

Total Productive Maintenance Analysis of The Oven Machine Using Overall Equipment Effectiveness Method (Case Study at CV. Halalan Thoyiban Bakery)

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Abstract

The oven machine is one of the important components of the production process in the bakery company. CV Halalan Thoyiban is a bakery company engaged in the manufacture of various breads. The products of this company are various bread such as Bakpia Green Bean and Bakpia Green Coconut. The problem that occurs in the company is the low efficiency of bakpia bread production, caused by the large number of machine breakdowns so that the optimal level of machine productivity is not achieved. The production machine, especially the oven machine often breaks down and causes the production process to stop. Based on these problems, in this study, an analysis of Total Productive Maintenance (TPM) was carried out using the Overall Equipment Effectiveness (OEE) method to measure the effectiveness of the machine. Further analysis of the cause-and-effect diagram is conducted to propose the improvement recommendation. The results of the analysis show the Overall Equipment Effectiveness (OEE) for the oven machine obtained an average of 38.1%, where the activity measured at the availability index is 59.72%, the performance index is 68.90% and the quality ratio is 93.30%. The OEE value is low and does not meet the World Class standard. The main causes are large breakdowns and long maintenance processes. The first improvement recommendation is applying preventive maintenance based on the planned maintenance schedule. The second recommendation is providing a training to operators about machine operation and maintenance. And the last is providing a simple installation for gas cylinder to avoid the long changing time to maximize performance of the oven machine.

Keywords : breakdown, OEE, total productive maintenance, oven machine, maintenance management.

INTRODUCTION

CV Halalan Thoyiban is a bakery company produces various kinds of bread. The company uses various machines in making various kinds of bread such as flattening machines, bread press machines, and oven machines. This study focusses on the analysis of the oven machine to maximize the production process. The machine breakdown in the production process is a factor that affects the company's performance. With the frequent breakdown to the machine, the production activities are stopped so that the entire production process will also stop. Because in the bakery, the production process will go through every machine, as well as the oven machine.

The Total Productive Maintenance (TPM) is one of the concepts that can be used to improve company performance. The maintenance of production support equipment that is often applied by manufacturing companies in Japan is TPM (Rahmad et al, 2012). The TPM generally consists of three parts, namely the total approach, productive action, and maintenance. With these three components, it is possible to clearly identify the problem and its causative factors. The advantage of this method is that the improvements made are focused on the problem. Therefore, it is necessary to apply the TPM concept in the company environment, so that the production process in the company will be optimal.

The Overall Equipment Effectiveness (OEE) aims to increase the effectiveness of production line equipment so as to achieve larger volumes with good results so that the production costs are lower. OEE is a comprehensive measure that identifies the level of productivity of machines and equipment from theoretical performance (Nakajima, 1988) (Hansen, 2022). The overall value of the effectiveness of the equipment and the value of performance and reliability are measures of the success of implementing TPM using the OEE method (Said and Susetyo, 2008).

The purpose of this research is to calculate the effectiveness of the overall equipment on the oven machine, to analyze the relationship between the autonomous maintenance concept and the Overall Equipment Effectiveness method, and to determine the recommendations to improve company performance. In line with previous research (Hamda, P, 2018), in this research analysis of TPM was conducted using the OEE method and a causal diagram analysis was carried out to generate the improvements recommendation.

LITERATURE REVIEW

Total Productive Maintenance (TPM)

Maintenance is an activity that aims to ensure a functional production system to produce the desired output (Blanchard, 1995). Basically, there are two main principles of the maintenance system. The first is reducing or shortening the failure period to a minimum by considering economic aspects. And the second is avoid the unplanned failure or sudden damage (Suharto, 1991). The maintenance of equipment that supports the production process must always be carried out regularly and planned (Daryus, 2007).

Total Productive Maintenance (TPM) is a philosophy that aims to maximize the effectiveness of the facilities used in the industry, which are not only applied to maintenance but to all aspects of the operation and installation of production facilities including improving the performance of the people who work in the company. The components of TPM generally consist of 3 parts. The first is total approach: everyone is involved, is responsible for maintains all existing facilities in the implementation of TPM. The second is productive action: proactive attitude of all employees to the operating conditions of the production facility. The thirds is maintenance: implementation and improvement of the effectiveness of facilities and unit production operations.

Total Productive Maintenance has a vision as a maintenance system that equipment can operate 100% in the available time with 100% good products (Nakajima, 1998). This vision can be obtained if the company carry out the correct implementation of total productive maintenance. The steps of TPM implementation are as follows: 1) Preparation Stage, 2)Initial Implementation Stage, 3)Implementation Phase, and 4) Stabilization stage.

TPM is a close cooperative relationship between maintenance and production organizations that aimed at improving production quality, reducing waste, reducing production costs, increasing equipment capabilities and developing the overall maintenance system in manufacturing companies. In TPM there are three pillars that play a role as follows:

1. Maximizing the effectiveness of the equipment, namely making the performance of the equipment optimally so that there is no breakdown time that can disrupt the production process.
2. Autonomous maintenance, namely the implementation of small maintenance work carried out by the operator, for example adding lubricating oil, cleaning equipment, tightening bolts
3. Small group activities, namely the existence of a small group that will make improvements to a process or equipment so that an optimal equipment or process will be obtained. This small group consists not only of supervisor level but also of operator level. (Nakajima, 1988)

The main goal in increasing production activities is to increase productivity by minimizing inputs and maximizing output. Not only concerned with quantity, but production output must look at the quality itself, including the suppression of costs and on time delivery. Input consists of labor, machinery and materials, while the output consists of production (P), quality (Q), cost (C), delivery (D), security (S), morale (M). The purpose of this Total Productive Maintenance is to increase Overall Equipment and eliminate six major losses which are the main obstacles to not achieving effectiveness. (Nakajima, 1988). The benefits of Total Productive Maintenance (TPM) are as follows:

1. Increase productivity and minimize losses to the company.
2. Improve quality with TPM, minimize damage to machines/equipment and machine downtime.
3. Delivery time to consumers can be maintained, because the production running without interruption
4. Low production costs due to loss and work that does not add value can be reduced.
5. Health and safety of the work environment is better.
6. Increase work motivation, because rights and responsibilities are delegated by everyone.

Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) is the overall equipment effectiveness to evaluate how well the performance and reliability of the equipment have been achieved. OEE is also used as an opportunity to improve products, improve the productivity of a company and ultimately as a decision-making step. The causes of the low OEE value are, among others, the lack of preventive, corrective maintenance, and high rates of defects and speed.

In machines or equipment, there are six most common causes of the efficiency decreasing in the manufacturing process called Six Big Losses (Denso, 2006). The Six Big Losses are as follows :

1. Startup loss, categorized as quality loss due to scrap/rejects during production startup caused by incorrect machine setup, insufficient warm-up, and so on.

2. Setup/adjustment loss, categorized as downtime loss due to time being “stolen” due to long setup times caused by product switching.
3. Cycle time loss, categorized as speed loss due to a decrease in processing speed caused by several things, for example: the machine is worn out, the machine is below the capacity written on its nameplate, the machine is below the expected capacity, and operator inefficiency.
4. Chokotei loss, (unplanned idling and minor stops), categorized as speed loss due to the presence of minor stoppages, namely machines that stop quite often with a short duration as usual, and do not require maintenance personnel.
5. Breakdown loss, categorized as downtime loss due to damage to machinery and equipment, unscheduled maintenance, and so on
6. Defect loss, categorized as quality loss due to rejects during production.

METHODS

Overall equipment effectiveness (OEE) is a performance evaluation method used to measure industrial equipment productivity as a key performance indicator (Atikno and Purba, 2021). Data analysis was carried out using the steps of the OEE method (Fauzi, 2015). To determine the OEE value, the calculation use the following formula:

$$\text{OEE} = \% \text{Availability} \times \% \text{Performance} \times \% \text{Quality} \quad (1)$$

$$\% \text{Availability} = (\text{Loading Time} - \text{Breakdown \& Setup Time}) / (\text{Loading Time}) \times 100\% \quad (2)$$

$$\% \text{Performance} = (\text{Output} \times \text{Cycle Time}) / (\text{Total Time}) \times 100\% \quad (3)$$

$$\% \text{Quality} = (\text{Good Units}) / (\text{Total Units}) \times 100\% \quad (4)$$

Note :

- Loading Time : The time available to work on products on each machine according to capacity.
 Setup / Adjustment Time : The time the adjustment process will be ready for use.
 Breakdown / Downtime : The time when the machine cannot operate due to a malfunction.
 Output : Number of products

OEE has world class standards based on JIPM (Japan Institute of Plant Maintenance) for all indicators as follows: Availability Rate $\geq 90\%$, Performance Rate $\geq 95\%$, Quality Rate $\geq 99\%$ and OEE $\geq 85\%$

With the following conditions:

1. OEE = 100% then the production is considered perfect: only produces without defects, works in fast performance, and there is no downtime
2. OEE = 85% Production is considered world class. For many companies, this score is a suitable score to be used as a long-term goal
3. OEE = 60%, production is considered reasonable, but indicates there is a large room for improvement.
4. OEE = 40%, production is considered to have a low score, but in most cases, it can be easily improved through direct measurement (eg.by tracing the reasons for downtime and addressing the sources of downtime causes one by one).

RESULT AND DISCUSSION

The primary data in this research are the production data for one month starting from January-February 2022, as well as interview data of the company employees to analyze the effectiveness of the oven machine used at CV Halalan Thoyyiban. The Table 1 shows the production data obtained from CV. Halalan Thoyyiban in one month, and Table 2 shows the defect ration among the products.

Table 1. The Production Output of Bakpia Green Bean and Bakpia Green Coconut

Week	Bread (Rp 1000)		Bread (Rp 1500)		Total Production (Pcs)
	Bakpia Green Bean (Pcs)	Bakpia Green Coconut (Pcs)	Bakpia Green Bean (Pcs)	Bakpia Green Coconut (Pcs)	
1	3552	11688	2583	3507	21330
2	8256	8808	2100	3045	22209
3	5328	7800	2310	1680	17118
4	9720	5064	2520	2961	20265
Total	26856	33360	9513	11193	80922

Table 2. The Products Defect Ratio

Week	Total Product (Pcs)	Product Defect (Pcs)	Defect Ratio (Pcs)
1	21330	1059	4,96%
2	22209	1473	6,63%
3	17118	1392	8,13%
4	20265	1434	7,08%
Total	80922	5358	6,62%

Table 3. Data of Total Break Downtime of Oven Machine

Week	Downtime (minutes)	Set Up Time (minutes)
1	450	150
2	720	170
3	600	160
4	500	150
Total	2270	630

Availability Rate

Before obtaining the Overall Equipment Effectiveness (OEE) value, the Availability Rate, Performance Rate and Quality Rate values are required. Availability rate is a ratio that describes the utilization of available time for machine or equipment activities. Table 4 shows the calculation of availability rate of oven machine. The availability rate is closely related to the effective production time and downtime. Here is the formula for finding the availability rate:

$$\%Availability = \frac{\text{Loading time} - \text{Breakdown \& Setup lose}}{\text{Loading time}} \times 100\% \quad (5)$$

Table 4. Calculation of Availability Rate of Oven Machine

Week	Loading Time (minutes)	Downtime (minutes)	Operation Time (minutes)	Set Up Time (minutes)	Availability Rate (%)
1	1800	450	1350	150	66,67%
2	1800	720	1080	170	50,56%
3	1800	600	1200	160	57,78%
4	1800	500	1300	150	63,89%
Total	7200	2270	4930	630	59,72%

From the results of availability rate calculations, the average availability rate of oven machines for 1 month is 59.72%. The value is considered low due to large breakdown time and setup time.

Performance Rate

Performance rate is a ratio that describes the ability of the equipment to produce goods. In this performance rate is the value of the output and mechanical capacity. Here is the formula:

$$\%Performance Rate = \frac{\text{Output} \times \text{Cycle Time}}{\text{Operation Time}} \times 100\% \quad (6)$$

Table 5. Calculation of Performance Rate of Oven Machine

Week	Output (pcs)	Cycle Time (minute / pcs)	Operation Time (minutes)	Performance Ratio
1	21330	0.041667	1350	65.80 %
2	22209	0.041667	1080	85.60%
3	17118	0.041667	1200	59.40%
4	20265	0.041667	1300	64.90%
Total	80922	0.041667	4930	68.93%

Table 5 shows the calculation of performance rate of oven machine. The average performance level of the oven machine in 1 month is 68.93 %.

Quality Rate

Quality Rate is a ratio that describes the ability of equipment to produce products that comply with standards. In the calculation of the Quality Rate, it is closely related to the data on the amount of production and results of good quality and there is also reject product data from the results of making spacing products at CV Halalan Thoyyiban. Here's the formula for finding the quality rate:

$$\%Quality = \frac{\text{output-reject}}{\text{Output}} \times 100\% \quad (7)$$

Table 6. Calculation of Quality Rate of Oven Machine

Week	Total Output (pcs)	Reject (pcs)	Quality Rate
1	21330	1059	95.04%
2	22209	1473	93.37%
3	17118	1392	91.87%
4	20265	1434	92.92%
Total	80922	5358	93.30%

Table 7 shows the calculation of quality rate of oven machine. The average quality rate of the oven machine for 1 month is 93.30%. The quality rate has higher value compare to the availability rate and performance rate.

OEE (Overall Equipment Effectiveness)

The OEE is a comprehensive measure that identifies the level of productivity of the machine/equipment and its performance. This measurement is very important to know which areas need to be improved in terms of productivity or machine/equipment efficiency. To determine the overall effectiveness of the oven machine at the CV Halalan Thoyyiban company, the formula used is:

$$OEE = \%Availability \times \%Performance \times \%Quality \quad (8)$$

After obtaining the value of the availability rate, performance efficiency and quality rate, next the Overall Equipment effectiveness (OEE) method can be calculated to determine the effectiveness of the oven machine, as shows on the Table 7.

Table 8. OEE Calculation

Week	Availability Rate	Performance Ratio	Quality Rate	OEE
1	66.67 %	65.80 %	95.04%	41.71 %
2	50.56 %	85.60%	93.37%	40.44 %
3	57.78 %	59.40%	91.87%	31.55 %
4	63.89 %	64.90%	92.92%	38.56 %
Average	59.72 %	68.90 %	93.30 %	38.06 %

Based on the result, the Overall Equipment Effectiveness (OEE) value of the oven machine is 38.06%. The OEE value is considered in the low-level category and the value does not meet the World Class standard of 85%. The main contributing factors are large breakdowns and long maintenance processes.

Comparison of the company OEE Results with World Class OEE Standards

Based on the results of the calculations of OEE that have been carried out, the next step is comparing the OEE results and the Word Class OEE Standard, as shown on the Table 8. In this comparison, the performance overall OEE value of the oven machine does not meet world class standards JIPM, this can be improved through direct measurement by tracing the reasons for downtime and addressing the sources of downtime causes one by one.

Table 9. Comparison of the company OEE and World Class OEE

OEE	Lean Sigma Enterprise (World Class)	Lean Sigma Enterprise (Company)	Note
Availability	≥ 90 %	59.72 %	The value does not meet the standard, so the company needs to make improvements.
Performance Efficiency	≥ 95 %	68.93 %	The value does not meet the standard, so the company needs to make improvements.
Rate of Quality	≥ 99,9 %	93.30 %	The value does not meet the standard, so the company needs to make improvements.
Overall Equipment Effectiveness	≥ 85 %	38.06 %	The value does not meet the standard, so the company needs to make improvements.

Fishbone Diagram

After obtaining a low OEE value, it is necessary to analyze the causes of the low effectiveness of the oven machine. The analysis was carried out using a cause-and-effect diagram, to find out the root cause of the problem. The diagram is made from the data obtained from interviews with production workers and direct observations for one month, as shown in Figure 1. The following are the factors that influence the low OEE value, such as man, machine, material and methods.

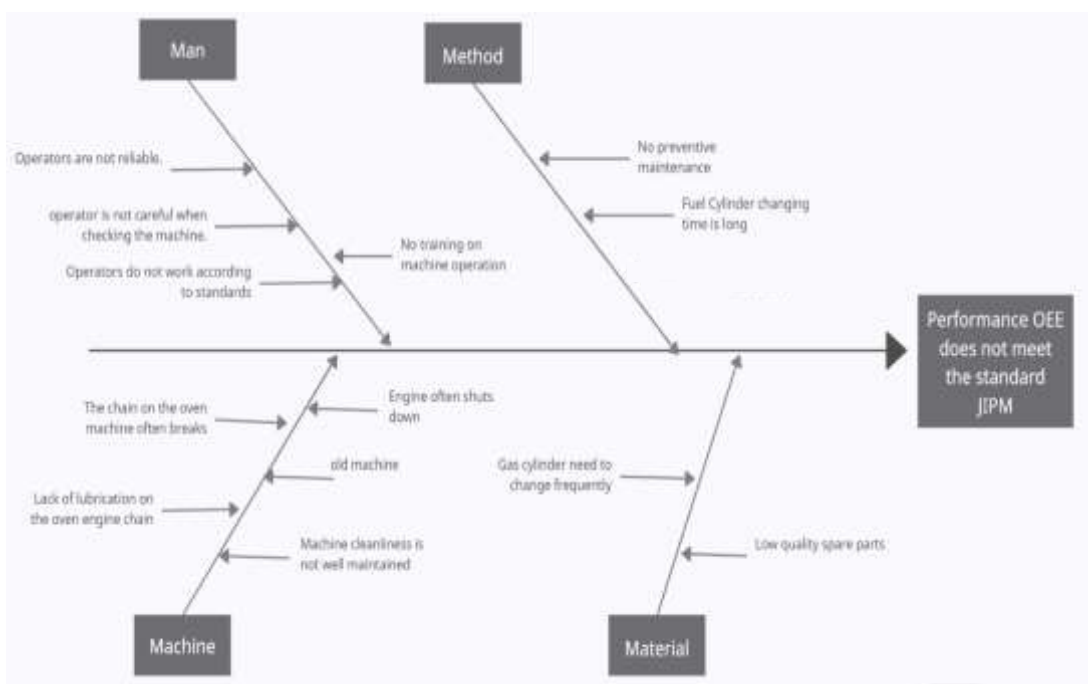


Figure 1. Fishbone diagram for analyzing the root cause of the problem

Table 9. Factors causing low OEE value

Category	Factors Causing Low Effectiveness
Man	a. Operators are not reliable. b. The operator is not careful when checking the machine. c. Operators do not work according to standards. d. No training on machine operation.
Machine	a. The chain on the oven machine often breaks b. Lack of lubrication on the oven engine chain c. Old machine d. Engine often shuts down e. Machine cleanliness is not well maintained
Material	a. Low quality engine spare parts b. Gas cylinder need to be changed frequently
Method	a. No preventive maintenance b. Fuel Cylinder changing time is long

Improvements Recommendations

After identifying and knowing the various root causes, the alternative solutions can be carried out as follows:

1. Man (human)

Provide training to operators about machine operation. and write down standard operation procedures of the oven machine. Implementing Autonomous maintenance on the oven machines.

2. Machine

Predictable replacement of machine components will hamper the production process in the future. Emphasizing the operator and maintenance staff to check the condition of the machine regularly. Lubricate the engine regularly to optimize engine performance.

3. Material

Replacing materials that are no longer suitable for use on a regular basis, prepare the gas cylinder for easy and fast changing, performing maintenance work and checking on existing materials periodically to maximize machine performance and prevent damage.

4. Method

Applying preventive maintenance on the oven machine regularly, especially on the chain because it often breaks during operation. Emphasize the production party for the operation of the oven machine according to written standards. Provide a simple installation for gas cylinder to avoid long changing time to maximize performance of the oven machine.

CONCLUSION

The results of the analysis show the Overall Equipment Effectiveness (OEE) for the oven machine obtained an average of 38.1%, where the availability index is 59.72%, the performance index is 68.90% and the quality ratio is 93.30%. These values do not meet the world class standard, so the company needs to make improvements. The main causes of low OEE are the large number of breakdown time in the oven machine during production process. After identifying the various root causes using the cause-and-effect diagram, the alternative solutions can be carried out as follows: Provide training to operators about machine operation and maintenance, apply preventive maintenance on the oven machine regularly, and provide a simple installation for gas cylinder to avoid long changing time to maximize performance of the oven machine.

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