maintenance schedules can also be optimized. Previous research by Martinus et al. (2019) proved that using the predictive maintenance method can improve machine availability by 49% and reduce downtime and maintenance costs simultaneously by 58%. The company can avoid unnecessary maintenance, reduce unplanned machine downtime, and optimize resource use using predictive maintenance.

### Conclusion

PT XYZ company’s productivity has been analyzed using the OMAX method for production data from January to December 2023. Measured criteria include machine efficiency, electrical energy consumption, raw material usage, and machine effectiveness. Each month's productivity index was generated, showing fluctuating performance. We identified the factors causing the decrease in productivity for five aspects: man, material, method, machine, and environment. We found that machine-related factors significantly impact productivity performance. We proposed the implementation of predictive maintenance to improve machine operational performance. Employing predictive maintenance enables proactive monitoring, analysis, and response to machine conditions, enabling early detection of potential problems, optimizing maintenance schedules, reducing downtime, and improving operational performance. Further research is necessary to develop a prediction model to improve the company's productivity performance.

A case study can be conducted to explore the impact of implementing a predictive maintenance model on operational performance, including machine efficiency, downtime, and maintenance costs. Therefore, the company can improve machine-related issues that impact productivity by using predictive techniques to schedule maintenance and predict downtime.

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## **Biographies**

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APPENDIX -A  
(Table 6. )

<b>Faktor</b>	<b>Problem</b>	<b>Causes</b>	<b>Improvement Suggestions</b>	<b>Proposed Improvement Methods</b>
Man	Lack of machine control	The operator is not careful	1. Improve SOPs	Education and Training
	The operator is not responsive	The level of operator's motivation and discipline is low	2. Carry out strict supervision and monitoring of operators	
	Lack of operator skills	Lack of training	3. Training and skills development	
Machine	Inconsistent output	Component or system failure	1. Implementing more flexible maintenance methods	Predictive Maintenance
	Machine wear	Instability in the production process	2. Monitoring machine condition	
	High machine downtime	Machine Failure	3. Make improvements to the production process	
Material	Quality below standard	Limit capacity transportation system due to limited infrastructure	1. Strictly carry out quality control inspections	Quality Management System (QMS)
	Minimal raw material stock	Instability of raw material supply Dependence on the supply of natural resources	1. Improve delivery schedule planning 2. Increase shipping transportation capacity	
Method	Maintenace method is inefficient	Lack of understanding regarding efficient maintenance	1. Training, education and implementation of more efficient maintenance	Predictive Maintenance
	Maintenance schedule is not optimal	Lack of information regarding machine condition	2. Make improvements to scheduling planning	
	The available facilities are insufficient	Limitations of Monitoring and Treatment Technology	3. Carrying out repairs and renewal to maintenance facilities	
Environment	Power failure	Disturbances in the electrical system	1. Electrical system monitoring	Predictive Maintenance
	Equipment clogged with dust	Humid and dirty environment	2. Implement cleaning scheduling	

