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Analysis of Air Shot Blasting Machine Effectiveness using Overall Equipment Effectiveness (OEE)

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Abstract. The effectiveness of a machine is one of the main factors for a production process to run smoothly so that it can meet its demand. Companies must always ensure that their production machines have high effectiveness. The shot blasting machine is one of the production machines used at PT. X. This machine has been in use for quite some time. Additionally, the machine often experiences breakdowns. This study was conducted to measure the effectiveness of the shot blasting machine at PT. X in order to determine its effectiveness. The overall equipment effectiveness (OEE) approach is used here to measure it. The OEE value is influenced by three factors, namely availability, performance, and quality. The result obtained is that the effectiveness of the machine is still quite high, with an OEE value of 81.82% and is still above the standard value for OEE, which is 85%. To enhance OEE, additional steps could involve documenting the issues as they arise, followed by generating a pareto chart to pinpoint the most common problems. This enables directing improvement endeavors towards addressing these significant challenges.

Keywords: Performance effectiveness, machine breakdown, the overall equipment effectiveness.

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1. Introduction

In an era that is developing rapidly where companies carry out production activities which are activities or processes that convert input into output. In a small interpretation of the production system, every running system requires input/data input [1]. In an information system, data consists of basic facts which are the main ingredients of the system [2]. The production process in a business is very important, and there are many things that must be considered [3]. Companies always pay attention to the stages of the production process, such as planning (checking raw materials, making designs and patterns), and making work schedules [4]. Companies need experts in the field of maintenance. To maintain machines, companies need to carry out maintenance, which is carried out for smooth running and safety [5]. The aim of this is to maintain the smooth use of production equipment/machines and equipment, installation safety, efficiency of several production units, extending the technical life of building machines and other equipment, to create the best possible working conditions while maintaining the condition of production activity facilities and their safety [6]. Another opinion states that maintenance aims to prevent machine damage, increase machine reliability and availability, and optimize the production process [7]. The benefits that will be obtained from good maintenance of the machine. Maintenance has a vital role in production because it is tasked with keeping machines working and to suppress failures as efficiently as possible in the production process [8]. To prevent defects caused by machines, this is by carrying out machine maintenance or servicing. This maintenance includes replacing damaged components, checking the condition of components, and general maintenance to maintain the performance and reliability of the machine [9]. Therefore, inspection is required, where inspection is an inspection activity using an observation method by checking to detect problems with certain objects and ensure that the object meets the specified requirements [10].

PT. X is a company operating in the Shipyard industry in Surabaya. PT. X possesses numerous large-scale machines characterized as aged, with some surpassing a decade in service. One of the most commonly used ones is the air shot blasting machine. The advanced age of these machines poses a challenge for the maintenance division, hindering effective upkeep efforts. These machines have endured issues such as overheating-induced damage to the driving engine, resulting in significant impairment to engine components. Additionally, recurrent electrical system malfunctions, primarily stemming from short circuits due to voltage spikes and subpar cable management, further compound maintenance woes [11]. To solve this problem, Overall Equipment Effectiveness (OEE) approach is used. OEE serves as a comprehensive metric for evaluating the efficiency and effectiveness of machine utilization, resource utilization, and time management within a production environment [12], [13]. Broadly, OEE assesses operational efficiency, aiding in the identification of areas for improvement in machine performance and production processes [14], [15]. This study aims to gauge the efficacy of shot blasting machines at PT. X, pinpointing factors contributing to inefficiency and offering maintenance strategies to enhance OEE. These strategies aim to optimize machine performance and streamline production processes within the company.

2. Method

2.1 Research Location and time

The research is conducted at a shipyard located in East Java, Indonesia. It commenced in November 2023 and will continue until a satisfactory amount of data is gathered.In this research, the dependent variable is the effectiveness level of the Shot Blasting machine. The independent variables are obtained through observational and interview methods. These variables include machine working time, machine downtime, breakdown frequency, machine setup time, machine stoppage time, processed quantity, and defect quantity.

2.2 Data collection

Primary data was gathered through observation directly within the production division of PT. X, focusing on the machining work and machine maintenance processes. Additionally, interviews were conducted with representatives Involving five expert teams, from the maintenance secretariat and blasting machine operators to supplement the data obtained. Secondary data collection involved acquiring existing company documents. Following data collection, processing ensued. The availability, performance, and quality values are calculated, and then the OEE value can be determined using equations 1-4.

$$Availability = \frac{loading\ time-(Breakdown+setup)}{Loading\ time} X\ 100\% \quad (1)$$

$$Performance = \frac{processed\ amount\ x\ ideal\ cycle\ time}{Oprating\ Time} \text{X } 100\% \quad (2)$$

$$Quality = \frac{processed\ amount - unit\ cacat}{processed\ amount} X\ 100\% \quad (3)$$

$$OEE = Availability\ x\ Performance\ x\ Quality \quad (4)$$

If the resulting OEE exceeds 85%, the next steps involve analysis and discussion. However, if it falls short of 85%. Then, the six major loss factors are investigated to determine the causes. Subsequently, the findings are discussed and conclusions are drawn.

2.3 Machine working time

The working time for the machines is based on the data provided by the company, where the standard working hours are 8 hours per day. If there is overtime, the machines will operate for a specified duration of overtime, with a maximum of 4 hours of overtime per regular workday and 7 hours on holidays.

Table 1. Data on working time for shot blasting machines in 2021

Month	Normal time (hours)	Overtime (hours)	Total hour)
January	160	16	176
February	160	0	160
March	160	4	164
April	160	4	164
May	160	0	160
June	160	16	176
July	160	0	160
August	160	4	164
September	160	8	168
October	160	0	160
November	160	16	176
December	160	16	176
Average	160	7.00	167.00

2.4 Planned Downtime

Planned downtime refers to scheduled time allocated within the production plan, including maintenance activities and other management-related tasks. This time is set aside for planned maintenance and management activities. Additionally, planned downtime may occur if there are indications of damage to machine components or the electrical system, requiring immediate attention and intervention.

Table 2. Planned Down time data for shot blasting machines in 2021

Month	Maintenance time (hours)
January	6
February	4.5
March	3.6
April	4
May	3.5
June	2.7
July	6.8
August	5.8
September	4.3
October	5.8
November	4.9
December	6
Average	4.83

2.5 Machine breakdown

Set up and adjustment refer to the time needed to prepare the operation for processing materials through various stages of the production process. This includes tasks such as configuring the machine settings, aligning components, and ensuring all necessary adjustments are made to accommodate the specific requirements of the production run.

Table 3. Machine breakdown data in 2021

Month	**Breakdown Time (hours)**
January	8.6
February	8.9
March	8.6
April	40
May	8.4
June	8
July	8.3
August	7.2
September	30
October	8.9
November	8.6
December	8
Average	12.79

2.6 Set up Time & Adjustment

Set up and adjustment refer to the time needed to prepare the operation for processing materials through various stages of the production process. This includes tasks such as configuring the machine settings, aligning components, and ensuring all necessary adjustments are made to accommodate the specific requirements of the production run.

Table 4. Data set up Time & Adjustment in 2021

Month	Set up **time** & Adjustment **(Hours)**
January	7
February	8.6
March	8
April	8.9
May	7.8
June	6.8
July	7.6
August	7
September	6.5
October	7
November	7.5
December	7
Average	7.48

2.8 Processed and defect amount

Processed amount refers to the quantity of products produced by the machine during a certain period of time. On the other hand, the defect amount represents the quantity of products that are deemed defective due to inadequacies in the production processes.

Table 5. Data processed and defect amount in 2021

Month	Processed amount	defect amount
January	956	7
February	958	5
March	970	10
April	970	15
May	957	11
June	958	23
July	956	16
August	970	9
September	988	5
October	956	9
November	1020	14
December	1020	10

2.7 Data processing

2.7.1 Availability

Availability is a metric that measures the ratio of the time a machine is operational to the total available time, taking into account various factors such as downtime and planned maintenance.

Table 6. Availability

Availability				
Month	**Loading time**	**Operating time**	**Downtime**	**Availability**
January	170	154.4	169.1	91%
February	155.5	138	154.6	89%
March	160.4	143.8	159.5	90%
April	160	111.1	159.3	69%
May	156.5	140.3	155.6	90%
June	173.3	158.5	172.4	91%
July	153.2	137.3	152.3	90%
August	158.2	144	157.3	91%
September	163.7	127.2	162.9	78%
October	154.2	138.3	153.3	90%
November	171.1	155	170.2	91%
December	170	155	169.1	91%
Average				87 %

2.8.2 Performance efficiency

Performance efficiency can be understood as a ratio that quantifies the number of products produced multiplied by the ideal cycle time, relative to the available time for conducting the production process, also known as the operating time.

Table 7. Performance efficiency

Performance efficiency				
Month	Processed amount	Operating Time	ICT	Performance efficiency
January	956	154.4	0.14	85%
February	958	138	0.14	95.09%
March	970	143.8	0.14	92.40%

April	970	111.1	0.14	119.59%
May	957	140.3	0.14	93.43%
June	958	158.5	0.14	82.79%
July	956	137.3	0.14	95.37%
August	970	144	0.14	92.27%
September	988	127.2	0.14	106%
October	956	138.3	0.14	94.68%
November	1020	155	0.14	90.14%
December	1020	155	0.14	90.14%
Average				95%

2.8.3 Rate of product quality

The product quality rate is a measure of the proportion of products that meet the predetermined standards for product qualification, indicating the percentage of good products in relation to the total produced.

Table 8. *Rate of product quality*

Month	Normal time (hours)	Overtime (hours)	Total hour)
January	956	7	99%
February	958	5	99%
March	970	10	99%
April	970	15	98%
May	957	11	99%
June	958	23	98%
July	956	16	98%
August	970	9	99%
September	988	5	99%
October	956	9	99%
November	1020	14	99%
December	1020	10	99%
Average			99%

3. Results and Discussion

The following Table 9 shows the results of overall equipment effectiveness measurement on the air shot blasting machine.

Table 9. Comparison PT.X OEE value with standard international

Factor	World Class Standard	Mark company
Availability	90.0%	87 .0%
Performance efficiency	95.0%	95.0%
Rate of product quality	99.0%	99.0%
Overall Equipment Effectiveness	85.0%	81.82%

The results of the OEE calculations for the shot blasting machine indicate a low level of effectiveness. These values are compared against international standards, particularly those set by the Japan Institute of Plant Maintenance (JIPM) [16]. According to JIPM standards, the minimum percentage value that a company needs to achieve for each factor is 85%, with specific targets for Availability set at 90%, Performance Efficiency at 95%, and Quality Rate at 99%, with the Availability value at 87% [17], [18]. The value is still below the world-class standard, which is 90%. Performance Efficiency at 95% that is equal to the world-class standard for that factor. Rate of Product Quality at 99% that is equal to the world-class standard for that factor [19]. The obtained OEE value is still below the JIPM standard, which is only 81.82. This indicates that the efficiency of the air shot blasting machine is not satisfactory and requires further improvement steps. Furthermore, to improve OEE, other measures that can be taken include: recording the occurring troubles, then creating a Pareto diagram to identify the most frequent troubles, allowing improvement efforts to focus on resolving these major issues [20]. In addition, approaches such as Lean Six Sigma and Total Productive Maintenance can also be used. Both approaches can effectively increase the OEE value of a machine.

4. Conclusion

The measurement of the machine's effectiveness using the Overall Equipment Effectiveness (OEE) approach at PT. X for the period of January to December 2021 yielded an OEE value of 82%. This value is composed of the factors in the OEE calculation: Availability at 87%, Performance Efficiency at 95%, and Rate of Product Quality at 99%. The OEE value calculated is only 81.82%, which is still below the JIPM standard of 85%. To enhance OEE, additional actions include documenting the issues that arise and creating a Pareto diagram to pinpoint the most common problems, enabling a targeted focus on addressing these major issues. Moreover, implementing approaches such as Lean Six Sigma and Total Productive Maintenance can also be effective. Both methods can significantly improve a machine's OEE value.

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