
Analysis of The Improvement of Cone Machine Using Overall Equipment Effectiveness Method (OEE)

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ABSTRACT

The cone machine is the main machine, which is used to produce the cone for ice cream. So, it is important for measuring the effectiveness of the machine. Overall Equipment Effectiveness (OEE) is one of method to determine the machine effectiveness. The calculation results that the cone machine effectiveness is still under the ideal standard of Overall Equipment Effectiveness, the percentage of effectiveness is 73.85%, percentage of availability rate is 91.55%, performance rate is 82.56%, and quality rate is 97.61%. The ideal OEE standard for manufacturing is 85%; while for food products it is 64%. This figure was adopted by this company. Meanwhile, using fishbone diagram, there are four factors that affect the productivity of cone production, that is, human, machine, method, and material (raw material). Improvements that are needed to be done are conducting training for the machine operators, and using better machine component, i.e. baking plate bearing components.

Keywords: Overall Equipment Effectiveness, Fishbone, Cone Machine, Ice Cream, Measurement.

INTRODUCTION

In manufacturing industry, machinery is a main factor in a company for continuity of the production process, in order to produce the good products, therefore competent employees, good quality raw materials, and processing using excellent machinery are needed. Every process in manufacturing that uses machines will depend on the speed of the machine and the accuracy of product processing as the key to the success of a production activity[1].

In calculating and increasing effectiveness, one approach that can be used is measurement of calculation value using Overall Equipment Effectiveness (OEE) introduced by Seiichi Nakajima in 1971[2]. Overall Equipment Effectiveness (OEE) is used to measure the effectiveness of machine which includes the calculation of availability, performance, and quality[3].

PT X is a company which is engaged in manufacture of various ice cream, one of the ice cream products that is the mainstay of this company is an ice cream cone. The company independently produces the cone to meet the market demand. There is one machine to produce cone belong to the company, and if there is a sudden breakdown or maintenance, the production process will be stopped, and it affects the number of cones produced by the company. When the machine stopped producing, the company theoretically faces production failure of 5400 pcs of cone per hour. If converted into minutes, the company failed to produce 90 pcs of cone every minute. During this time, if the cone production target is not reached, then it will be decided by the Production Planning and Inventory Control department to buy cone products from other company to meet the cone need.

Since PT.X was established, it has not yet had a structured measurement to evaluate the cone machine, so the level of its effectiveness of is unknown. Moreover, the calculation of engine effectiveness is selected using the Overall Equipment Effectiveness calculation formula to determine the effectiveness. It is due to the OEE method takes into account the time measurement of machine availability, performance, and product quality produced by machine. These

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factors are closely related to the production process of a machine in a manufacturing company in order to achieve effectiveness of production process[4]. Cone is the main component for producing cone type ice cream variant, therefore if the machine has a problem that causes the cone production process to stop, it will disrupt production process at a later stage. It is the only machine used by company to meet the demand for a variety of flavors and colors of cone according to ice cream cone product they have, so identification regarding the effectiveness of this machine is considered feasible[5].

Total Productive Maintenance (TPM)

Total Productive Maintenance was first defined around 1970 by Seiichi Nakajima. TPM focuses on increasing and improving activities on equipment related to the effectiveness of production machine. Understanding the TPM can be interpreted as a relationship between maintenance and production organizations aimed at increasing production effectiveness, product quality, reducing production costs, reducing waste in manufacturing companies[6].

Nakajima suggests Overall Equipment Effectiveness to evaluate the development of TPM because OEE requires production machine data such as operating time, stopping time, repairing time, and others[7].

Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness is a measure of the effectiveness of a machine in achieving its normal output target which consists of the time machine available for production activities, the quantity of products produced, and the quality of products produced[8]. The greater the percentage of the calculation results is achieved, the more effectiveness of the machine will be shown. Ideal conditions in OEE calculations are[9]:

- a. Availability Rate: more than or equal to 90%
- b. Performance Rate: more than or equal to 95%
- c. Quality Rate: more than or equal to 99%
- d. From the above values, the ideal OEE condition is $0.9 \times 0.95 \times 0.99 \times 100\% = 85\%$

OEE calculation as follows: $OEE = \text{availability rate} \times \text{performance rate} \times \text{quality product rate}$

Measurements to get an OEE value include:

- 1) Availability rate, is the availability of time which is a ratio that describes the utilization of time available for machine operation activities in producing products..
- 2) Performance rate, to considers factors that cause the production process to be incompatible because the maximum speed of the machine is reduced when it is operated.
- 3) Quality rate, is the ratio between good products divided by the total production produced by the machine. A good amount of product is obtained by subtracting the amount of actual production produced by the number of defective products.

Cause and Effect Diagram (Fishbone Diagram)

The use of fishbone diagrams is to illustrate the factors that cause decrease in productivity and the impact on productivity (consequences) caused by these causative factors[10]. The main causes were identified using the 4M concept, namely machines, methods, materials, humans. There are some advantages of fishbone diagrams as the following[11]:

- 1) Helping identify the root cause of a problem.
- 2) Breaking down the cause requiring analysis of a problem if there is difficulty in separating the cause from the effect.
- 3) Describing the existing problems as well as the causes of the problem by classifying according to main causes.

METHODS

Field Study

The field study stage is the first step for this research. The aim is to directly observe the condition of the cone production workstation so that information can be obtained related to the production activities.

Literature Study

The study is conducted related to the topic of the research material and the formulation of the problem discussed. Literature studies that have been determined by researchers are related to Total Productive Maintenance (TPM), measurement of Overall Equipment Effectiveness (OEE), effectiveness, and fishbone diagrams.

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Collecting Data

The data used are secondary data types, namely data obtained from company documentation, production activity reports, operator records, and company archive files. The following data that are used:

- a) Actual operation time.
- b) Downtime.
- c) Output.
- d) Defect.
- e) Cycle time.

Data Processing

Data processing is done after the data has been obtained. Data processing to get the OEE value is done by multiplying the percentage of availability rate, performance rate, and quality rate [12].

Data Analysis

When the data processing is complete, the next step is to compare the results of data processing with the ideal standard OEE percentage value, and also analyze the root causes of the problem with the fishbone diagram.

Conclusion

Through the results of data analysis, it will be concluded that the researcher's hope that it can be used as an evaluation material for the company as an effort to reduce defective products and increase the effectiveness of the cone machine, and also suggestions as improvements for further research.

DISCUSSION

Availability Rate Measurement

Availability rate is the percentage of time utilization available for production activities. Please note that the planned operation time is the planned time for production activities. Thus the formula used to measure the percentage of availability rate is as follows:

$$\text{Availability rate} = \frac{\text{Actual operation time}}{\text{Planned operation time}} \times 100\%$$

Table 1. Results Calculation of Availability Rate

Week	Availability Rate
37	94,59%
38	62,45%
39	90,13%
40	91,22%
41	94,59%
42	91,96%
43	93,35%
44	93,30%
45	94,49%
46	93,95%
47	94,30%
48	93,85%
49	94,20%
50	94,79%
51	94,25%
52	93,65%

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Performance Rate Measurement

Performance rate is a parameter to show the percentage of the ability of a production machine to operate according to its standard speed. Thus, the formula used to measure the percentage of engine performance is as follows:

$$\text{Performance rate} = \frac{\text{ideal cycle time} \times \text{output}}{\text{actual operation time}} \times 100\%$$

Table 2. Results Calculation of *Performance Rate*

Week	Performance Rate
37	86,14%
38	81,38%
39	85,94%
40	72,23%
41	87,33%
42	86,53%
43	85,12%
44	86,71%
45	88,90%
46	87,12%
47	90,06%
48	81,15%
49	88,85%
50	76,67%
51	74,67%
52	90,08%

Quality Rate Measurement

Quality rate is a parameter to determine the percentage of good products (not defective) produced by the machine during production activities. Actual output (good products) is obtained by subtracting output (total production amount) by the number of defective products. Thus the formula used to measure the percentage of product quality from the machine is as follows:

$$\text{Quality product rate} = \frac{\text{actual output}}{\text{output}} \times 100\%$$

Table 3. Results Calculation of *Quality Rate*

Week	Quality Rate
37	98,14%
38	96,97%
39	97,03%
40	97,16%
41	97,60%
42	97,19%
43	97,17%
44	97,75%
45	98,50%
46	98,60%
47	98,72%
48	93,19%
49	97,47%
50	98,79%
51	98,50%
52	98,42%

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Overall Equipment Effectiveness Measurement

OEE percentage value is a parameter to assess the effectiveness of a machine obtained by multiplying the percentage of availability rate, performance rate, and quality rate[13]. The following is the OEE calculation formula:

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

Table 4. Results Calculation of *Overall Equipment Effectiveness*

Week	OEE
37	79,96%
38	49,28%
39	75,16%
40	64,02%
41	80,63%
42	77,34%
43	77,21%
44	79,08%
45	82,74%
46	80,71%
47	83,84%
48	70,97%
49	81,57%
50	71,80%
51	69,32%
52	83,02%

Fishbone Diagram Identification

Fishbone diagram is a tool to identify the possible causes of problems that occur. Data that have been collected as in the data contained in the appendix will be used as material to find out the possible causes of problems with the effectiveness of cone production so that the percentage of OEE is not ideal. To find this problem, a relevant tool is needed, then a fishbone diagram was made to make it easier in order to find the potentials causing the percentage of OEE not ideal through the data obtained.

Discussion of Percentage Availability Rate

Availability rate is the percentage of time utilization available for production activities. Please note that the ideal availability rate is 90%. Then the following is a discussion of the results of the measurement of availability rates starting from week 37-52:

Through table 1 it can be seen that the percentage of availability rate ranges from 62.45%-94.79%. The lowest availability is at week 38 with percentage 62.45% and the highest percentage is at week 50 with percentage 94.79%. The overall availability percentage is 91.55%.

Through the percentage of the availability rate obtained, it can be concluded that the percentage has reached an ideal value of more than or equal to 90% meaning that it has been in accordance with the ideal amount of time planning for production activities.

Discussion of Percentage Performance Rate

Performance rate is a parameter to determine the percentage of the ability of a production machine to operate according to its standard speed. Please note that the percentage of the ideal performance rate is 95%. Then, the following is a discussion of the results of performance rate measurements starting from week 37-52:

Through table 2 it can be seen the percentage of the performance rate ranges from 72.23%-90.08%. The lowest performance is at week 40 with percentage of 72.23% and the highest percentage is at week 52 with percentage of 90.08%. The overall performance rate percentage is 82.56%.

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Accordingly, it can be concluded that the percentage did not reach the ideal value of 95% meaning that the cone machine did not operate at its ideal speed and did not meet the expected ideal amount of output.

Discussion of Percentage Quality Rate

Quality rate is a parameter to determine the percentage of good products (not defective) produced by the machine during production activities. Please note that the percentage of the ideal quality rate is 99%. Then the following is a discussion of the results of the quality rate measurement starting from week 37-52 :

According to table 3, it can be seen that the percentage of quality rate ranges from 93.19%-98.79%. The lowest quality is at week 48 with percentage of 93.19% and the highest percentage is at week 50 with percentage of 98.79%. With a percentage of the overall quality rate is 97.61%.

In conclusion, the percentage did not reach the ideal value of 99% meaning that the cone machine did not succeed in producing good products as much as the ideal percentage of the OEE value.

Discussion of Percentage Quality Rate

OEE percentage value is a parameter to assess the effectiveness of a machine obtained by multiplying the percentage of availability rate, performance rate, and quality rate[14]. Please note that the ideal percentage OEE score is more than 85%. The following is an analysis of the results of the Overall Equipment Effectiveness (OEE) calculation:

Based on table 4, it can be noted that the percentage of OEE achievement ranges from 49.28%-83.84%. The lowest percentage is at week 38 with percentage of 49.28% and the highest percentage at week 47 with percentage of 83.84%. The overall OEE percentage is 73.85%.

The calculation of the OEE percentage shows that the effectiveness of the engine has not reached the ideal target of the percentage of OEE with a standard of more than 85%.

Discussion of Fishbone Diagram Identification

Identification using fishbone diagram is done through direct observation in the workstation of cone machine and based on documented information. Further information can be seen in the appendix[15].

The following is a fishbone diagram that will identify the causes not ideal for the value of OEE (effectiveness) of the cone machine based on 4 categories, there are method, material, machine, human :

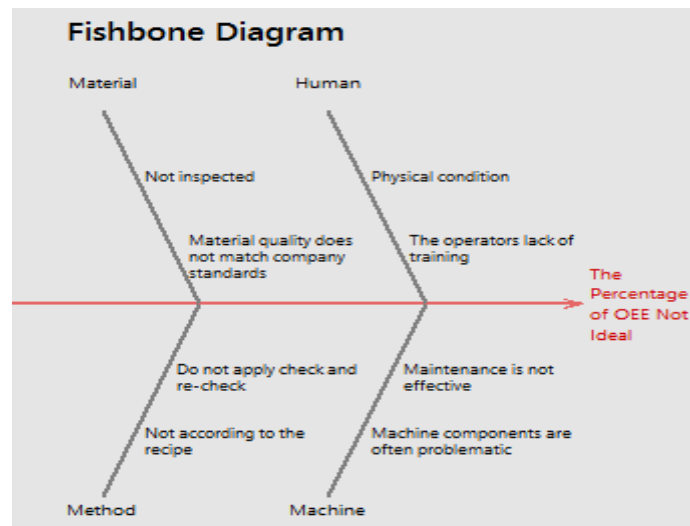


Figure 1. Fishbone Diagram of OEE: Not Ideal Effectiveness Percentages

Figure 1 explains the causes of the percentage of OEE that is not ideal divided into 4 categories, namely as follows:

1. Material

Materials such as cone wrapping paper (commonly called sleepe) that are received will go through a process of inspection by the quality control department before being used for cone production. However, there are samples taken randomly accidentally take a good part and pass the defect material so that there is sleepe excess glue or sleepe folds do not fit. As the result, when it is used on the machine, it does not meet specifications.

2. Human

Employees and operators naturally have different levels of fatigue, but this greatly affects the concentration of operators who are operating the machine. In addition, other things that need to be considered regarding the problem of operators who do not master the operation of the machine. As the result, they are not able to master things that occur on the machine in which a condition that causes production activities in trouble.

3. Method

When doing repairs to the machine is not checked (re-check), it causes the increasing the potential for negligence in repairing or replacing engine components. Another thing to note is that cooking the dough does not match the recipe.

4. Machine

Maintenance for machine is one way to improve and maintain the effectiveness of the engine, but if maintenance is not effective it will certainly greatly affect the productivity of the machine. Then, another thing that becomes a problem is the frequent occurrence of damage to the baking plate bearing parts of the machine.

Every 1% increase in OEE will provide a profit potential of Rp. 225 per hour. This is based on the machine's production rate of 500 units per hour, with a profit margin of Rp. 45 per unit.

CONCLUSION

Based on the results of the analysis, the following conclusions are drawn; First, percentage of availability rate is 91.55%, performance rate is 82.56%, quality rate is 97.61%, and overall equipment effectiveness is 73.85%. Second, cone machines have not ideal effectiveness. Third, the most influential factor for effectiveness of cone machine is performance rate, caused by the damage of the baking plate bearing. Lastly, Evaluation that needs to be done is to provide training for the employees and operators on duty at the work station, and purchase quality machine components. The training focuses on quality management for 24 to 50 hours, targeting participants ranging from operators to managers, regard to their respective job descriptions.

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