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Performance Analysis of Filling Machine Using Overall Equipment Effectiveness Metric in Beverage Company

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ABSTRACT

The purpose of this study is to measure the *machine's performance in the filling process which often experiences damage to one of* the *companies engaged in the food sector that produces coffee and goat milk powder sachet packaging. The company targets the production process results on coffee products as much as 15,600 sachets per day. In Filling Line 3 machines, there are often losses caused by machine breaks, so the daily production target is not achieved. The method used is the machine performance measurement method (OEE) which consists of 3 factors, namely Availability, Performance, and Quality. The results of the study were obtained from the Overall Equipment Effectiveness (OEE) value for the period of December 2021 (53.4%), January 2022 (60.6%), February 2022 (61%), and March 2022 (63.3%). The OEE value obtained from the calculation is still too far from the World Class standard (85%). The factors in the Six Big Losses analysis that caused the low OEE value consisted of Equipment Failure (52.7%), and Setup & Adjustment (30.7%). The proposed improvements that can be used to increase the effectiveness value of the machine include that the company must conduct training for employees and add maintenance operators. Making SOPs for workers must also be considered because SOPs are standards passed by the company to be followed. The company must also monitor the engine components used.*

Key Words: Availability, Overall Equipment Effectiveness, Performance, Quality, Total Productive Maintenance.

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1. INTRODUCTION

In the filling and packaging process on sachet packaged ground coffee products, the company uses a sachet packaging machine with the Cing Fong Jumbo brand obtained by the company in a previously used condition. The company has targeted the packaging process to produce 15,600 sachet packaged ground coffee drink products per day. Due to problems often experienced by sachet packaging coffee filling machines in each production process, causing the daily production target is not achieved by the provisions owned by the company.

Overall Equipment Effectiveness (OEE) is the most commonly used measure of equipment performance [1], [2]. This is a way of measuring the percentage of time against a piece of equipment that produces a quality product. Thus, the OEE provides a barometer to measure how well the capital assets are used. In addition, this method can provide data on the impact of losses related to the equipment. OEE can also affect productivity plans by breaking losses into more specific categories.

Total Productive Maintenance (TPM) is a maintenance that is *preventive maintenance* in nature and involves all employees in the industry, with the expected goal of eliminating waste. There are two basics of *maintenance* activities, namely cleaning and inspection. TPM also uses basic 5S concepts such as *Seiri* (Sorting), Seiso (Set in order), *Seiso* (Shine), *Seiketsu* (standardized), and *Shitsuke* (Sustain or self-discipline) [3].

2. METHODOLOGY

The method used uses analysis in the existing literature review, namely by analyzing the performance value of the *Filling* machine and looking for the largest *Six Big Losses* actor by Pareto diagram analysis, and completing the study with *5 WHY Analysis* and *Fishbone Diagram.*

Overall Equipment Effectiveness (OEE) is a measuring tool when applying the concept of *Total Productive Maintenance* (TPM), which aims to keep equipment in ideal condition by eliminating *six significant losses* of equipment [4]. OEE comprises three components: availability, *Performance,* and *Quality* [5]. OEE is a value that is considered the ratio of actual performance to equipment performance under the best-operating conditions. The purpose of OEE is as a tool to measure the performance of a treatment system, where in this way can be seen the values obtained from the formula [3], [6]:

a. Availability

A relationship that describes the time available for the operation of the machine. This value is a measure of the success of machine maintenance activities. Some critical factors in calculating *Availability* are:

- *Operating Time*: obtained from (*Loading time – Downtime*).
- *Downtime*: Machine downtime in the event of a breakdown.
- *Loading time*: Represents the time planned to run the machine.

Availability Formula :

$$Availability = \frac{Loading\ time - Downtime}{Loading\ time} \times 100\% \quad (1)$$

b. Performance

The machine can produce products. The calculation method compares the *results of* the machine output with the available time. Some of the critical factors needed in performance calculation are:

- *Operation Speed Rate*: Production speed time
- *Output Product/process amount*: Number of products manufactured
- *Operation Time*: Machine operation time

Performance Formula:

$$Performance = \frac{Ideal\ Cycle\ Time\ x\ Process\ Amount}{Operation\ Time} \times 100\% \quad (2)$$

c. Quality Rate

It is the result of the ratio of the number of products that meet the standard to the number of products produced at that time (*output*). Some crucial factors needed in calculating *the Quality Rate* are:

- *Process amount*: Number of products manufactured
- *Defect*: Number of defective products

Quality Rate Formula:

$$Performance = \frac{Process\ Amount - Product\ Defect}{Process\ Amount} \times 100\% \quad (3)$$

d. *Overall Equipment Effectiveness* (OEE)

After the calculation of *Availability, Performance* and *Quality Rate* is calculated, the formula can calculate the OEE calculation:

$$OEE = A\ x\ P\ x\ Q \quad (4)$$

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Criteria for assessing OEE scores include [7]:

1. OEE = 100%: Production is considered perfect, with fast *performance* and no *downtime* from defects or *rejects* of production results.
2. OEE = 85%: At this value, production is considered *World Class*; this *score* is viewed as a score that is suitable for the company's long-term reference in the production process.
3. OEE = 60%: Production is considered reasonable but shows an excellent opportunity for *improvement.*
4. OEE = 40%: Production is considered to have a low score; in most cases, it can be *easily improved* through direct measurement.

The OEE tells us whether our equipment is underutilized or overutilized [8]. Where of the three components (*Availability, Performance, and Quality*) reaches all the main problems that influence the production process that produces products from the equipment and system operators that the company uses. *Six big losses* include Equipment Failure, Setup & Adjustment, Idling & Minor Stoppages, Reduced Speed Losses, Reduced Yield, and Defect Process [4]. Meanwhile, in terms of human resources, it is necessary to carry out work training to increase the knowledge and expertise of the workforce, which is expected to be able to complete maintenance tasks [9].

3. RESULT AND DISCUSSION

3.1 OEE Analysis

OEE value analysis aims to determine the percentage value of machine performance of the *Filling* machine used in the sachet packaging production process at PT. JKL. Based on the results of data collection and processing during the period December 2021 – March 2022, the OEE *filling* machine can be seen in table 1.

Table 1. Data OEE

Period	Week days	Time Available (Minutes)	Planned Downtime (Minutes)	Machine Break (Minutes)	Non-Productive Time (Minutes)	Machine settings (Minutes)	Loading Time (Minutes)	Op. Time (Minutes)
Of the 21	22	11.880	2.640	1.031	174	1.030	9.240	7.005
Jan 22	21	11.340	2.940	904	116	485	8.400	6.895
Feb 22	18	9.720	2.160	701	109	305	7.560	6.445
Mar 22	22	11.880	3.060	675	125	415	8.820	7.605
Total		44.820	10.800	3.311	234	2.235	34.020	27.950

Table 2. OEE calculation

Period	Number of Productions (Sachets)	Actual Cycle Time (Min)	Ideal Cycle Time (Min)	Defect Product (Sachet)	Availability (%)	Performance (%)	Quality (%)	OEE (%)
Of the 21	256.035	0,02	0,0273	9.391	75,8	73,1	96,3	53,4
Jan 22	262.800	0,02	0,0262	8.221	82,1	76,2	96,9	60,6
Feb 22	235.350	0,02	0,0273	4.635	85,3	73	98	61
Mar 22	286.700	0,02	0,0265	7.196	86,2	75,4	97,5	63,3

(Source: Company Data, 2022)

Table 2 shows that in the period December 2021 – March 2022, the OEE value does not seem to reach the *World Class* value standard of 85%. In contrast, if you look at the highest OEE value of only 63.3% in March 2022, the company is required to *make* improvements to increase the percentage value of the performance of the filling machine; therefore, an analysis of the *calculation of Six Big Losses* is carried out. To find out the most significant factor causing the decline in OEE values.

3.2 Six Big Losses Analysis

Analysis of *Six Big Losses* needs to be carried out to determine the causal factors of the low OEE value that affects

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[10]. The significant contributions that affect engine performance are six significant losses such as breakdowns, setting and adjustments, minor stops, speed reduction, start-up rejection, and production rejection. Table 3 shows data on *Six Big Losses* for December 2021 – March 2022.

Table 3. Data *Six Big Losses*

Period	Weekdays	Cycle Time (Min)	Actual Cycle Time (Min)	Number of Productions (Sachets)	Defect Product (Sachet)	On-Time (Min)	Downtime (Min)	Loading Time (Min)	Engine Settings (Min)
Of the 21	22	0,02	0,0273	256.035	9.391	7.005	1.205	9.240	1.030
Jan 22	21	0,02	0,0262	262.800	8.221	6.895	1.020	8.400	485
Feb 22	18	0,02	0,0273	235.350	4.635	6.445	810	7.560	305
Mar 22	22	0,02	0,0265	286.700	7.196	7.605	800	8.820	415

Table 4. *Six Big Losses* Calculation

Period	Equipment Failure (%)	Setup & Adjustment (%)	Idling & Minor Stop (%)	Reduced Speed Losses (%)	Reduced Yield (%)	Defect Process (%)
Of the 21	13	11,1	1,9	0,000079	0,29	2
Jan 22	12,1	5,8	1,4	0,000087	0,29	2
Feb 22	10,7	4	1,4	0,000097	0,29	1,2
Mar 22	9,1	4,7	1,4	0,000083	0,29	1,6
Losses Minute	3.835	2.235	524	0	99	585

(Source: Company Data, 2022)

In table 4, it can be seen that the *Six Big Losses* count data is then analyzed using a Pareto diagram.

3.3 Pareto Diagram Analysis

To find out the value of the most significant *losses*, a Pareto diagram is made from the calculation of the *Six Big Losses* shown in table 5.

Table 5. Data Six Big Losses

No	Types of Losses	Time Losses (Min)	Percentage (%)	Cumulative (%)
1	*Equipment Failure*	3.385	52,7	52,7
2	*Setup & Adjustment*	2.235	30,7	83,4
3	*Defect Process*	585	8	91,4
4	*Idling & Minor Stoppages*	524	7,2	98,6
5	*Reduced Yield*	99	1,4	100
6	*Reduced Speed Losses*	0	0	100
	Total *Losses*	7.278		

(Source: Company Data, 2022)

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Figure 1 is a Pareto Diagram showing the two biggest factors: Equipment *Failure* and *Setup & Adjustment.*

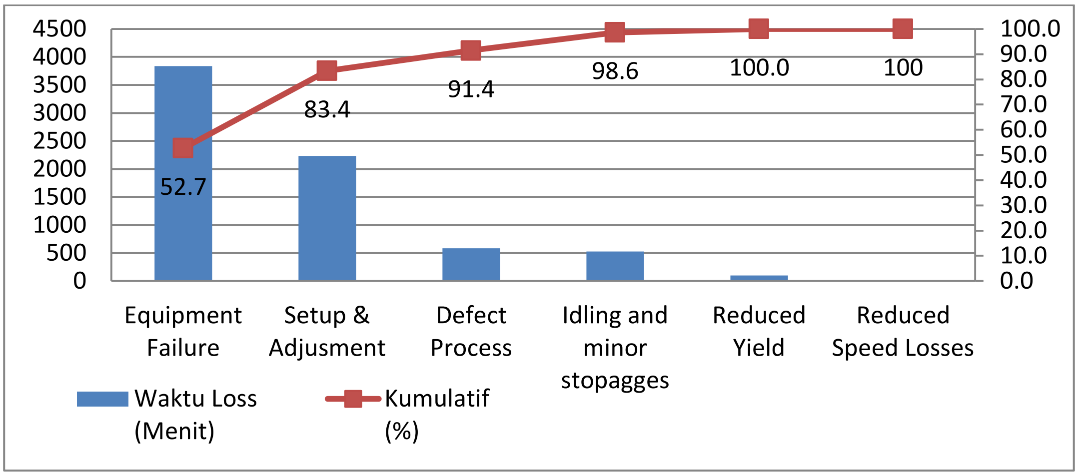

Figure 1. Diagram Pareto *Six Big Losses*

As seen in figure 1 above, the two biggest *loss the most significant filling* machine *Equipment Failure* and *Setup & Adjustment.* These two factors will be analyzed more profoundly using *5 WHY Analysis* and *Fishbone Diagrams*, which will produce proposed improvements to the problem of the most considerable *Losses*.

3.4 Analysis of *5 WHY Analysis* (Two Biggest Factors of *Losses*)

In the two most significant factors, the *Six Big Losses* analysis was carried out 5 *WHY Analysis* which was carried out by conducting the "why" question 5 times to the supervisor of the relevant division.

a. Analisis *5 WHY Analysis Equipment Failure*

"Why can the *loss* value on engine failure reach the value (3,835 minutes)?". The first five to fourth Why and the causes for equipment failure analysis can be seen in table 6.

Table 6. Five WHY Analysis Equipment Failure

Why 1	Because the operator does not understand the condition of the machine, and there is no sense of belonging to the device used
Why 2	Lack of good communication between the operator and *the maintenance* party
Why 3	Because the operator and *maintenance* do not understand to repair the machine used
Why 4	Because it does not have Standard Operating Procedures (SOPs) for handling the event of an abnormal condition on the machine and what actions should be taken when an abnormal condition occurs.
Cause	Absence of training or training for employees if the machine is *abnormal* and how to handle it

b. Analisis *Five WHY Analysis Setup & Adjustment*

"Why did the *Setup and AdjMachine's Setup and Adjustment losses value* (2,235 minutes)?". The first to fourth five Whys and causes for analysis setup and adjustment can be seen in table 7.

Table 7. Five Why Analysis Setup and Adjustment

Why 1	*Maintenance* operator fatigue in carrying out repairs
Why 2	Because the number of *maintenance* operators is limited (few)
Why 3	Because the capabilities of each *maintenance* operator are different
Why 4	Because the number of problems on the machine is more than 1 (one)

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Cause	The absence of Standard Operating Procedures (SOPs) in handling problems on related machines and communication of problem reports from operators to *maintenance* could be better.

After analysis using *5 WHY Analysis,* further research uses the *Fishbone Diagram* to find out the problem of each factor.

3.5 Fishbone *Diagram Analysis*

To find out the problem in each factor of 5M + 1E, a follow-up analysis was carried out from the results of the previous discussion using the *Fishbone Diagram*. Cause and effUsing Fishbone Diagrams, cause and effect analysis can be analyzed using the factors of Material, Method, and Environment [12]. *The fishbone diagram* can be seen in figure 2.

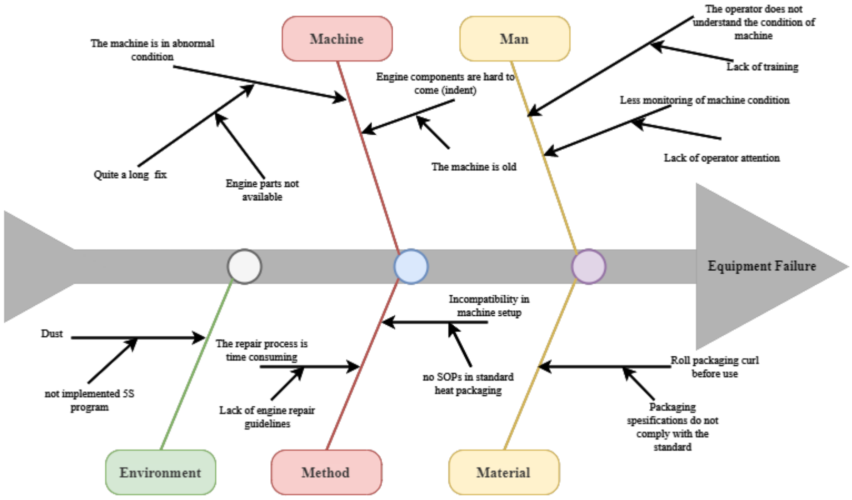

Figure 2. ***Fishbone Factor Diagram Equipment Failure***

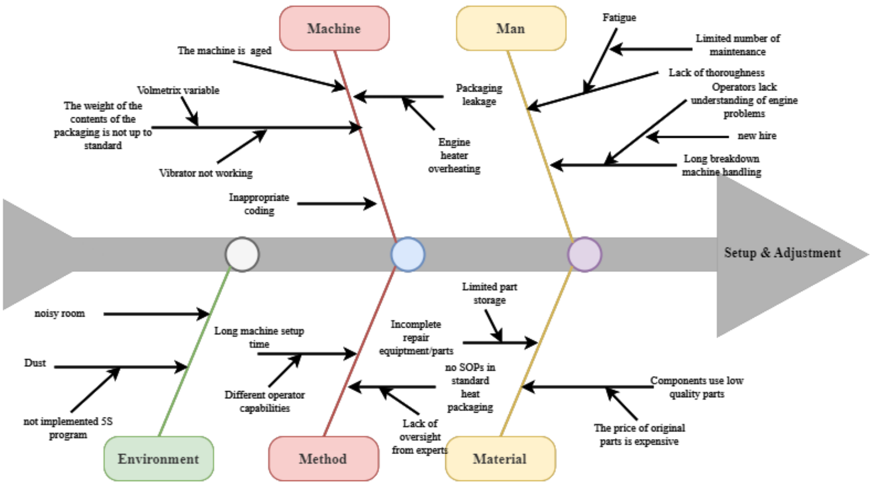

Figure 3. ***Fishbone Diagram Factor Setup & Adjustment***

3.6 Proposed Improvements

After the analysis using the *Fishbone Diagram*, an improvement proposal was found that could be used by the company to increase the performance value of the *Filling* machine on the *Equipment Failure* and *Setup & Adjustment* factors; the following are suggestions that can be used:

a. Equipment Failure Factor

Improvements can be made to the human resources training program so that damage can be detected early,

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implement 5S in the production environment so that it is neat and clean, and control empty components to suit production needs.

b. *Setup & Adjustment Factor*

Improvements can be made by adding maintenance operators to the company so as not to rely on several other *maintenance* operators, making SOPs for tuning and using filling machines to match the conditions expected by the company, and looking for alternative components from devices that are better than existing *parts*.

4. CONCLUSION

Based on the analysis of the OEE value on the Jumbo type filling machine for the period of December 2021 to March 2022, the performance results of the *filling* machine were obtained in December 2021 (53.4%), January 2022 (60.6%), February 2022 (61%), and March 2022 (63.3). The World Class standard value of OEE is 85%. 2 dominant Six Big Losses factors aff t the performance of the filling machine; these factors include the *Equipment Failure* factor (52.7%), or equivalent,t to 3,835 minutes. The second is Setup and Adjustment (30.7%), or equal to 2,235 minutes from data collection for December 2021 – March 2022. To increase the effective value of the Filling machine, the company must conduct training for employees and add maintenance operators so that if there is a breakdown, they do not have to wait for other maintenance operators to make repairs. It is necessary to create and set SOPs that become standards passed by the company to be followed by employees. The company must also monitor the engine components.

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