Advance Sustainable Science, Engineering and Technology (ASSET) ISSN:2715-4211
DOI:https://doi.org/10.26877/asset.v2i2.6xxx

Analysis of the Effectiveness of Automatic Lathes Using the OEE and FMEA Methods

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Abstract. UD AMJ Jaya Teknik is a manufacturing company that produces various kinds of construction products and spare parts, one of which is boshing products made using an automatic lathe. This research aims to identify the performance of automatic lathe machines to measure the productivity of automatic lathe machines using Overall Equipment Effectiveness and using the Failure Mode and Effect Analysis method. Based on the advantages of OEE, further analysis is carried out to calculate the six big losses. The results obtained from the OEE calculation of 68.22%, this value does not meet the standard ideal OEE value of 85.00%. Meanwhile, the results of the six big loss calculations obtained large values and influenced the effectiveness of the lathe to be minimized, namely process defect loss, reduce speed loss, idling and minor stoppages, and setup and adjustment loss. For the results of the FMEA analysis, the largest RPN value was obtained, namely 336 for the Man factor, with the failure mode that occurred being workers who lacked focus and lack of experience. From the research results of the above calculations, it can be seen that the effectiveness of the UD AMJ Jaya Teknik workshop still needs to be improved, where UD AMJ Jaya Teknik can find out and take corrective action in aspects of machine maintenance and workforce awareness.

Keywords: OEE, FMEA, Engine Performance, Six Big Losses, Lathe

1. Introduction

In the current era of global competition in industry 4.0, technological developments are progressing very rapidly, especially in the manufacturing sector. Where the use of technology is something that is inevitable, seen from the many activities carried out conventionally that have shifted to automation with the use of machines or tools that provide effectiveness and efficiency in an activity thereby increasing productivity[1]. Due to the widespread use of machines, companies need to think about how to increase and carry out production activities smoothly[2]. The effectiveness of machines or equipment is one of the factors that must be considered and optimized so that the machine does not experience damage or problems which results in production activities stopping and the resulting product being defective. This can be prevented by thinking about ways to improve it in an effort to increase effectiveness so that productivity can be sustainable, one of which is by carrying out maintenance on machines or equipment.

In the future, it is possible that manufacturing technology will continue to develop, so that the manufacturing industry will be required to become a technology company.

UD Amj Jaya Teknik is a company engaged in the field of turning and manufacturing spare parts for factory machines which is currently developing. The company produces various products including: straight gears, oblique/helical gears, internal gears, boshings, worm gears, worm axles, filtering, pulleys, rolls, springs, knives and seals and chucks. This company produces various kinds of custom construction products (the company produces products according to customer requests). Based on the company's history in the last 3 months, boshing products have had the most demand for different diameters. In this way the production process will take place continuously. Production is carried out using an automatic lathe. In the boshing production process, several products experience defects caused by several factors, one of which is the machine factor. Among the causes of defects in boshing products are rusty grease, broken lathe blades, worn bearings, worn gearboxes, damaged lathe speed sensors and damaged lathe motors. Therefore, it is necessary to measure machine performance and evaluate in repairing or optimizing automatic lathe machines.

Based on the conditions described above, it is necessary to measure machine performance using the OEE (Overall Equipment Effectiveness) method. OEE is the value of the effectiveness of a machine/equipment[3]. In the OEE calculation there is an analysis of the six big losses to meet quality standards related to the OEE value. Six big losses are things that can cause losses due to inefficient use of machines or equipment such as Breakdown loss, Setup and Adjustment loss, Reduced Speed Loss, idling and minor stoppage loss, Process Defect Loss and Reduced Yield Loss[4]. After the effectiveness value is known, the machine performance will then be evaluated using the FMEA method[5]. FMEA (Failure Mode and Effects Analysis) is a method for knowing or observing the level of failure in a process which will later be analyzed so that failure can be properly anticipated.

2. Methods

The method used in this research is the OEE and FMEA method to calculate and evaluate machine performance to increase productivity at UD AMJ Jaya Teknik. This research uses data types including: ideal time data for automatic lathe machines, production results data, product damage data, details of machine working time (availability time), unplanned downtime data (production downtime data, maintenance downtime data) and planned downtime data (preventive maintenance data). Data collection in this research was carried out by observation and interviews. The data samples taken by researchers were the last 3 months March - May 2023, then data processing and analysis was carried out using Microsoft Excel, Microsoft Word and Visio software.

2.1. Overall Equipment Effectiveness (OEE)

It is a tool for measuring overall equipment performance that shows how effectively the equipment can do what it is supposed to do[6]. This method is also called the main part of the maintenance system which is widely used by several of the largest companies in Japan. Several improvements to increase the OEE percentage both in terms of available time (Availability), equipment usability (Performance), and quality (Quality)[7].The purpose of this method is to compare the performance lines across the company where it will show unimportant flows and be able to identify which machines have poor performance.[8]. The benefit of the OEE method is to identify productivity losses and increase OEE and Increase productivity[9].

To find the results of the OEE value, you can use 3 main ratios by calculating Availability, Performance and Quality Rate (journal) with the following formula:

$$\text{OEE (\%)} = \text{Availability X Performance X Quality Rate X } 100\% \quad [1]$$

Table 1.OEE Ideal Value Standard

OEE Factor	*OEE Procented*
Availability	90.00%
Performance Efficiency	95.00%
Rate Of Quality Products	99.00%

Overall Equipment Effectiveness (OEE)	85.00%

(Nakajima, 1988)

The following are the components of OEE:

A. *Availability*

It is a ratio to find out the actual or actual time available for machine operational activities compared to the predetermined time[11].

$$Availability = \frac{Operation\ Time}{Loading\ Time} X\ 100\% \quad [2]$$

*Loading time*is the available time (availability) per day or month minus the planned machine downtime. Operation time is the result of reducing loading time with machine downtime (non-operation time). So the mathematical formula is as follows:

- *Loading time* =Working hours — Planned downtime
- *Downtime = Breakdown time + Setup and Adjustment*
- *Operation time = Loading time – Downtime*production - Downtime Maintenance – setup and adjustment

B. *Performance Efficiency*

It is a ratio to show the quality of actual production output then multiplied by the ideal cycle time versus operation time[12].

$$Performance\text{Efficiency} = \frac{Processed\ Amount\ x\ Ideal\ Cycle\ time}{Operating\ Time} x\ 100\% \quad [3]$$

*Process amount*is the total amount of production while the ideal cycle time is the ideal cycle time required in a product process.

C. *Rate of Product Quality*

This is a ratio to see the level of machine ability to produce quality products according to specifications[13].

$$Rate\ Of\ Quality\ Product = \frac{Process\ Amount - Defect\ Process}{Process\ Amout} X\ 100\% \quad [4]$$

*Process defects*is the number of defective or failed products processed.

Six big losses

The definition of six big losses is as follows[14]:

Table 2. Six Big Losses

Six big losses	**Understanding**
Breakdown losses	Losses related to equipment failure or damage. Which results in time losses and guantity losses.
Setup and Adjustment of losses	Losses related to congestion that occur when there are changes to work systems such as during operation, changes in products and equipment.
Reduced Speed Loss	Losses related to actual operating speed which is lower than ideal operating speed.
idling and minor stoppage loss	Losses are related to small stoppages when the production process is interrupted by temporary damage or when the machine is idle.
Defect Loss Process	Time losses related to defects and process rework, financial losses related to reduced product quality, and loss of time needed to repair defective products to perfection. Which is caused by the malfunction of production equipment.

Advance Sustainable Science, Engineering and Technology (ASSET) ISSN:2715-4211
DOI:https://doi.org/10.26877/asset.v2i2.6xxx

Reduced Yield Loss	Material losses related to insufficient input of material weight and weight of quality products.

Breakdown losses=$\frac{\text{Total } Breakdown\ Time}{Loading\ Time}x100\%$[5]

Setup and adjustment loss =$\frac{Set\ up\ and\ adjustment\ Time}{Loading\ Time}x100\%$ [6]

Reduce Speed Loss=$\frac{\boldsymbol{Operation\ Time - (Ideal\ Cycle\ Time\ x\ Processed\ Amount)}}{\boldsymbol{Loading\ Time}}x100$[7]

Idling and minor stoppage loss=$\frac{\boldsymbol{Doentime\ \text{perpindahan}}}{\boldsymbol{Loading\ Time}}x100\%$ [8]

Defect Loss Process = $\frac{Ideal\ Cycle\ Time\ x\ Defect}{\boldsymbol{Loading\ Time}}x100\%$[9]

Reduce Yield Loss=$\frac{Ideal\ Cycle\ Time\ x\ Scrap}{Loading\ Time}x100\%$ [10]

2.2. Failure Mode and Effect Analysis (FMEA)

It is a method used to determine the level of failure in a process that can be analyzed so that failure can be properly anticipated.[15]RPN is used to determine the priority of a failure and has no value or meaning with the following formula:
RPN = S x O x D.[16]

3. Results and Discussion

Data collection

The data needed in this research relates to manual lathes. So the data collected for this research is manual lathe machine ideal time data, production results data, product damage data, machine working time details (availability time), unplanned downtime data (production downtime data, maintenance downtime data) and planned downtime data (preventive maintenance data). The automatic lathe machine data used in this research was taken for the last 3 months March – May 2023 and is presented in Tables 3 and 4 as follows:

Table 3.Data collection

Month	**Production target (Pcs)**	**Production/month (Pcs)**	***Unplanned downtime* (O'clock)**	***Planned downtime* (O'clock)**	**Product defects (Pcs)**	***Set up* (O'clock)**
March	155	98	3	0.25	19	1.25
April	109	72	2.5	0.25	11	0.83
May	113	61	2	0.16	9	1.67

Source: company data

Table 4.Data collection

Month	***Ideal cycle time* (O'clock)**	***Downtime***		***Availability time* (O'clock)**
		Production (Hours)	***Maintenance* (O'clock)**	
March	0.25	0.5	-	28
April	0.25	-	0.383	21
May	0.25	-	0.33	21

Source: company data

The results of this quantitative data are used in OEE analysis, the determination of which is based on

DOI:https://doi.org/10.26877/asset.v2i2.6xxx

in measuring three main ratios, including availability, performance efficiency, and rate of quality. Then proceed with qualitative data in FMEA analysis, the determination is based on severity, occurrence and detection. Then proceed with risk priority number analysis.

Data processing

The data collected for this research is data*ideal time*manual lathe machine, production results data, product damage data, detailed machine working time data (availability time), setup and adjustment data, unplanned downtime data (production downtime data, and maintenance downtime data) and planned downtime data (preventive maintenance data and data no delivery order). From this data, data processing is then carried out using calculations for each existing machine.

3.1 OEE calculation of automatic lathes

Overall Equipment Effectiveness (OEE) is a calculation and magnitude of the effectiveness of equipment. The steps for calculating the OEE value are:

3.1.1 Availability calculation

*Availability*is a ratio that describes the utilization of time available for machine or equipment operation activities [11]. After there is the necessary data using the formula in number [2], below is the calculation data*availability*automatic lathe.

Table 5.Availability value of automatic lathes for March – May 2023

Month	*Loading time* (O'clock)	*Operating time* (O'clock)	*Availability (%)*
March	27.75	26	93.69%
April	20.75	19.53	94.15%
May	20.84	18.84	90.40%
Average	23.11	21.45	92.74%

Example of calculation for March:

- *Loading time* =28 - 0.25 = 27.75
- *Operating time* =27.25 - 0.5 - 0 – 1.25 = 26
- $Availability = \frac{26}{27,75} X\ 100\% = 93,69\%$

DSee table 5. Each month's Availability Calculation has different results. The largest percentage value was in April with a value of 94.15% and the lowest percentage value was in May with a value of 90.40%. However, after calculating the overall average availability value of 92.74%, it already meets the ideal OEE availability standard value of 90.00% in table 1.

3.1.2 Calculation of performance efficiency

*Performance Efficiency*is a ratio to show the quality of actual production output then multiplied by the ideal cycle time versus operation time [12]. After there is the necessary data using the formula in number [3], below is the calculation data for the performance efficiency of an automatic lathe machine.

Table 6.Automatic lathe machine efficiency performance value for March – May 2023

Month	*Processed Amount* (Pcs)	*Ideal Cycle Time* (O'clock)	*Operation Time Availability*	Boshing Displacement	*Operating Time*	*Performance Efficiency* (%)

March	98	0.25	26	1.25	24.75	98.99%
April	72	0.25	19.53	0.83	18.7	96.25%
May	61	0.25	18.84	1.67	17,17	88.81%
Average	77	0.25	21.45	1.25	20,20	94.68%

Example of calculation for March:

- *Operating time* =26 - 1.25 = 24.75
- *Performance Efficiency* $\frac{98\ x\ 0,25}{24,75} x\ 100\% = 98,99\%$

DSee table 6. Each month's Performance Efficiency Calculation has different results. The largest percentage value was in March with a value of 98.99% and the lowest percentage value was in May with a value of 88.81%. After calculating the average performance efficiency value, the result was 94.68%. This value does not meet the ideal OEE performance efficiency value standard, namely 95.00% in table 1. With a deficiency of 0.32%.

3.1.3 Calculation of rate of quality

Rate of Quality Product is a ratio to see the level of machine ability to produce quality products according to specifications [13]. Once there is what is needed using formula number [4], below is the data for calculating the rate of quality for automatic lathe machines.

***Table*7.**Rate of quality for automatic lathes for March – May 2023

Month	*Processed Amount* (pcs)	*Defect Amound* (Pcs)	*Quality Rate* (%)
March	98	19	97.81%
April	72	11	71.85%
May	61	9	60.85%
Average	77	13	76.84%

Example of calculation for March:

- *Quality Rate*$=\frac{98-19}{98} X\ 100\% = 97,81\%$

Insee table 7. Each month's Rate of Quality calculation has different results. The highest percentage of scores was in March with a score of 97.81% and the lowest percentage of scores was in May with a score of 60.85%. After calculating the average rate of quality value, which is 76.84%, it does not meet the standard OEE ideal rate of quality value, namely 99.00% in table 1. With a deficiency of 22.16%.

3.1.4 Calculation of OEE value

After obtaining the availability, performance efficiency and quality rate of the manual lathe, the OEE value can be calculated to determine the effectiveness of the automatic lathe using formula number [1.]

***Table*8.**OEE value of automatic lathes for March – May 2023

Month	*Availability (%)*	*performance efficiency* (%)	*Quality Rate* (%)	OEE Value (%)
March	93.69%	98.99%	97.81%	90.71%
April	94.15%	96.25%	71.85%	65.11%
May	90.40%	88.81%	60.85%	48.85%
Average	92.74%	94.68%	76.84%	68.22%

Example of calculation for March:

- MarkOEE (%) =93.69% X98.99% X97.81% X 100% =90.71%

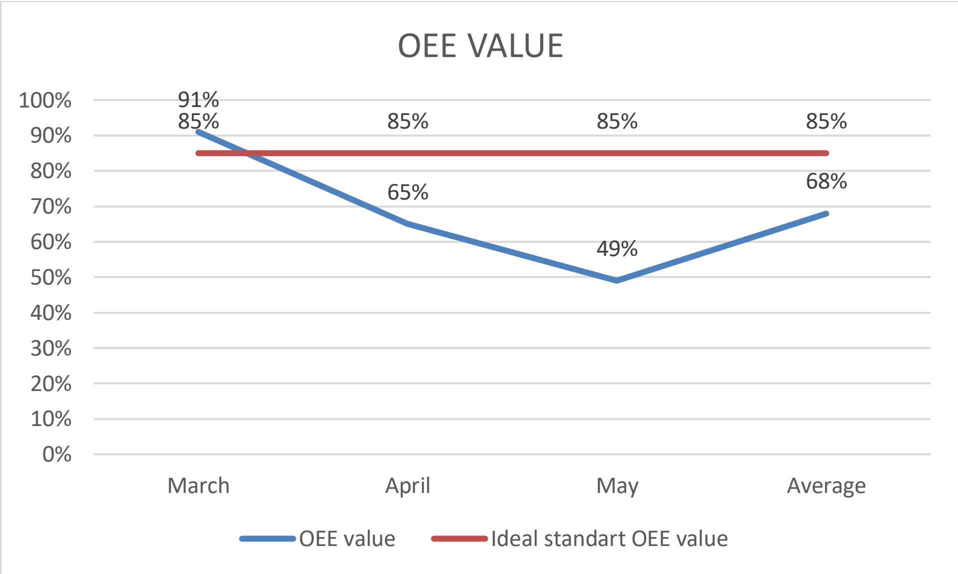

Figure 2. **OEE value**

Figure 1 above shows the results of different OEE values every month. The largest percentage value occurred in March at 90.71% and the lowest was in May at 48.85%. With an average OEE value of 68.22%, this value does not meet the ideal OEE value standard, namely 85.00% in table 1. With a deficiency of 16.78%. Meanwhile, if you look at the OEE value each month, only March does not need to be repaired

3.1.5 Calculation of the value of six big losses

From the comparison of the OEE value of manual lathe machines with the standard ideal OEE value, the company needs to take corrective action to increase the OEE value of the machine, therefore it is necessary to calculate the six big losses. From the data collection that has been carried out, there are five losses from the six big losses that occur on manual lathes, namely equipment failure (breakdown loss), setup and adjustment, idling and minor stoppages, reduced speed loss, and process defect loss.

***Table* 9.**Value of six big losses for automatic lathes for March – May 2023

Six big losses	***Percentage (%)***	***Cumulative percentage (%)***
Breakdown losses	1.74%	5.2%
Setup and Adjustment Losses	5.50%	16.4%
Reduce Speed Loss	7.07%	21.10%
Idling and Minor Stoppage Loss	5.50%	16.4%
Defect Loss Process	13.71%	40.90%
Reduce Yield Loss	0 %	0 %
Total	33.52%	100%

Seen in Table 9, the average percentage of the six big losses for 3 months. It can be concluded that there are 5 loss factors that influence machine performance, namely Process Defect Loss, Reduce Speed Loss, Idling and Minor Stoppage Loss, Setup and Adjustment Loss and Breakdown loss. The largest percentage in this calculation is Process Defect Loss of 40.90%, and the lowest is Breakdown loss of 5.2%. For the Reduce Yield Loss calculation, no symptoms were found on the automatic lathe. It can be concluded that based on the percentage for the Defect Loss Process category, more intensive maintenance is needed for automatic machines and to maintain raw materials to meet standards in order

DOI:https://doi.org/10.26877/asset.v2i2.6xxx

to produce a product according to the Company's wishes. For the next step, for a more detailed explanation, a Fishbone diagram was created to find out what factors caused the product to lose.

Fishbone diagram

*Fishbone diagram*is identifying multiple potential causes of a single effect or problem. After identifying the Losses of boshing products, it is determined that in this fishbone there are 5 main causal factors that influence quality, namely people, methods, machines, materials, environment. However, from the results of observations there are only 4 factors that cause losses. Below is a picture to see several factors of losses on automatic lathe machines.

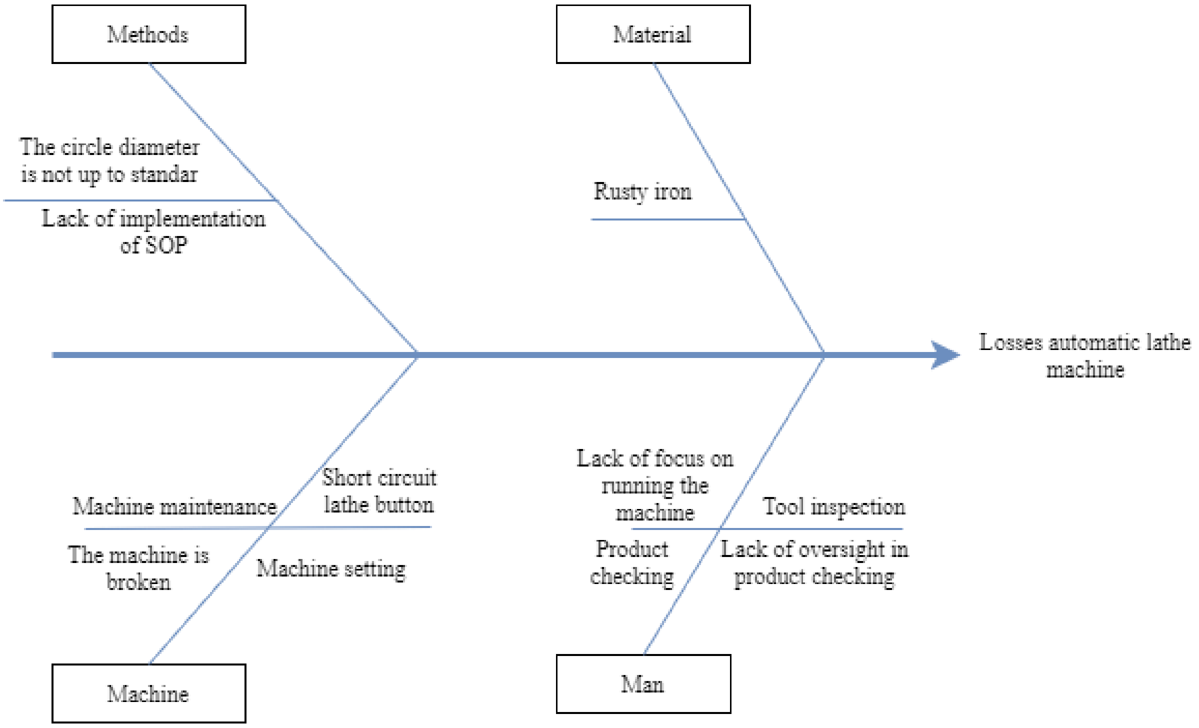

Figure 2. Cause and effect diagram of boshing defects on automatic lathe machines

From the diagram above, it can be concluded that product defects are divided into four parts, namely methods, materials, humans and machines. Next, an analysis of each factor will be carried out in the explanation in FMEA Analysis

FMEA analysis

FMEA has several components that were obtained when conducting field studies with interviews and the results of identifying defects in the boshing turning process using an automatic lathe obtained the following results:

1. Man Factor: There are some workers who lack focus in doing their work because they are sleepy when running the machine and have too much mental stress, workers do not have experience in running the machine due to lack of training.
2. Machine Factors: There are several defective products due to less than optimal machine performance due to lack of machine maintenance, damaged machines and errors in machine settings.
3. Material Factor: High rate of product failure due to errors or errors in the material ordering process from suppliers.
4. Methods Factor: There are several machines that experience problems or even damage due to a lack of updates to the SOPs implemented.

Table 10.Determination of SOD and RPN

Factor	**S (severity)**	**O (Occurrence)**	**D (detection)**	**RPN**	***RPN Percentage (%)***	***Cumulative percentage (%)***
Man	8	7	6	336	45.40%	45.4%
Machines	8	7	4	224	30.27%	75.67%
Material	5	4	6	120	16.21%	91.88%
Methods	4	5	3	60	8.10%	100%
Total				**740**	**100%**	**100%**

Seen in table 10, there is the highest RPN value for the man factor for the failure mode, namely workers who lack focus and do not have experience. With an RPN value of 336, while the lowest RPN value in the Methods factor for the failure mode is because the work does not comply with the SOP with an RPN value of 60. So for the solution that is implemented, it is hoped that workers will be more careful in carrying out their work and provide training so that workers are not careless.

4. Conclusion

Based on the calculations above, it can be concluded that the average value of availability within 3 months of an automatic lathe is 92.74%. Where it has met the ideal OEE standard value of 90.00%, while the average performance efficiency value has a value of 94.68% and the rate of quality has a value of 76.48%, where both values still do not meet the ideal standard value of 95.00% and 99.00% with deficiencies of 0.32% and 22.16% respectively. With the final result, the average Overall Equipment Effectiveness value for automatic lathes in 3 months was 68.22%, this value does not meet the ideal standard Overall Equipment Effectiveness value of 85.00% with a deficiency of 16.78%. Looking at table 9, it can be concluded that there are 4 loss factors that influence machine performance, namely Defect Loss Process, Reduce Speed Loss, Idling and Minor Stoppage Loss and Setup and Adjustment Loss. Therefore, it is necessary to improve so that machine performance increases by minimizing the value of losses and the causes of defects. From the results of the RPN calculation, it was obtained that the largest value was found in the Man factor with a value of 336 with the failure mode that occurred namely workers who lacked focus and lack of experience. From the research results of the above calculations, it can be seen that the effectiveness of the UD AMJ Jaya Teknik workshop still needs to be improved, where UD AMJ Jaya Teknik can find out and take corrective action in aspects of machine maintenance and workforce awareness.

This research still has shortcomings, because the object observed is only one product out of several products produced. In future research, it is hoped that the objects observed will have a wide coverage or the entire object, the number of production samples can be increased so that the research is more complete and accurate. Apart from that, you can also use other methods to add methods and references for further research

References

[1] H. Hidayat, M. Jufriyanto, and AW Rizqi, "Analysis of Overall Equipment Effectiveness (Oee) on Cnc Cutting Machines,"*Rotor*, vol. 13, no. 2, p. 61, 2020, doi: 10.19184/rotor.v13i2.20674.

[2] NH Ummah and SS Dahda, "Analysis of the Performance Effectiveness of Manual and Automatic Cutting Machines Using the OEE (Overall Equipment Effectiveness) Method at PT. XYZ,"*J. Tech. Ind. J. Has. Researcher. and Science Works. in Bid. Tech. Ind.*, vol. 8, no. 2, p. 345, 2022, doi: 10.24014/jti.v8i2.19765.

[3] H. Ariyah, "Application of the Overall Equipment Effectiveness (OEE) Method in Increasing the Efficiency of Batching Plant Machines (Case Study: PT. Lutvindo Wijaya Perkasa),"*J. Technol. And Manaj. Ind. Apply.*, vol. 1, no. 2, pp. 70–77, 2022.

[4] NR Nurwulan and DK Fikri, "Productivity Analysis using the OEE and Six Big Losses Method: Case Study in a Coal Mine,"*J. IKRA-ITH Econ.*, vol. 3, no. 3, pp. 30–35, 2020.

[5] Irsan, "Integration of Overall Equipment Effectiveness (Oee) and Failure Mode and Effect Analysis (Fmea) to Increase the Effectiveness of Hammer Mill Machines at Pt. Salix Bintama

Prima,"*J. Optim.*, vol. 4, no. 7, pp. 97–107, 2015, [Online]. Available: http://jurnal.utu.ac.id/joptimalisasi/article/view/1524/1220.
[6] H. Fauzi, J. Alhilman, and FTD Atmaji, "Analysis of the Application of Overall Equipment Effectiveness (Oee) and Overall Resource Effectiveness (Ore) in Evaluating the Effectiveness of Cnc Millac Machines at Pt Dirgantara Indonesia Analysis of Overall Equipment Effectiveness (Oee) and Overall Equipment Resource E,"*eProceedings Eng.*, vol. 8, no. 2, p. 2107, 2021.
[7] O. Rabiatussyifa, FN Azizah, and AD Ardhani, "Analysis of Buffing Machine Productivity Using the Overall Equipment Effectiveness (OEE) Method at PT. XYZ Cikarang, West Java,"*J. Ilm. Educator's Ride.*, vol. 8, no. 3, pp. 95–102, 2022, doi: 10.5281/zenodo.6301691.
[8] VI Lestari and JA Suryadi, "Analysis of Machine Effectiveness at Boiler Stations Using the Overall Equipment Effectiveness (Oee) Method at Pt. Xyz,"*Tekmapro J. Ind. Eng. Manag.*, vol. 16, no. 2, pp. 36–47, 2021, doi: 10.33005/tekmapro.v16i2.240.
[9] DF Rahmadhani, H. Taroeprajetka, and L. Fitria, "Proposal for Increasing the Effectiveness of Manual Printing Machines Using the Overall Equipment Effectiveness (OEE) Method (Case Study at the TTN Crackers Company),"*J. Online Inst. Technol. Nas.*, vol. 2, no. 4, pp. 156–165, 2014.
[10] S. Nakajima, "Introduction to TPM: Total Productive Maintenance.pdf,"*Productivity Press, Cambridge*. p. MA, 1988, doi: http://www.plant-maintenance.com/articles/tpm_intro.shtml.
[11] A. Wahid, "Application of Total Productive Maintenance (TPM) Production Using the Overall Equipment Effectiveness (OEE) Method in the Bottle Production Process (PT.*J. Technol. And Manaj. Ind.*, vol. 6, no. 1, pp. 12–16, 2020, doi: 10.36040/jtmi.v6i1.2624.
[12] K. Hafiz and E. Martianis, "Analysis of Overall Equipment Effectiveness (OEE) on Caterpillar Type 3512B Machines,"*SYNTEK JJ Ilm. Tech. Machine*, vol. 13, no. 2, p. 87, 2019, doi: 10.24853/sintek.13.2.87-96.
[13] A. Candra, F. Hendra, and R. Effendi, "Suggestions for Improving the Effectiveness of Rollforming Machines Using the Overall Equipment Effectiveness (OEE) Method,"*J. Sound Tech.*, vol. 13, no. 1, pp. 30–38, 2022.
[14] H. Adiyatna, "MEASUREMENT OF MOLDING MACHINE EFFECTIVENESS USING THE OVERALL EQUIPMENT EFFECTIVENESS (OEE) VALUE APPROACH AT PT XVIII, pp. 58–73, 2021.
[15] DA Kifta and T. Munzir, "Welding Defect Rate Analysis and Overcoming Using Six Sigma and Fmea Methods at Pt. Profab Indonesia,"*J. Dimensions.*, vol. 7, no. 1, pp. 162–174, 2018, doi: 10.33373/dms.v7i1.1676.
[16] N. Andri, "Quality Control of Steel Products Using Statistical Quality Control Methods(SQC) and Failure Mode Effect Analysis (FMEA) at PT XYZ," Fak. Tech., pp. 1–112, 2018.