Exhibition and Seminar on Science and Creative Technology, University of Al-Azhar Indonesia (EXSACT-A 2024) Proceeding

DOI: https://doi.org/10.36722/exc.v2i1.2340

Analysis of The Effectiveness of Casting Machine Using OEE Method and 5 *Whys Analysis*

Rydhoni[1*], Budi Aribowo[1], Nunung Nurhasanah[1].

[1]Industrial Engineering Study Program, Faculty of Science and Technology, University of Al-Azhar Indonesia, Jakarta Selatan, DKI Jakarta, Indonesia.

Corresponding author /E-mail: rydhonichndr@gmail.com

Abstract— **Casting machine is a production tool with the function of molding liquid aluminum into wheel rim products used at PT XYZ. In carrying out the production process, casting machines often experience failures that affect high machine downtime and also ineffective use of machines. The first purpose of this research is to run Total Productive Maintenance using OEE method to determine the value of their effectiveness. The second purpose is to use the 5 why's analysis method to find the root of the problem that affects the calculation of the OEE values, and find the relevant solution. Based on OEE calculations on the casting machine for the January-June 2022 period, the performance rate measurements in January and May were 89. 19% and 83.28% which were below the Nakajima standard of 82.17%. It was found that cause for the problem was human error. The operator made changes to the machine settings which increased the actual cycle time of machine operation before and causes therefore reduced speed losses.**

Keywords— *Casting machine, OEE, performance rate, 5 why's analysis, reduce speed losses*.

INTRODUCTION

The development of the industry in Indonesia is currently increasingly spreading to various regions, causing many business actors to be present in various industrial groups and resulting in high market competition. In the manufacturing industry, companies need to pay attention to many aspects to be able to meet the market with a variety of consumer behavior. From a consumer's point of view, the determining factors in the decision to choose a product are sufficient availability, easy to obtain and easy to reach [1]. Apart from the availability aspect, consumers will also pay attention to the product quality aspect as a consideration when making a purchase. Every company that sells products, the quality of the products produced will be one of the important factors that influence consumer assessments and even influence customer satisfaction [2].

If it is pulled far back in discussing a product, then the discussion will change to the production process to produce that product. The production process as one of the upstream processes in the manufacturing industry includes several aspects, namely human resources, machinery, capital, materials and methods. The production process is of course impossible to carry out if one of these aspects is missing, but the machine has an important role as the creator of a product. One of the factors supporting the success of the manufacturing industry is determined by the smooth production process. If the production process is smooth, the effective use of production equipment will produce quality products, on time, and at low costs [3].

The smoothness of production is related to the machines used to carry out the production process, healthy, well-maintained and well-calibrated machines will make machines produce quality products, and vice versa. Improper maintenance and handling of the machine can cause a decrease in the level of productivity and efficiency of the machine [3].

To have a machine that works effectively, it can be done with a variety of approaches and methods, one of which is the Total Productive Maintenance (TPM) approach. TPM is a continuous improvement that focuses on optimizing production effectiveness by identifying and eliminating things that are detrimental to production equipment and reducing the level of production efficiency throughout the production cycle by a team that is formed in a structured manner [4]. In the TPM approach, there are several methods that function as formulas for measuring machine effectiveness values and become standard machine effectiveness parameters. OEE is a method used to measure the implementation of the TPM program with the aim of keeping equipment in ideal condition and eliminating the six big losses [5].

In this study, the casting machine was used as a research object as one of the production machines used by PT XYZ based on the results of an analysis of the Company's machine maintenance data which showed that the machine downtime rate was higher than other production machines.

This research aims to calculate the effectiveness value of the casting machine that has been used in mass-production by the Company and carry out further analysis of the calculation results to find problems that cause high or low results in calculating the effectiveness value of using the machine.

METHOD

Overall Equipment Effectiveness

This research uses Total Productive Maintenance approach with the Overall Equipment Effectiveness calculation method to calculate the casting machine effectiveness value supported by machine usage data, machine maintenance data, and production data from January to June in 2022. The OEE calculation results will be observed and analyzed further continue to find the root causes of the calculation results below the international OEE standard using the 5 Why's Analysis method.

The OEE calculation includes three aspects, namely availability (A), performance rate (PR), and quality yield (QY) which can be calculated using the following formula. Materials and Methods should be described with sufficient details to allow others to replicate and build on the published results.

$$A = \frac{LT-UD}{L\,T} \times 100\% \qquad (1)$$

$$P = \frac{PP\ x\ ICT}{OT} \times 100\% \qquad (2)$$

$$Q = \frac{PP-PR}{PP} \times 100\% \qquad (3)$$

The calculation results of these three aspects will be part of the OEE calculation formula which can be calculated using the following formula

$$OEE = A(\%) \times P(\%) \times Q(\%) \qquad (4)$$

A =*Availability*

P =*Performance Rate*

Q =*Quality Yield*

To find out the value of the effectiveness of a machine used in the production process, there are parameters or international standards developed by the Japan Institute of Maintenance (JIPM) with the following values

Availability	≥ 90%
Performance Rate	≥ 95%
Quality Yield	≥ 99%
OEE	≥ 85%.

Six Big Losses

The Apart from OEE, there are six big losses which are also a form of further analysis to find out the type of losses experienced by the machine along with their magnitude. Six big losses consist of

1. Equipment Failure Losses
2. Setup and Adjustment Losses
3. Idle & Minor Stoppage Losses
4. Reduce Speed Losses
5. Process Defects
6. Reduce Yield

The calculation of six big losses can be done using six formulas, namely.

$$BD\ Losses = \frac{TD}{LT} \times 100\% \qquad (5)$$

$$S\&A\ Losses = \frac{S\&A\ Time}{LT} \times 100\% \qquad (6)$$

$$I\&M\ Stoppage\ Losses = \frac{NPT}{LT} \times 100\% \qquad (7)$$

$$RS\ Losses = \frac{OT-(ICT\ x\ PP)}{LT} \times 100\% \qquad (8)$$

$$PDF\ Losses = \frac{ICT\ x\ DF}{LT} \times 100\% \qquad (9)$$

$$RY\ Losses = \frac{ICT\ x\ R}{LT} \times 100\% \qquad (10)$$

5 Why;s Analysis

Method 5WHY (5W). It is a method that detects the causes of quality problems or failures by asking a few questions, "Why?" It allows to get to the root of the problem, thoroughly analyse the cause and focus on the efficient solving. By asking more questions, "Why?" problem becomes more understandable, so that can apply remedial measures to eliminate a particular non-compliance. The main advantages of this method are its efficiency and uncomplicated nature. The method can be used in every company.

However, it requires logical thinking and independent problem identification by the research team [6].

RESULT AND DISCUSSIONS

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn. Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.
Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections A-D below for more information on proofreading, spelling and grammar.

Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads-the template will do that for you.

Overall Equipment Effectiveness
To perform calculations on OEE, some data is needed relating to the history of use and maintenance of the machine for a certain period. The data required includes.

AT =*Available Time*
PD =*Planned Downtime*
LT =*Load Time*
UD =*Unplanned Downtime*
OT =*Operating Time*
PP =*Product Processed*
PR =*Product Reject*
ICT =*Ideal Cycle Time*
ACT =*Actual Cycle Time*

The following is supporting data for OEE calculations on casting machines at plant 11.

Table 1. Machine Maintenance & Usage History

Month	AT (minutes)	PD (minutes)
January	44640	3435
February	40320	4695
March	44640	3435
April	43200	6225
May	44640	4875
June	43200	1935
Semester 1	260640	24600

Table 2. Machine Maintenance & Usage History

Month	LT (minutes)	UP (minutes)	OT (minutes)
January	41205	330	40875
February	35625	285	35340
March	41205	190	41015
April	36975	0	36975
May	39765	490	39275
June	41265	30	41235
Semester 1	236040	1325	234715

Table 3. Machine Maintenance & Usage History

Month	PP (units)	PR (units)
January	24305	26
February	24536	13
March	26579	13
April	24747	25
May	21806	24
June	28373	37
Semester 1	150346	138

Table 4. Machine Maintenance & Usage History

Month	ICT (minutes)	ACT (minutes)
January	1.50	1.68
February	1.50	1.44
March	1.50	1.54
April	1.50	1.49
May	1.50	1.80
June	1.50	1.45
Semester 1	1.50	1.56

Based on these data, the results of calculating the availability, performance rate and quality yield of the casting machine at plant 11 for the January-June 2022 period are as follows.

Table 5. OEE Calculation

Month	A	P	Q
January	99.20%	89.19%	99.89%
February	99.20%	100.00%	99.95%
March	99.54%	97.20%	99.95%
April	100.00%	100.00%	99.90%
May	98.77%	83.28%	99.89%
June	99.93%	100.00%	99.87%
Semester 1	99.44%	96.08%	99.91%

In the calculation table, there are two calculations on performance rates in January and May that get color markings. The color marking indicates that the performance rate of the casting machine in those two months is below international standards. To get these results, the researcher carried out a calculation process using a formula that would be exemplified by one sample of A, P, and Q calculations in semester one. And here is the calculation process.

$$A = \frac{236040 - 1325}{236040} \times 100\%$$

$$A = 99{,}44\% \qquad (1)$$

$$P = \frac{150346\ x\ 1{,}56}{234715} \times 100\%$$

$$P = 96{,}08\% \qquad (2)$$

$$Q = \frac{150346 - 138}{150346} \times 100\%$$

$$Q = 99{,}91\% \qquad (3)$$

The A, P, and Q calculations will then become factors for calculating OEE. The following is the first semester OEE calculation as a sample of the casting machine OEE calculation process for the period January to June 2022.

$$OEE = 99{,}44\% \times 96{,}08\% \times 99{,}91\%$$

$$OEE = 95{,}46\% \qquad (4)$$

With the same calculation process and carried out every month from January to June 2022, the OEE values are as follows.

Table 6. OEE Calculation

Month	OEE
January	88.38%
February	99.15%
March	96.71%
April	99.90%
May	82.17%
June	99.80%
Semester 1	95.46%

Based on these data, it can be seen that the OEE calculation results in May were below standard, this was due to the performance rate calculation results which refer to table five.

After going through the calculation process, researchers identified losses manually. Idle & Minor Stoppage and Reduce Speed Losses are forms of losses which are part of the performance rate[6]. Therefore, if identified manually, the possible losses experienced by the casting machine in January and May are Idle & Minor Stoppage and Reduce Speed Losses.

To find out more about the losses experienced by the casting machine in January and May, the researchers decided to carry out a comparative calculation of the magnitude of the calculation results for the two losses.

Six Big Losses

Using formulas (7) and (8), the researcher calculated the six big losses for performance rate, namely Idle & Minor Stoppage and Reduce Speed Losses with the following calculation results.

$$I\&M\ Stoppage\ Losses = \frac{0}{236040} \times 100\%$$

$$I\&M\ Stoppage\ Losses = 0\% \qquad (7)$$

$$RS\ Losses = \frac{234715 - (1{,}50\ x\ 150484)}{236050} \times 100\%$$

$$RS\ Losses = 3{,}81\% \qquad (8)$$

The results of the six big losses calculation show that there is a speed reduction on the casting machine in January and May. The results of these calculations are also strengthened by manual analysis of the comparison of ideal cycle time and actual cycle time. The actual cycle time or actual cycle time used by casting machines to run production in January and May is quite far from the ideal cycle time or ideal cycle time which is the standard cycle time for machines with standard panel settings according to the machine manual. The comparison of ICT and ACT can be seen in table four.

5 Why's Analysis

After calculating OEE and carrying out six big losses analysis. The researcher carried out further analysis using the 5 why's analysis method which serves to explore the problem to find the root cause of the losses in the casting machine.

The analysis process using the 5 why's analysis method begins with determining the main question. The main question that has been set is "Why are the results of casting machine performance rate calculations in January and May low?"

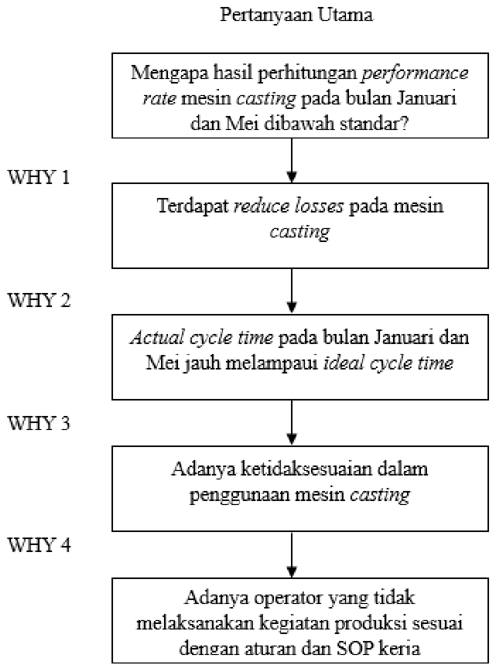

Figure 1. 5 Why's Analysis

Through analysis using the 5 why's analysis method as seen in figure one, the fundamental problem of the low performance rate calculation results in January and May which had an impact on not achieving international OEE standards in May was the manpower aspect. In the analysis process, researchers found that there were actions outside the authority and violating work rules by operators, such as changing casting machine settings via the panel. Therefore, the form of improvement that can be carried out by the Company regarding the operator's actions is by carrying out job training, monitoring work in the field more regularly, creating visual diagrams in the form of OPL which contain information regarding work standards and rules.

CONCLUSION

The conclusions derived from this study are as follows:

1. The OEE calculation results for overall semester coverage showed good results, they exceeded Nakajima standards. However, the results were unsatisfactory for some specific months, namely January and May. The low performance rate in January did not have an impact on OEE, but the low performance rate in May had an impact on the OEE calculation results which also did not reach the standard.

2. The results of the analysis and calculation of six big losses show that the type of losses in the performance rate aspect of the casting machine is reduced speed. This is also evidenced by the high actual machine cycle time in January and May.

3. The results of the analysis using the 5 why's analysis method shows that the root of the problem of low performance rate values is caused by operators who do not follow SOPs and work rules, resulting in casting machines experiencing reduced speed losses.

ACKNOWLEDGMENT

By producing this research, the researcher would like to express his deepest gratitude to.

1. PT XYZ for the opportunities given to me to conduct research in the company and act cooperative in the research process for sharing the company data dan discussing about research stuff.

2. Mr Budi Aribowo and Mrs Nunung provided guidance and direction in the process of making this research.

3. Mr. Edi Chandra and Mrs. Nurlen who always support researchers in carrying out research activities to writing research results in the form of theses and journals.

REFERENCES

[1] C. Eko, "Ketersediaan Produk Dan Harga Di Toko Sama Tani Terhadap Keputusan Pembelian Pupuk Bersubsidi (Studi Pada Petani Padi Sawah Desa Tonusu)," *Univ. Andalas*, vol. 10, no. 3, p. 1, 2014.

[2] T. Suhartati, "Pentingnya Kualitas Produk Dan Kepuasan Pelanggan Guna Mewujudkan Loyalitas Pelanggan Toast Story Di Kota Malang," □□□ □ □□, no. May, p. 106, 2013.

[3] N. C. Dewi and D. I. Rinawati, "Analisis Penerapan Total Productive Maintenance (TPM) Dengan Perhitungan Overall Equipment Efectiveness (OEE) Dan Six Big Losses Mesin Cavitec PT. Essentra Surabaya (Studi Kasus PT. Essentra)," *Ind. Eng. Online J.*, vol. 4, no. 4, 2016, [Online]. Available: https://ejournal3.undip.ac.id/index.php/ieoj/article/view/9868

[4] J. R. Díaz-Reza, J. L. García-Alcaraz, and V. Martínez-Loya, *Impact Analysis of Total Productive Maintenance*. Ciudad Juárez: Springer Nature Switzerland, 2019. doi: 10.1007/978-3-030-01725-5.

[5] F. Cahya and A. Pusakaningwati, "Usulan

Perbaikan terhadap Manajemen Perawatan dengan Menggunakan Metode Total Productive Maintenance (TPM) di PT. SNA MEDIKA,” 2018.

[6] S. T. Dziuba, M. A. Jarossová, and N. Gołębiecka, “Applying the 5 Why Method To Verification of Non-Compliance Causes Established Afterapplication of the Ishikawa Diagram,” *Prod. Eng. Arch.*, vol. 2/1, pp. 16–19, 2014, doi: 10.30657/pea.2014.02.05.