



Measuring the Efficiency of Contiform Machines with the Overall Equipment Effectiveness Method at PT Tirta Investama Pandaan

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ABSTRACT

PT Tirta Investama Pandaan Plant is a manufacturing company focused on mineral drinking water (Bottled Water) production. So as to produce a standards product need to take the role of the machine to help people to do it, in the production process machine performance is still not effectively and efficiently yet, so that need for machines maintenance and performance measurement. One method used to measure the effectiveness of that Overall Equipment Effectiveness (OEE). The principles contained in this method are Avaibility, Performance and Quality. From the results of research conducted Contiform machine OEE values obtained 75.62%. Therefore, according JIMP could not be categorized as a Word Class Company. It is necessary to Six Big Losses calculation that includes Equipment Failure Set up and Adjustment Losses, Idle Stopppage Minor Losses, Reduce Speed Defect and Rework Quality and Yield or Losses. Six Big Losses From calculations carried out, there are 2 types of losses are dominant, namely Idle Minor Stoppage with a percentage of the value of the Reduce Speed 13:53% and amounted to 29.82%. So do need root cause analysis that includes human factors, machine, material and method with fishbone diagram.



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1. Introduction

In the modern era of competitive industry, the effectiveness and efficiency of the production process are crucial elements that determine the competitiveness of the company. One of the main factors in achieving such efficiency is the performance of production machines (Ariyah, 2022). Machines that are able to operate stably, quickly, and produce quality products will help companies maintain consistency in production results and reduce operational costs (Liker, 2004). Therefore, monitoring and measuring the effectiveness of machines is an important activity in the operational management system of a manufacturing company (Nakajima, 1998).

PT Tirta Investama Pandaan is one of the companies engaged in the Bottled Water (AMDK) industry sector, which relies heavily on automation systems and machine performance to support its

production activities. One of the main machines used in the production line is the Contiform machine, which is a bottle forming machine based on heating technology and air pressure against preform.

However, along with the high intensity of the machine's work and the high production target, various problems began to emerge. Some of the obstacles identified are the high frequency of machine downtime, the number of defective or rejected products, and the mismatch between the ideal capacity of the machine and the actual output produced. This problem not only has an impact on production efficiency, but also increases maintenance costs and reduces labor productivity. The data obtained during the production process of the Contiform machine is as follows.

Table 1. Contiform Machine Production Data

TANGGAL	Calendar time	Durasi Produksi (menit)	HASIL PRODUKSI	Operation Time	Planned Downtime	Failure & Repair	Set Up & Adj	Reject and rework	Nonproductive time
1 Juni 2019	480,00	390,00	13.640	350	90	40	0,00	1.108	26,27
2 Juni 2019	480,00	390,00	14.400	383	90	7	0,00	214	6,00
10 Juni 2019	480,00	450,00	11.680	338	30	112	0,00	946	138,53
11 Juni 2019	480,00	450,00	13.640	403	30	47	0,00	1.519	86,27
12 Juni 2019	480,00	450,00	16.200	440	30	10	0,00	290	18,00
13 Juni 2019	480,00	450,00	16.320	446	30	4	0,00	174	14,80
14 Juni 2019	480,00	360,00	10.560	291	120	69	0,00	402	78,40
15 Juni 2019	480,00	450,00	15.520	429	30	21	0,00	229	36,13
16 Juni 2019	480,00	240,00	6.720	198	0	42	0,00	228	60,80
17 Juni 2019	480,00	450,00	14.160	391	30	59	0,00	238	72,40
18 Juni 2019	480,00	450,00	15.440	419	30	31	0,00	328	38,27
19 Juni 2019	480,00	450,00	14.440	413	30	37	0,00	1.427	64,93
20 Juni 2019	480,00	330,00	11.760	467	0	13	0,00	136	16,40
21 Juni 2019	480,00	360,00	12.840	348	120	12	0,00	83	17,60
22 Juni 2019	480,00	450,00	16.240	431	30	19	0,00	297	16,93
23 Juni 2019	480,00	240,00	5.800	173	0	67	0,00	1.944	85,33
24 Juni 2019	480,00	450,00	14.920	424	30	26	0,00	522	52,13
25 Juni 2019	480,00	450,00	8.880	253	30	197	0,00	335	213,20
26 Juni 2019	480,00	450,00	15.760	430	30	20	0,00	216	29,73
27 Juni 2019	480,00	450,00	15.640	424	30	26	0,00	621	32,93
28 Juni 2019	480,00	360,00	13.000	349	120	11	0,00	243	13,33
29 Juni 2019	480,00	480,00	15.520	437	0	43	0,00	418	66,13

The problem that occurred showed that the Contiform machine at PT Tirta Investama had not worked optimally. This is reinforced by the fact that the company has not fully implemented a quantitative and comprehensive machine effectiveness measurement system. In fact, with the right approach and methods, the root cause of machine inefficiency can be identified, analyzed, and corrected. One of the methods that is widely used in measuring machine effectiveness is Overall Equipment Effectiveness (OEE). This method assesses the effectiveness of the machine based on three main indicators: Availability (availability of machine operating time), Performance (machine working speed compared to ideal standards), and Quality (the number of products that comply with quality standards) (Hutabarat & Muhsin, 2020).

The OEE method not only provides an overview of machine performance, but also opens up opportunities for deeper analysis through the identification of the Six Big Losses—the six main sources of losses in the production system. The six sources of losses include machine failure, setup time, minor stops, speed drops, product defects, and faulty production starts. By knowing the dominant source of loss, management can design a strategy to improve machine performance in a more precise and focused manner (Ilyas et al., 2023).

The purpose of this study is to analyze the performance of the Contiform machine based on the measurement of the OEE value, identify the type of largest losses based on the *six big losses approach*, and formulate suggestions for improvements to the engine performance based on the root of the problems found.

2. Literature Review

1) Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) is a key metric in operational management that is used to measure the efficiency and effectiveness of an equipment or machine in the production process (Wahid, 2020). This concept was first introduced by Seiichi Nakajima in the 1980s as part of the Total Productive Maintenance (TPM) methodology. OEE is calculated based on three main components, namely Availability, Performance, and Quality, each of which reflects a different aspect of machine productivity. Availability measures the percentage of machine operating time compared to available time, Performance evaluates the machine's operating speed relative to its maximum capacity, and Quality calculates the ratio of products that meet quality standards to the total products produced. By multiplying these three components, OEE provides a comprehensive picture of how optimally a piece of equipment is used in the production process.

2) Six Big Losses

Six Big Losses are a classification of different types of inefficiencies that significantly affect equipment performance and lower the value of OEE (Kristanto et al., 2022). This concept is directly related to the three components of the OEE, where each component of the OEE is affected by two main types of losses. In the Availability component, losses consist of Equipment Failure (unexpected machine breakdowns that cause downtime) and Setup and Adjustments (time wasted on preparation or production setup changes). For Performance components, the disadvantages include Idling and Minor Stops (short stops that disrupt the production flow) and Reduced Speed (engine operation below the specified maximum capacity). Meanwhile, in the Quality component, losses include Process Defects (product defects during the production process) and Reduced Yield (products fail during the production start-up phase). An in-depth understanding of the Six Big Losses allows production teams to implement targeted solutions, such as preventive maintenance to reduce Equipment Failure or process standardization to minimize Setup and Adjustments.

3. Methodology

Types of Research

This study is a descriptive quantitative research that aims to measure the work effectiveness of Contiform machines at PT Tirta Investama Pandaan using the Overall Equipment Effectiveness (OEE) method. The quantitative approach is carried out to obtain numerical data that can be measured systematically, while the descriptive approach is used to describe and analyze phenomena that occur in actual time in the field.

Research Location and Time

This research was carried out at PT Tirta Investama Pandaan, a company engaged in the production of Bottled Drinking Water (AMDK). The research location is focused on production lines that use Contiform machines. Data collection was carried out for a period of one month, namely from June 1 to June 29, 2019.

Research Object

The object of this study is the Contiform machine, which is a bottle forming machine from preform material with a heating and air pressure system. This machine is one of the vital machines in the bottled water production process because it determines the physical quality of the products produced.

Data Collection Methods

The data used in this study was collected through three methods, namely:

- a. Direct observation of the production process using Contiform machines to record working time, downtime, working speed, and number of defective products.

- b. Interviews with employees in the production department, machine operator, and engineering department to obtain information related to the causes of downtime and the quality of production results.
- c. Literature review of relevant scientific literature such as journals, books, and previous research results that discuss the OEE method and its application in measuring machine effectiveness (Nakajima, 1998; Erlinda et al., 2009; Susetyo, 2017).

Data Processing and Analysis Techniques

Data analysis was carried out using the Overall Equipment Effectiveness (OEE) method. There are three main parameters that are calculated:

- a. Availability (A): Measures the proportion of actual operating time to planned time.
- b. Performance (P): Measures the actual production speed compared to the ideal speed of the machine.
- c. Quality (Q): Measures the percentage of products produced without defects.

OEE Formula:

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

Data from each parameter was obtained from the results of field recording and calculated per day, then averaged over one month.

Six Big Losses and Root Cause Analysis

To find out the source of losses that cause low OEE values, the Six Big Losses approach is used, which identifies six main causes of loss of efficiency in production, namely: *Equipment Failure, Setup and Adjustment, Idling and Minor Stoppage, Reduced Speed, Defects in Process, and Reduced Yield (Start-up losses)*

After that, a root of the problem analysis was carried out using the Fishbone Diagram (Cause-and-Effect Diagram) with the 4M+1E (*Man, Machine, Method, Material, Environment*) approach to identify the dominant factors causing the inefficiency.

4. Results and Discussion

Data Processing and Analytics

The data processing in this study is a measurement of the Overall Equipment Effectiveness (OEE) value for Contiform machines. The value of Overall Equipment Effectiveness (OEE) depends on three ratios, namely: availability, performance, and quality. The data obtained on the Contiform machine can be seen in table.1 and the stages of data processing carried out in this study are:

a. Planned down time

Planned Down Time is the time allocated to carry out preventive maintenance or other maintenance activities that have been scheduled in advance so that the condition of the machinery and other production equipment is in good condition to support the production department in realizing their production schedule.

b. Down Time Losses

For example, the Set up and Adjustment time on June 1, 2019 on the Contiform machine data is 0 minutes.

$$\begin{aligned} \text{Downtime} &= \text{Failure Repair} + \text{Setup and Adjustment} \\ &= 70 + 0 \\ &= 70 \end{aligned}$$

c. Number of defect

Number of Defects is divided into two types of defects, namely Reduced Yield and Reject and Rework Component. As on June 1 in the Contiform engine data, the amount of damaged goods produced was 0 bottles (none) which is referred to as the Reduced Yield amount.

d. Operating time

Where Operating Time is the Loading Time minus the Failure and Repair Time and Set up & Adjustment Time. For example, June 1 in the Contiform machine data is as follows:

$$\begin{aligned}\text{Operating time} &= \text{Loading time} - \text{Failure and Repair} - \text{Set up and Adjustment} \\ &= 390 \text{ minutes} - 40 \text{ minutes} - 0 \text{ Minutes} \\ &= 350 \text{ minutes}\end{aligned}$$

Availability Ratio Calculation

The data used in the measurement of the Availability Ratio are machine working time, planned downtime, downtime (Failure and repair and Set up and Adjustment) and the formula used to find the Availability Ratio is as follows:

$$\text{Availability} = \frac{\text{operational Time}}{\text{Loading Time}} \times 100\%$$

From this calculation, it is known that the overall availability ratio value reaches 56.2% - 99.1%, for the lowest availability value is found on June 25, 2019 which is 56.2%, and the highest availability value is found on June 13, 2019 which is 99.1%. The Availability Ratio value of the entire machine is 89.54%.

Judging from the standard availability value for the analysis in this study, which is 95%, it can be concluded that the analyzed machine is still far below the standard value for the measurement of the Overall Equipment Effectiveness (OEE) value. The value of the difference between these values is very different, which is 5.6%.

Performance Ratio Value Measurement

The calculation of the Performance Ratio begins by calculating the Ideal Cycle Time which is the ideal cycle time of the engine. To calculate, it is necessary to pay attention to the percentage of working hours to delay, where the delay is equal to the total downtime. The formula for working hours is:

$$\text{Performance} = \frac{\text{Total downtime}}{\text{operation timr}} \times 100\%$$

$$\text{ideal Cycle Time} = \frac{\text{Loading time}}{\text{total produksi}} \times \text{jam kerja}$$

Thus, the performance calculation from June 1, 2019 to June 29, 2019 is as follows:

Table 2. Performance Standards

Tanggal	Operatio n Time	Total Downtime	Jam Kerja %	Loading Time	Hasil Produk si (box)	Cycle Time	ideal Cycle Time	Performance Rate
1 Juni 2019	350	70	80.00	390	13,640	0.03	2.29	89.14
2 Juni 2019	383	37	90.34	390	14,400	0.03	2.45	91.99
10 Juni 2019	338	142	57.99	450	11,680	0.04	2.23	77.20
11 Juni 2019	403	77	80.89	450	13,640	0.03	2.67	90.33
12 Juni 2019	440	40	90.91	450	16,200	0.03	2.53	92.98
13 Juni 2019	446	34	92.38	450	16,320	0.03	2.55	93.21
14 Juni 2019	291	189	35.05	360	10,560	0.03	1.19	43.36
15 Juni 2019	429	51	88.11	450	15,520	0.03	2.55	92.43
16 Juni 2019	198	42	78.79	240	6,720	0.04	2.81	95.50
17 Juni 2019	391	89	77.24	450	14,160	0.03	2.45	88.89
18 Juni 2019	419	61	85.44	450	15,440	0.03	2.49	91.76
19 Juni 2019	413	67	83.78	450	14,440	0.03	2.61	91.28
20 Juni 2019	467	13	97.22	480	11,760	0.04	3.97	99.92
21 Juni 2019	348	132	62.07	360	12,840	0.03	1.74	64.21
22 Juni 2019	431	49	88.63	450	16,240	0.03	2.46	92.54
23 Juni 2019	173	67	61.27	240	5,800	0.04	2.54	85.00
24 Juni 2019	424	56	86.79	450	14,920	0.03	2.62	92.11
25 Juni 2019	253	227	10.28	450	8,880	0.05	0.52	18.28
26 Juni 2019	430	50	88.37	450	15,760	0.03	2.52	92.48
27 Juni 2019	424	56	86.79	450	15,640	0.03	2.50	92.11
28 Juni 2019	349	131	62.46	360	13,000	0.03	1.73	64.43
29 Juni 2019	437	43	90.16	480	15,520	0.03	2.79	99.03
Total	374.4091	78.32	76.13	415.91	13321.82	0.03	2.37	83.55

And from the table, it can be seen that the overall Performance ratio value reaches 18.28% - 99.03%, for the lowest performance value is on June 25, 2019 which is 18.28%, and the highest performance value is 99.03%. The Performance Ratio value of the entire machine is 83.55%.

Judging from the standard performance value for the analysis in this study, which is 95%, it can be concluded that the analyzed machine is still far below the standard value for the measurement of the Overall Equipment Effectiveness (OEE) value. The value of the difference between these values is very different, which is 11.45%.

Quality Ratio Value Measurement

The formula used to find the Quality Ratio is

$$Quality = \frac{\text{processed amount} - \text{defect amount}}{\text{processed amount}} \times 100\%$$

The following is a table of Quality Ratio Value Measurements on machines on June 1, 2019 – June 29, 2019:

Table 3. Quality Calculation

Tanggal	Hasil Produk si (box)	Reject (pcs)	Quality
1 Juni 2019	13,640	1108	91.88%
2 Juni 2019	14,400	214	98.51%
10 Juni 2019	11,680	946	91.90%
11 Juni 2019	13,640	1519	88.86%
12 Juni 2019	16,200	290	98.21%
13 Juni 2019	16,320	174	98.93%
14 Juni 2019	10,560	402	96.19%
15 Juni 2019	15,520	229	98.52%
16 Juni 2019	6,720	228	96.61%
17 Juni 2019	14,160	238	98.32%
18 Juni 2019	15,440	328	97.88%
19 Juni 2019	14,440	1427	90.12%
20 Juni 2019	11,760	136	98.84%
21 Juni 2019	12,840	83	99.35%
22 Juni 2019	16,240	297	98.17%
23 Juni 2019	5,800	1944	66.48%
24 Juni 2019	14,920	522	96.50%
25 Juni 2019	8,880	335	96.23%
26 Juni 2019	15,760	216	98.63%
27 Juni 2019	15,640	621	96.03%
28 Juni 2019	13,000	243	98.13%
29 Juni 2019	15,520	418	97.31%
Total	13,322	542	95%

Overall Equipment Effectiveness (OEE) Measurement

After the Availability ratio, Performance ratio, and Quality ratio values are obtained, the next step is to calculate the OEE value. And the formula used for the measurement of the OEE value is:

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

Table 4. OEE Calculation Results

Tanggal	Avaibility %	Performance %	Quality %	OEE %
1 Juni 2019	89.74%	89.14	91.88%	73.50
2 Juni 2019	98.21%	91.99	98.51%	89.00
10 Juni 2019	75.11%	77.20	91.90%	53.29
11 Juni 2019	89.56%	90.33	88.86%	71.88
12 Juni 2019	97.78%	92.98	98.21%	89.28
13 Juni 2019	99.11%	93.21	98.93%	91.39
14 Juni 2019	80.83%	43.36	96.19%	33.72
15 Juni 2019	95.33%	92.43	98.52%	86.81
16 Juni 2019	82.50%	95.50	96.61%	76.11
17 Juni 2019	86.89%	88.89	98.32%	75.94
18 Juni 2019	93.11%	91.76	97.88%	83.63
19 Juni 2019	91.78%	91.28	90.12%	75.50
20 Juni 2019	97.29%	99.92	98.84%	96.09
21 Juni 2019	96.67%	64.21	99.35%	61.67
22 Juni 2019	95.78%	92.54	98.17%	87.01
23 Juni 2019	72.08%	85.00	66.48%	40.74
24 Juni 2019	94.22%	92.11	96.50%	83.76
25 Juni 2019	56.22%	18.28	96.23%	9.89
26 Juni 2019	95.56%	92.48	98.63%	87.16
27 Juni 2019	94.22%	92.11	96.03%	83.35
28 Juni 2019	96.94%	64.43	98.13%	61.30
29 Juni 2019	91.04%	99.03	97.31%	87.73

Calculation of six big losses

In this part, an analysis of the results of the loss calculation is carried out. This analysis aims to determine which losses are the most dominant cause low OEE values. The calculation of the average value of each loss in the period from June 1, 2019 to June 29, 2019 can be seen as follows:

Table 5. Loss Calculation Results

no	Jenis Losses	Rata - Rata
1	equipment failure losses	10.46
2	Set-up losses	0
3	Idle and Minor Stoppage	13.53
4	Reduce speed losses	29.82
5	scrap losses	0
6	Rework losses	3.46
Total		9.55

Root Cause Analysis

This analysis was carried out by direct observation in the field and interviewing employees related to this study, namely operators, engineering departments, and quality control departments. The results of the interview are one of the possible causes of the difficulty in achieving the desired OEE

target. To obtain the results of the analysis that are in accordance with the purpose of this study, tools that are relevant to the data that have been collected are needed, so that to make it easier to identify this, a Cause and Effect Diagram is made later which will later be formulated an improvement plan to overcome the root of the problem.

And in the interview, several parameters were taken, namely materials, machines, humans (employees), and methods.

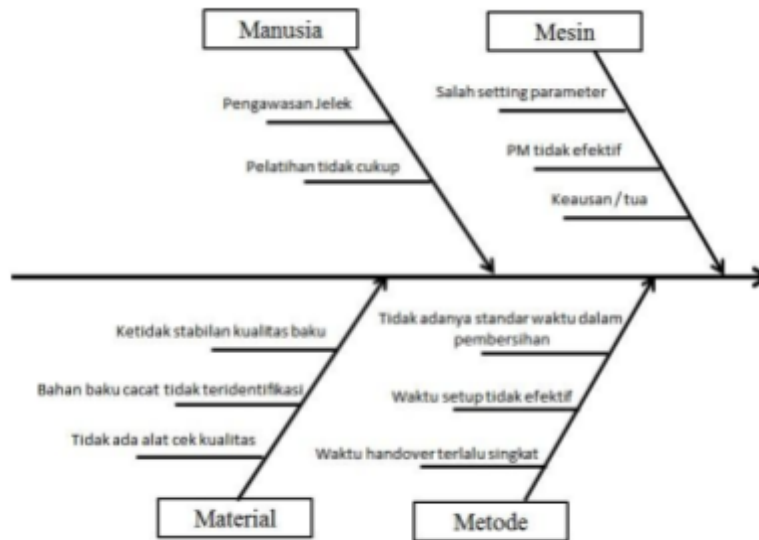


Figure 1. Root Diagram of the Problem

The above cause and effect diagram identifies causes based on 4 categories, namely humans, machines, materials and methods.

4. Conclusion

This study measured the efficiency of the Contiform machine at PT Tirta Investama Pandaan using the Overall Equipment Effectiveness (OEE) method. The results of the study showed an OEE value of 75.62%, which is still below the world class standard of 85%. The analysis of OEE components revealed that engine availability reached 89.54%, performance of 83.55%, and quality of 98.72%. The low availability value is mainly due to downtime for fault repair and setup adjustment, while suboptimal performance comes from reduced speed and minor stoppages. Even though the quality value is fairly good, there are still product defects that need to be fixed.

The Six Big Losses analysis identified the two most dominant major losses, namely idle minor stoppage of 29.82% and reduce speed of 13.53%. Through the fishbone diagram approach, the root of the problem can be categorized into four main factors. Human factors include the operator's lack of skills in handling machine troubleshooting. The engine factor is related to the age of the old engine and the lack of preventive maintenance. The method factor shows that the standard operating procedure is not optimal, while the material factor is related to the inconsistent quality of the preform.

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