# Analysis of the Effectiveness of 3D Print Machine Performance using the Overall Equipment Method Effectiveness

M Rafiq Muzadi[1] and Rifqi Amalya Fatekha[2]

[12] Department of Electrical Engineering, Politeknik Negeri Batam, Kepulauan Riau, Indonesia
rafiqmuzadi56@gmail.com

**Abstract.** The industrial revolution 4.0 has produced many advances in the field of science and technology. 3D printing machines are one of the advances in the manufacturing sector. Machines play an important role in the production process, so the condition of the machine must be maintained so that it is stable during operations. One of the performance measurement methods that is widely used is "Overall Equipment Effectiveness (OEE)". Which aims to determine the effectiveness of the performance of the process, as well as maximizing production against time availability (Availability) in producing output (Performance) with the best product quality (Quality). The results obtained after calculating the availability value were 80.72%, the performance rate was 78.83%, the quality rate was 90.11% and the OEE value was 52.93%.Improvements from this analysis are in- creasing operating time on the 3D Print machine to reduce downtime on the ma- chine, monitoring raw materials so that there are not many defects during the process, increasing working time so that the machine does not experience downtime, and increasing maintenance on the machine.

**Keywords:** OEE, 3D Print, Maintenance.

## 1 Introduction

Machines are the main factor in the production process. So the machine must be maintained so that its condition still looks new or is in a reasonable condition for operation. As time goes by, the machine's capabilities will decrease due to the age of the machine and maintenance carried out by humans with minimal experience. The problems that are often found are: downtime on machines, so continuous and periodic improvements are needed to maintain machine efficiency and increase productivity[1]. When a machine experiences damage, the production process will be affected and, most fatally, the production process will stop, causing a decrease in production and losses [2].

It often happens that the machine stops operating due to problems in the pro- duction machine, long setup and adjustment times, the machine produces defective products and often the machine operates but does not produce the product, causing losses because apart from reducing the level of efficiency and effectiveness of the machine/equipment, it results in costs that have to be paid[3]. issued due to this damage.


L. Lumombo et al. (eds.), *Proceedings of the 7th International Conference on Applied Engineering (ICAE 2024)*, Advances in Engineering Research 251,
https://doi.org/10.2991/978-94-6463-620-8_3

Apart from that, there is also a lot of downtime because the machine often breaks down suddenly during production.

An approach that is often used to solve problems down time on the machine ie. Total Productive Maintenance (TPM) is the application of maintenance that is often carried out in the manufacturing industry. Total Productive Maintenance (TPM) is measured using the method Overall Equipment Effectiveness (OEE). Measurement Overall Equipment Effectiveness (OEE) is carried out based on the third category six big losses, namely Availability (Machine Availability Time), Performance (Number of units produced), and Quality (The resulting quality)[4].

## 2 Methods

In this research, the object of research is machines 3D Print Any cubic i3 Mega. The data taken is 3D machine data operating in October 2023 for calculations. The research was carried out in the Brail Polibatam laboratory environment. Which aims to increase the effectiveness of machine work and can identify calculations to reduce large value results from six big losses. In order to identify damage to a 3D printing machine, the following method is needed:

### 2.1 System Block Diagram

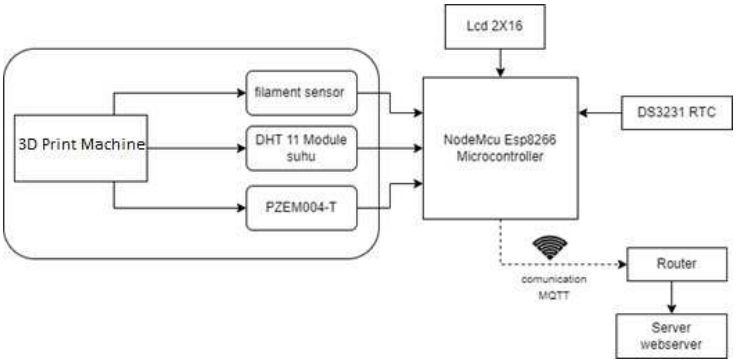


**Fig. 1.** System Block Diagram

The block diagram in Figure 1 shows that the system used in this research consists of 4 different sensors, namely the DS3231 RTC module as a real-time time and date sensor, the DHT 11 module which functions to read temperature and humidity values, the Pzem 004-t module which is a sensor for reading voltage and incoming current tool. After that, the data from the sensors above is sent to the server using MQTT communications as real time communication. MQTT communications is a standards- based messaging protocol, or set of rules, used for machine-to-machine communications using networks with limited resources and bandwidth.

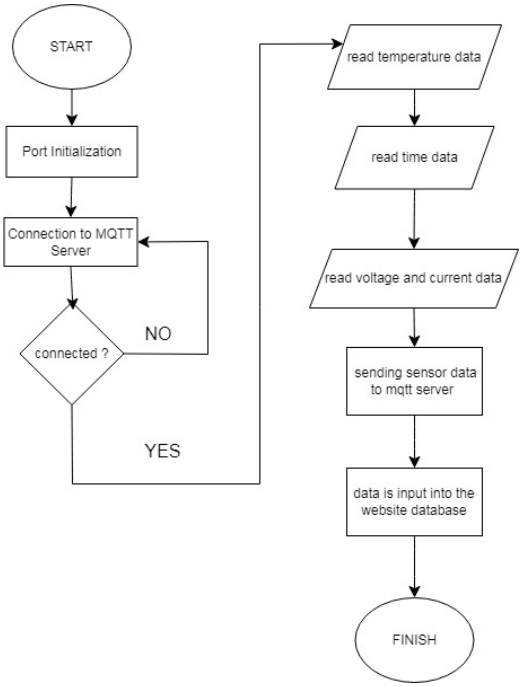


**Fig. 2.** System flowchart

Figure 2 explains the working system starting from connecting the pins of the dht11 sensor, DS3231 sensor, pzem004-t sensor, to the NodeMcu esp8266. After that, connect the NodeMcu to the server using MQTT communication which aims to send data from the sensor to the server and then store it in the website server database.

## 2.2 Overall Equipment Effectiveness (OEE)

OEE is a way to measure the performance of production machines by implementing the TPM program. (OEE) is a tool for measuring productivity and the best way to monitor and improve the efficiency of manufacturing processes with maximum output under the best machine performance conditions. OEE is based on 3 main components, namely *Availability, performance efficiency, and rate of product quality*[5].

**Table 1.** Ideal OEE values

| Description | Rate |
|---|---|
| Availability | > 90% |
| Performance Efficiency | > 95% |
| Quality | > 99% |
| OEE | > 85% |

**Availability.** Availability is a ratio that shows the time available to operate the machine. Availability is a comparison between machine operational time and the planned time[8]. to find value availability you can use the following formula:

$$AV = \frac{Operating\ time}{Production\ time}\ x\ 100\% \quad (1)$$

Where *Operating Time* is the available operating time after time *downtime*-machine remove from total *availability* planned time. *Production time* is the machine time available per day. Whereas *Downtime* is the processing time used by the machine when repairing[6].

**Performance.** Performance is a ratio that describes the speed of a machine in producing goods. Performance also considers factors that cause the production process not to comply with the maximum speed that has been determined. To find value performance can use as follows:

$$PE = \frac{\text{Total good process } x \text{ ideal cycle time}}{Production\ time}\ x\ 100\% \quad (2)$$

Where total good process is the number of products produced well and in accordance with standards. Ideal cycle time is the ideal time needed to process a product [13].

**Quality.** Quality is a ratio that describes the machine's ability to produce products in accordance with existing standards rate of quality also provides a comparison of products that comply with predetermined product quality specifications against the quantity that has been processed by subtracting the quantity of products disabled[7]. To find the value of quality you can use the following formula:

$$PE = \frac{\text{Total good process}}{Total\ actual\ production}\ x\ 100\% \quad (3)$$

Where total actual production is the total amount of production produced in a certain time [15].

Calculation Overall Equipment Effectiveness (OEE) obtained by multiplying the 3 main com- ponents, this is done with the aim of knowing the effectiveness of machine use[8]. To find the OEE value, you can use equations (1), (2) and (3) as follows:

$$OEE\ \%\text{=Availability } \%x \text{ Performance Rate } \%\ x \text{ Quality Rate } (\%) \quad (4)$$

# 3 Result and Discussion

## 3.1 Data Collection

The data taken on the 3D printing machine is Production time, Operating time, Downtime production, Cycle time, Total actual production and Total good production of 3D printing machines are in accordance with Table 2 and Table 3.

**Table 2.** Production data for 3D printing machines

| Day | Production Time (min.) | Operation Time (min.) | Downtime (min.) | Cycle time (min.) |
|---|---|---|---|---|
| 1 | 1440 | 1260 | 180 | 60 |
| 2 | 1440 | 1080 | 240 | 51,40 |
| 3 | 1440 | 1020 | 360 | 60 |
| 4 | 1440 | 1260 | - | 55,03 |
| 5 | 1440 | 960 | 300 | 59,10 |
| 6 | 1140 | 660 | 480 | 43,32 |
| 7 | 1440 | 1260 | 120 | 60 |
| 8 | 1440 | 1200 | 120 | 59,13 |
| 9 | 1440 | 1080 | 300 | 60 |
| 10 | 1440 | 1260 | 180 | 60 |
| 11 | 1440 | 1140 | 240 | 60 |
| 12 | 1440 | 1260 | 180 | 60 |
| 13 | 1440 | 960 | 300 | 56,74 |
| 14 | 1440 | 1260 | 180 | 60 |
| 15 | 1230 | 840 | 390 | 50,41 |
| 16 | 1440 | 900 | 360 | 50,91 |
| 17 | 1440 | 1260 | 180 | 60 |
| 18 | 1440 | 1260 | 180 | 60 |
| 19 | 1440 | 780 | 540 | 65,06 |
| 20 | 1440 | 1260 | 180 | 60 |

**Table 3.** Production data for 3D printing machines

| Day | Total Production Actual (g) | Total Good Production (g) |
|---|---|---|
| 1 | 21,00 | 19,15 |
| 2 | 21,00 | 18,80 |
| 3 | 21,00 | 19,21 |
| 4 | 21,00 | 19,32 |
| 5 | 21,00 | 19,00 |
| 6 | 15,23 | 12,89 |
| 7 | 21,00 | 19,02 |
| 8 | 21,00 | 19,11 |

| | | |
|---|---|---|
| 9 | 21,00 | 18,76 |
| 10 | 21,00 | 18,67 |
| 11 | 21,00 | 18,88 |
| 12 | 21,00 | 18,94 |
| 13 | 21,00 | 19,95 |
| 14 | 21,00 | 19,10 |
| 15 | 16,66 | 15,07 |
| 16 | 21,00 | 19,00 |
| 17 | 21,00 | 19,10 |
| 18 | 21,00 | 19,03 |
| 19 | 21,00 | 18,99 |
| 20 | 21,00 | 18,98 |

Table 2 and Table 3 show the data on the values production time where the value of 1440 minutes is the machine value that has been determined per day. The difference in value production time only located on day 15, namely 1230 minutes which is caused by value downtime which is high due to improvements in the engine. For value operating time, downtime, ideal cycle time and total actual production for each value remains the same for operating time of 1260 minutes, downtime of 180 minutes, ideal cycle time of 60 minutes and value total actual production of 21.00 grams, this value is the standard that has been determined. The difference in value occurred on day 6 and day 15 which was caused by machine repairs because it occurred reject suddenly during production. and value on total good process from day 1 to day 20 is different because total good production according to the standards every day is different.

### 3.2 Data Processing

**Availability.** Availability rate used to determine the OEE value by paying attention to the total time of damage caused by unscheduled downtime, setup and adjustment, and other damage[9]. Equation used to measure availability using, equation 1, get the following values:

$$availability\ day\ 1 = \frac{1260}{1440}\ x\ 100\% = 87{,}5\% \quad (5)$$

**Table 4.** Data Availability

| Day | Production Time (min.) | Operation Time (min.) | Avaibility (%) |
|---|---|---|---|
| 1 | 1440 | 1260 | 87,50 % |
| 2 | 1440 | 1080 | 75,00 % |
| 3 | 1440 | 1020 | 70,83 % |
| 4 | 1440 | 1260 | 87,50 % |
| 5 | 1440 | 960 | 66,67 % |
| 6 | 1140 | 660 | 57,89 % |

| | | | |
|---|---|---|---|
| 7 | 1440 | 1260 | 87,50 % |
| 8 | 1440 | 1200 | 83,33 % |
| 9 | 1440 | 1080 | 75,00 % |
| 10 | 1440 | 1260 | 87,50 % |
| 11 | 1440 | 1140 | 79,16 % |
| 12 | 1440 | 1260 | 87,50 % |
| 13 | 1440 | 1260 | 66,67 % |
| 14 | 1440 | 1260 | 87,50 % |
| 15 | 1230 | 840 | 68,29 % |
| 16 | 1440 | 900 | 62,5 % |
| 17 | 1440 | 1260 | 87,50 % |
| 18 | 1440 | 1260 | 87,50 % |
| 19 | 1440 | 780 | 54,16 % |
| 20 | 1440 | 1260 | 87,50 % |
| **Average** | | | **80,72%** |

Tabel 4 shows the results of the value calculation availability October 2023, in the data above it can be seen that the value availability per day is quite good. There are 2 days with value availability the lowest was the 6th day at 57.89% and the 19th day at 54.16%. average value availability October 2023 amounting to 80.72%, with this figure not yet meeting the standard value availability itself, which is >90% according to Table 1.

**Performance.** Performance rate is an indicator that describes how well and efficiently a machine can produce products within a certain time span. measure the performance of machines or equipment in carrying out the production process by considering their productivity within a predetermined time period by considering how efficient the machine is in producing the expected output within a predetermined time limit[10]. The equation used to measure the performance rate value can use equation 2 with the value as follows **:**

$$performance\ day\ 1 = \frac{(19{,}15\ x\ 60)}{1440}\ x\ 100\% = 79{,}79\% \quad (6)$$

**Table 5.** Data Performance

| Day | Production Time (min.) | Cycle Time (min.) | Total Good Process (g) | Performance (%) |
|---|---|---|---|---|
| 1 | 1440 | 1260 | 87,50 % | 79,79% |
| 2 | 1440 | 1080 | 75,00 % | 67,10 % |
| 3 | 1440 | 1020 | 70,83 % | 80,04 % |
| 4 | 1440 | 1260 | 87,50 % | 73,83 % |
| 5 | 1440 | 960 | 66,67 % | 77,97 % |
| 6 | 1140 | 660 | 57,89 % | 48,98 % |

| | | | | |
|---|---|---|---|---|
| 7 | 1440 | 1260 | 87,50 % | 79,25 % |
| 8 | 1440 | 1200 | 83,33 % | 78,47 % |
| 9 | 1440 | 1080 | 75,00 % | 78,16 % |
| 10 | 1440 | 1260 | 87,50 % | 77,79 % |
| 11 | 1440 | 1140 | 79,16 % | 78,66 % |
| 12 | 1440 | 1260 | 87,50 % | 78,91 % |
| 13 | 1440 | 1260 | 66,67 % | 78,60 % |
| 14 | 1440 | 1260 | 87,50 % | 79,58 % |
| 15 | 1230 | 840 | 68,29 % | 61,76 % |
| 16 | 1440 | 900 | 62,5 % | 67,17 % |
| 17 | 1440 | 1260 | 87,50 % | 79,58 % |
| 18 | 1440 | 1260 | 87,50 % | 79,29 % |
| 19 | 1440 | 780 | 54,16 % | 85,79 % |
| 20 | 1440 | 1260 | 87,50 % | 79,08 % |
| **Average** | | | | **78,83%** |

The highest occurred on the 19th day with value performance namely 85.79%. This value occurs because the machine speed is in accordance with the target and runs stably without decreasing speed, thereby causing the maximum operating time and output values. The same height. Average performance in October 2023 it was 78.83%, this value is very far from the standard, namely >95%.

**Quality.** Quality rate is an indicator that reflects the level of success of a machine or production line in creating products according to predetermined standards. Through this measurement, monitoring can be carried out on the extent to which the machine or production line meets the desired quality standards. This makes it possible to carry out necessary corrective or adjustment action to improve the quality of the products produced measure quality[11]. The ratio can use equation 3 with the following values:

$$Quality\ day\ 1 = \frac{19{,}15}{21{,}00}\ x\ 100\% = 91{,}19\% \tag{7}$$

**Table 6.** Data Quality

| Day | Total Actual Production (g) | Total Good Process (g) | Quality (%) |
|---|---|---|---|
| 1 | 21,00 | 19,15 | 91,19 % |
| 2 | 21,00 | 18,80 | 89,52 % |
| 3 | 21,00 | 19,21 | 91,47 % |
| 4 | 21,00 | 19,32 | 92,00 % |
| 5 | 21,00 | 19,00 | 90,47 % |
| 6 | 15,23 | 12,89 | 84,63 % |
| 7 | 21,00 | 19,02 | 90,57 % |
| 8 | 21,00 | 19,11 | 91,00 % |

| | | | |
|---|---|---|---|
| 9 | 21,00 | 18,76 | 89,33 % |
| 10 | 21,00 | 18,67 | 88,90 % |
| 11 | 21,00 | 18,88 | 89,90 % |
| 12 | 21,00 | 18,94 | 90,19 % |
| 13 | 21,00 | 19,95 | 95,00 % |
| 14 | 21,00 | 19,10 | 90,95 % |
| 15 | 16,66 | 15,07 | 90,45 % |
| 16 | 21,00 | 19,00 | 90,47 % |
| 17 | 21,00 | 19,10 | 90,95 % |
| 18 | 21,00 | 19,03 | 90,61 % |
| 19 | 21,00 | 18,99 | 90,42 % |
| 20 | 21,00 | 18,98 | 90,38 % |
| **Average** | | | **90,11%** |

From the table above, the average value can be seen Quality rate namely 97.59%. Mark Quality rate the highest was on the 13th day, namely 99.00%, this value has not yet reached the international standard, namely <99%. Then the lowest value occurred on day 6 at 84.63%. So the value can be concluded quality rate many of the products produced do not yet meet the standards but have value quality rate in October 2023 shows consistent values. Values that have not reached the standard are caused by too many rejects or vials that do not comply with the standard quality control, many products.

**Overall Equipment Effectiveness (OEE).** Overall Equipment Effectiveness (OEE)is a method used to assess comprehensively how effective is the use of machines in a production environment with a focus on reducing the six main causes of loss (six big losses). OEE is a value calculated to evaluate and measure the performance of machines and equipment in an operation. By analyzing the OEE value, it can be understood how the machine works and identify areas for improvement or improvements can be made to increase overall efficiency and productivity[12]. The calculation is done by multiplying the values availability, mark performance, and mark quality according to equation 4 with the value as

$$OEE\ day\ 1 = 87{,}50\%\ x\ 79{,}79\%\ x\ 91{,}19\% = 63{,}66\% \quad (8)$$

**Table 7.** Data OEE

| Day | Avaibility (%) | Performance (%) | Quality (%) | OEE (%) |
|---|---|---|---|---|
| 1 | 87,50 % | 79,79% | 91,19 % | 63,66% |
| 2 | 75,00 % | 67,10 % | 89,52 % | 45,05% |
| 3 | 70,83 % | 80,04 % | 91,47 % | 51,85% |
| 4 | 87,50 % | 73,83 % | 92,00 % | 59,85% |
| 5 | 66,67 % | 77,97 % | 90,47 % | 47,02% |
| 6 | 57,89 % | 48,98 % | 84,63 % | 23,99% |
| 7 | 87,50 % | 79,25 % | 90,57 % | 62,80% |
| 8 | 83,33 % | 78,47 % | 91,00 % | 59,50% |

| | | | | |
|---|---|---|---|---|
| 9 | 75,00 % | 78,16 % | 89,33 % | 52,36% |
| 10 | 87,50 % | 77,79 % | 88,90 % | 60,51% |
| 11 | 79,16 % | 78,66 % | 89,90 % | 55,97% |
| 12 | 87,50 % | 78,91 % | 90,19 % | 62,27% |
| 13 | 66,67 % | 78,60 % | 95,00 % | 47,44% |
| 14 | 87,50 % | 79,58 % | 90,95 % | 63,33% |
| 15 | 68,29 % | 61,76 % | 90,45 % | 38,14% |
| 16 | 62,5 % | 67,17 % | 90,47 % | 34,58% |
| 17 | 87,50 % | 79,58 % | 90,95 % | 62,93% |
| 18 | 87,50 % | 79,29 % | 90,61 % | 62.86% |
| 19 | 54,16 % | 85,79 % | 90,42 % | 42,01% |
| 20 | 87,50 % | 79,08 % | 90,38 % | 62,53% |
| **Average** | 80,72% | 78,83% | 90,11% | 52,93% |

Based on Table 1, the standard OEE value is <85%. It can be seen in Table 7 that the OEE value in October 2023 does not meet international standards. The average OEE value is 52.93% which is still far from the international standard value according to Table 1. The highest value occurred on day 1 at 63.66%. The lowest value occurred on day 6, namely 23.99%. This is due to value performance Rate because a lot happens downtime.

### 3.3 Analysis of OEE calculations (Overall Equipment Effectiveness)

Available for machine or equipment operation activities. Based on the results of data processing, the average value can be seenavailability3D Print machine on October 2023 is 80.72%, in table 4 it can be seen that these results indicate that the use of time available for operational activities is still insufficient, because it does not meet the standard value availability according to the Japan Institute of Plant Maintenance, namely 90.0%[13]. High and low values availability This is because the amount of pro- duction time available each month is not the same because there are holidays (big days) which cannot be avoided. Apart from that, there are factors that influence the high and low values availability are activities/activities that should be carried out outside the production schedule but are carried out within the production activity schedule, so that this can hinder the production process and result in downtime.

Average value performance machine amounting to 78.83%. This value shows that the machine's ability to produce goods or products is quite low, because it does not meet the value standards performance according to the Japan Institute of Plant Maintenance, namely 95.0%. The results obtained are much different from the standards set by JIPM. Mark performance the lowest was on day 6 at 48.98%. Mark performance This very low value is due to the very large difference in values between actual production capacity with cycle time[5], [14]

Quality a ratio that shows good quality units produced as a percentage of total units produced. Based on the calculation results quality It can be seen in table 6 that the average value quality in October it was 90.11%[18]. This value shows that the total good quality products produced by the machine are very good, even though they do not

meet the world class benchmark standard recommended by JIMP, namely 99.9%. High and low values quality Every month it is influenced by defective products and good quality products produced[15]. The greater the number of good products produced, the higher the value quality that month. Vice versa, the smaller the number of good products produced, the lower the value quality that month.

Based on the OEE calculation results, it can be seen in table 7 that the average OEE value in October was 52.93%. These results cannot meet the world class benchmark standards recommended by JIMP, namely 85%. The lowest OEE value was on day 6, namely 23.99%,therefore improvement was necessary[16]. A low OEE value will result in significant economic losses and very low company competitiveness. Among the values *availability, performance and quality* which forms the OEE.

## 4 Conclusion and Future Work

Based on the results of calculations and analysis of OEE on 3D Print machines during October 2023 in Table 7, the average overall equipment failure (OEE) value is around 60.78%. This shows that the effectiveness of the 3D Print machine in the production process or achieving targets is still not in ideal conditions, namely more than 85%. So there are several improvements to reduce damage, namely:

a. Provide training and training regarding SOPs for machine use and maintenance as a basis for correct machine operation so that operators know that if there is a problem or the machine is not running correctly[17].
b. Create a schedule and directions for cleanliness in the work area by implementing the 5Rs both before and after work, to create comfortable conditions while working.
c. Provide maintenance SOPs in accordance with manual book which has been determined by the section maintenance or technician[18].
d. Carrying out the program total preventive maintenance by scheduling routine maintenance on the machine, carrying out repairs quickly if a machine experiences problems break down and must have reserves of components that are considered important and vital [19].

**Acknowledgments.** This research is one of the outputs of the project-based learning and the student's final project in the Robotics Engineering Technology Study Program, Department of Electrical Engineering, Politeknik Negeri Batam. We thank the Politeknik Negeri Batam and Barelang Robotics and Artificial Intelligence Lab (BRAIL) for providing facilities and equipment resources to support research.

## References

1. G. Primula and M. I. Hamdy, “Evaluasi Efektivitas Mesin Ripple Mill Melalui Pendeka- tan Overall Equipment Effectiveness (OEE),” *Jurnal Teknologi dan Manajemen Indus- tri Terapan (JTMIT)*, vol. 2, no. 4, pp. 301–309, 2023.

2. M. Syahlul Choluq, "ANALISIS NILAI OEE DAN FMEA SEBAGAI DASAR PERAWATAN MESIN FINE DRAWING 24 B PT. ABC," 2022.
3. D. Astrie Anggraini, Mh. Priyadi, and M. Riau Jl Tuanku Tambusai Ujung Pekanbaru, "Analisis Efektivitas Kinerja Mesin Asphalt Mixing Plant dengan Metode Overall Ef- fectiveness Equipment," *December*, vol. 10, no. 2, pp. 779–787.
4. S. Mustika Ayuningtyas, D. Herwanto, S. P. Khan, Z. I. Vindari, A. G. Azzahra, and W. Rohmah, "Analisa Penerapan Total Productive Maintenance Menggunakan Metode Overall Equipment Effectiveness pada Mesin Press Sinohara 55 T di PT. Ciptaunggul Karya Abadi," vol. VIII, no. 1, 2023.
5. J. Ilmiah and M. Bisnis, "Winarto dan Ediyanto: Analisis Perhitungan Nilai Overall Equipment Effectiveness…," 2019.
6. T Budi Agung, Miftahul Imtihan, and Suwaryo Nugroho, "USULAN PERBAIKAN MELALUI PENERAPAN TOTAL PRODUCTIVE MAINTENANCE DENGAN METODE OEE PADA MESIN TWIN SCREW EXTRUDER PVC DI PT. XYZ," *TEKNOSAINS : Jurnal Sains, Teknologi dan Informatika*, vol. 8, no. 1, pp. 10–22, Jan. 2021, doi: 10.37373/tekno.v8i1.78.
7. A. Haradito, I. Sabarisman, and S. B. Anoraga, "ANALISIS EFEKTIVITAS MESIN PADA DIVISI PENGALENGAN JAMUR DI PT XYZ MENGGUNAKAN METODE OVERALL EQUIPMENT EFFECTIVENESS."
8. "ANALISA EFEKTIFITAS MATERIAL HANDLING MESIN AUTOMATED."
9. Y. Wijaya, L. P. S. Hartanti, and J. Mulyono, "Pengukuran Kinerja Mesin Cetak Menggunakan Metode Overall Equipment Effectiveness Untuk Mengurangi Six Big Losses," *Jurnal Tekno Insentif*, vol. 16, no. 1, pp. 38–53, Apr. 2022, doi: 10.36787/jti.v16i1.578.
10. R. Nurcahyo *et al.*, "ANALISIS KUALITAS KINERJA MESIN WRAPPING PADA INDUSTRI PANGAN DENGAN METODE OVERALL EQUIPMENT EFFECTIVENESS (OEE) : STUDI KASUS DI INDUSTRI MAKANAN RINGAN Performance Quality Analysis of Wrapping Machine In The Food Industry Using Over- all Equipment Effectiveness (OEE) Methods : Case Study In A Snack Food Industry."
11. D. Dafa Ashari *et al.*, "ANALISIS KINERJA MESIN AMG CNC PLATE CUTTING MENGGUNAKAN METODE OEE (OVERALL EQUIPMENT EFFECTIVENESS)," vol. 15, no. 2, 2022.
12. D. Priyanto and R. T. Suhada, "Analisis Pengukuran Nilai Overall Equipment Effec- tiveness (OEE) Pada Mesin Rice Milling Unit (RMU) di PT. FSTJ," *Agustus*, vol. XVII, no. 2, pp. 209–222.
13. M. J. Syaputra, "ANALISA KINERJA MESIN KEMAS PRIMER, DENGAN METODE OVERALL EQUIPMENT EFFECTIVENESS (OEE) DI SEBUAH INDUSTRI FARMASI," 2020.
14. Hermanto, "ANALISIS KINERJA MESIN GF FSSZ 65/132 B DENGAN METODE OVERALL EQUIPMENT EFFECTIVENESS (OEE) DI PT PRN," *Journal Industrial Manufacturing*, vol. 3, no. 2, pp. 15–22, 2018.
15. "516-1-1495-1-10-20240315".
16. J. Bayesian *et al.*, "ANALISIS PRODUKTIVITAS MESIN FILLING KRIM PADA PT. XYZ DENGAN MENGGUNAKAN METODE OVERALL EQUIPMENT EFFECTIVENESS", doi: 10.46306/bay.v2i1.
17. O. T. Ahdiyat and Y. A. Nugroho, nal.com/index.php/JCI ANALISIS KINERJA MESIN BANDSAW MENGGUNAKAN METODE OVERALL EQUIPMENT EFFECTIVENESS (OEE) dan SIX BIG LOSSES PADA PT QUARTINDO SEJATI FURNITAMA," 2022. [Online]. Available: http://bajangjournal.com/index.php/JCI

18. A. Wahid, M. Munir, A. Misbah, and A. Pusakaningwati, “MENGUKUR EFEKTIFITAS MESIN CHENYUEH MENGGUNAKAN OVERALL EQUIPMENT EFFECTIVENESS (OEE) DAN SIX BIG LOSSES Pada CV. ABI Surabaya.”
19. G. P. Susanto and A. Profita, “Analisis Kinerja Mesin Rotary dengan Menggunakan Metode Overall Equipment Effectiveness (OEE) (Studi Kasus : PT. XYZ),” vol. 1, no. 2, 2023. Author, F.: Article title. Journal **2**(5), 99–110 (2016)