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Overall Equipment Effectiveness and Autonomous Maintenance Methods in Manufacturing Industry

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Abstract. The measurement of machine effectiveness using Overall Equipment Effectiveness (OEE) method can be used as a basis for evaluating the machine performance. The autonomous maintenance approach is used as the improvement framework to reduce breakdown and downtime through basic maintenance performed by operator to improve the effectiveness. Measuring machine effectiveness using OEE method can identify types of losses based on the six big losses and design improvement steps using Autonomous maintenance approach. The research results shows that the average OEE value of the 200TR press machine is 78.16%, indicating that it is still below the ideal standard. The largest loss contribution come from setup (8.75%) and adjustment losses (6.21%). The implementation of Autonomous Maintenance is proposed to increase the role of operator in basic machine maintenance, reducing breakdown frequency, and improve the machine effectiveness.

1 Introduction

Machines play a crucial role as the primary resources that support the continuity of production; therefore, the productivity and effectiveness of a good machine are needed in the production process. Machine productivity can be defined as the level of effectiveness of a machine in processing raw materials into products that have value and utility [1]. Efforts to increase production efficiency essentially reflect efforts to enhance productivity, which subsequently have an impact on increasing overall production output [2]. A maintenance management system that does not operate optimally can lead to increase machine downtime, reduced production capability, and have an impact on the quality of products produced [3]. Machines and equipment that are used must be maintained properly to ensure that productivity and effectiveness are consistently preserved [4].

Overall Equipment Effectiveness (OEE) is a metric used to calculate the level of equipment effectiveness in the production process by considering three main components: availability, performance, and quality [5]. The OEE method has the advantage of relatively simple calculation, although it requires a considerable amount of data. Through measuring the machine effectiveness using this method, the level of equipment effectiveness can be determined quantitatively, and the results can be used as a basis or reference for future improvement and enhancement of machine performance [6]. The implementation of the

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autonomous maintenance method is able to increase the OEE level of the machine, which indicates an improvement in the effectiveness and reliability of the machine after the implementation of the autonomous maintenance program [7, 8]. The OEE method aims to maintain the optimal condition of the equipment by eliminating the six big losses, while also being used to assess the overall effectiveness and performance of the production system [9].

2 Methodology

2.1 Overall Equipment Effectiveness (OEE)

The OEE value is obtained by multiplying availability, performance, and quality which collectively reflect how optimal the machine operates. OEE measurement aims to identify areas that need improvement, thereby enhancing the efficiency and effectiveness of equipment within the production system [10]. The OEE method is used to assess the machines or equipment's effectiveness level in the production process. The application of Total Productive Maintenance (TPM) principle can reduce machine downtime production speed losses, and defect loss, thereby enabling machine to operate optimally and maximizing production output [5].

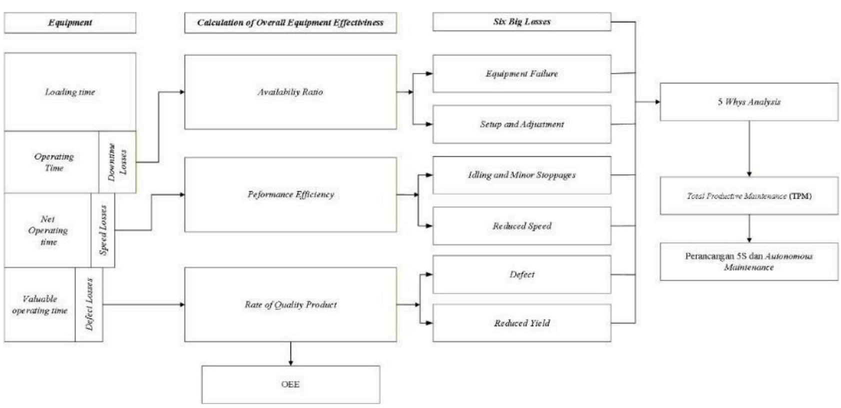

Fig 1. Research Methodology Framework

Availability Ratio

Availability ratio is an indicator that is used to measure the level of machine readiness to operate compared to the planned operational timeline [10].

$$Availability\ Ratio = \frac{Operating\ Time}{Loading\ Time}\ x\ 100\ \% \qquad (1)$$

Performance Efficiency

Performance efficiency is an indicator that is used to measure the level of the working speed of machines compared to the maximum speed that can be reached [10].

$$Performance\ Efficiency = \frac{Processed\ Amount - Ideal\ Cycle\ Time}{Operating\ Time}\ x\ 100\% \quad (2)$$

Rate of Quality Product

The measurement of the quality indicator is carried out by comparing the number of products that meet quality standard with the total number of products produced [10]

$$Rate\ of\ Quality\ Product = \frac{Processed\ amount\ x\ Defect\ Amount}{Processed\ Amount}\ x\ 100\ \% \quad (3)$$

The value of Overall Equipment Effectiveness (OEE) is

$$OEE = Availability\ Ratio\ x\ Performance\ Efficiency\ x\ Rate\ of\ Quality\ Product \quad (4)$$

Determining the ideal OEE value is based on specific criteria that represent the optimal level of equipment effectiveness [5].

Table 1. Ideal OEE value

OEE Component	Ideal Condition	Description
Availability Ratio	> 90 %	The machine rarely sops due to downtime or setup
Performance Efficiency	> 95 %	The machine operates close to its designed speed
Quality Rate	> 99 %	Product defects are very low (≤ 1 %)
OEE Total	≈ 85 %	"World-Class OEE" standard

2.2 Six Big Losses

Six big losses are six types of main losses that can reduce the performance of machines and equipment. This loss is divided to three main categories based on their causes: downtime losses, losses due to equipment damage and setup and adjustment time; speed losses, losses due to short machine stops and reduced operating speed; and quality losses, losses due to product defect and reduced production output [5]. These six losses must be eliminated to reach the maximum equipment effectiveness and efficiency. The relationship between OEE and six big losses can be seen on figure 2.

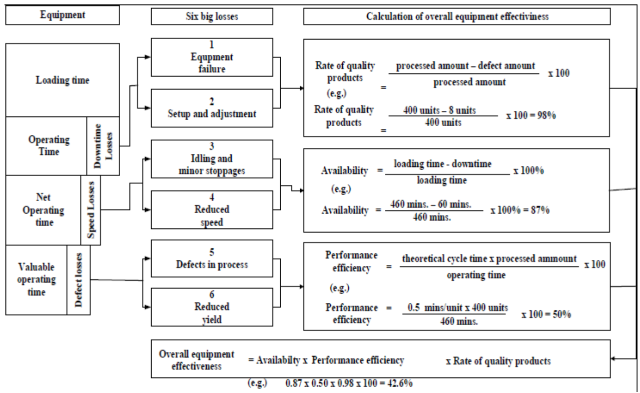

Fig. 2. Connection between Six Big Losses with OEE

2.3 Five Whys Analysis

The 5 whys analysis method is a qualitative data analysis approach which purpose is to identify the root cause of a problem. The analysis process is carried out by repeatedly asking "why" question until the primary underlying cause is identified. This method is considered simple and practical investigative tool, as it can be done without the need of a complex statistical analysis [11].

2.4 *Total Productive Maintenance* (TPM)

TPM is a concept that involves all human resources in equipment maintenance with the goal of achieving optimal operating conditions for the equipment used [5]. TPM is built upon eight main pillars, where each pillar has a specific role while remaining interconnected with one another [12]. The eight TPM pillars are shown in figure 3.

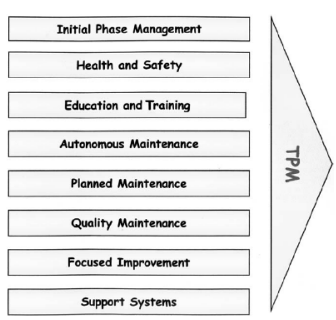

Fig. 3. Total Productive Maintenance (TPM) Pillars

2.5 *5S Principles (Seiri, Seiton, Seiso, Seiketsu dan Shitsuke)*

The implementation of the 5S method aims to create a well-organized and orderly work environment in order to improve safety aspect, work efficiency, and minimalize activities that does not add value through proper monitoring of well-organized work environment [13].

2.6 *Autonomous Maintenance*

Autonomous maintenance is a form of collaboration between machine operator and maintenance personnel, in which both parties share responsibility for the performance and maintenance of production equipment [12].

3 Result

CV Reka Cipta Anugrah experienced issues related to the failure to achieve production targets on the 200TR press machine. The 200TR press machine became the focus of attention due to its higher frequency of breakdown compared to other machines. That machine operates for seven hours per day with a production capacity around 1,000 to 2,000 units per product types. A comparison between the production target and the actual production output is shown in figure 4.

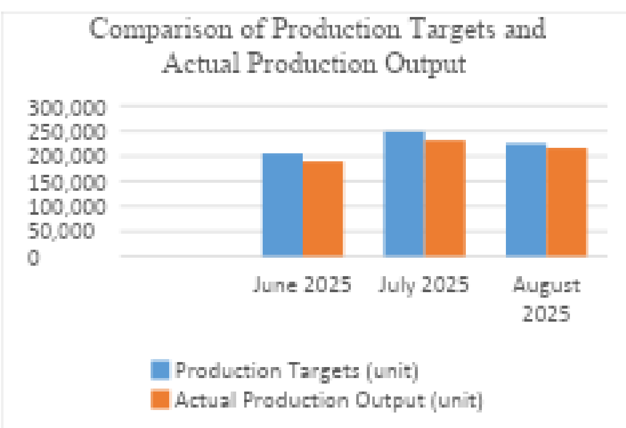

Fig. 4. Production target and actual production comparison

Overall Equipment Effectiveness Value

The resulting OEE calculation was conducted to determine the effectiveness of 200TR machine. OEE is calculated by multiplying the value of Availability Ratio, Performance Efficiency, and Rate of Quality Product produced by the 200TR machine. The recapitulation of the OEE for the 200TR press machine in June 2025 – August 2025 can be seen in Table 2.

Table 2. Recapitulation of OEE calculation from June to August 2025

Month	OEE	JIPM Standard Value	Description
June 2025	78,27 %	85%	Does not meet the standard
July 2025	77,97 %	85%	Does not meet the standard
August 2025	78,24 %	85%	Does not meet the standard
Average	78,16 %	85%	Does not meet the standard

Six Big Losses

The calculation of six big losses shows that the losses ranked from the largest to smallest is as follows: downtime losses, speed losses, and quality losses. The total value of downtime losses is 14.96%, speed losses account for 9.22%, and quality losses represent the smallest portion at 0.09%.

5 Whys Analysis

Using the 5 Whys analysis, it was found that the root problem for downtime losses category (Equipment Failure Losses) is the absence of standardize autonomous maintenance and clear work instruction. Meanwhile, for the downtime losses category (Setup and Adjustment Losses), the root cause is the lack of standard procedures for dies preparation and identification.

5S Principles (Seiri, Seiton, Seiso, Seiketsu dan Shitsuke)

The 5S is proposed as recommendation based on the problem identified in the 200TR press machine. The proposed implementation of the 5S principle can be sen on Table 3

Tabel 3. 5S Principles Implementation Proposal

Steps	Implementation Proposal
Seiri	Sorting dies, ring spanner, open-end wrenches, and supporting tools in the 200TR press machine area by separating tools that are used from those that are not used and providing clear labeling to reduce item accumulation in the work area.
Seiton	Arranging ides and work tools in fixed, designated, and labeled location so that they are easy to find and can speed up the machine setup process.
Seiso	Performing routine cleaning on the 200TR press machine and the area around it, especially the lubrication system and die area, to prevent dirt buildup that may interfere with the machine performance.

Seiketsu	Establishing work and cleanliness standards through simple work instructions and routine cleaning so that the implementation of 5S is carried out consistently by the operator.
Shitsuke	Accustom the operator to implement 5S through supervision, periodic evaluation, and providing work directions to establish sustainable work discipline.

Autonomous Maintenance

Autonomous maintenance is a proposed improvement designed to increase the involvement of operators in maintenance activities in order to keep the machine in optimal condition. The implementation of this method is based on the problem that occurs in 200TR press machine, particularly the high frequency of unplanned downtime, long repair times, and the decrease in machine operating speed. The proposed implementation of autonomous maintenance can be seen in Table 4.

Tabel 4. Autonomous Maintenance Method Proposal

No	Steps	Activity
1	Improve Operator Knowledge	Creating a discussion forum between maintenance division and operator to discuss the functions of the main components of the press machine, operating procedures, and potential failures in the lubrication system and dies.
2	Initial Cleaning and Inspection	Carrying out cleaning of the 200TR press machine and performing visual inspection to identify leaks, wear, and abnormal conditions.
3	Eliminating the Source of Contamination	Removing dust, dirt, and leakage through seal repair.
4	Establishment of Maintenance Standards and Routine Inspections	Developing a simple maintenance standard which includes lubrication, machine component check, die condition, and machine cleanliness.
5	Implementation of Routine Inspection	Conducting daily routine inspection by the operators in accordance with the established standard.
6	Visual Maintenance Standards	Providing visual control in the form of work instruction and brief inspection guidelines in the 200 TR press machine area.
7	Continuous Improvement	Performing periodic evaluation while involving operator in repair activity to reduce downtime, speed losses, and improve OEE values.

4 Conclusion

The average Overall Equipment Effectiveness (OEE) of 78.18% is still below the Japan Institute of Plant Maintenance (JIPM) standard of 85%. The OEE value obtained from this calculation can be used as a reference by CV Reka Cipta Anugrah to improve the effectiveness of its production process. The results of the six big losses data processing shows that the larges failure losses of 6.21% and setup and adjustment losses of 8.75%, which significantly contribute to the low OEE value. Further analysis using the 5 Whys method identifies two main root problem, namely frequent machine breakdowns that require maintenance time, thus disrupting production working hours, and lengthy setup processes due to the need of adjustment. The implementation of the 5S principles (Seiri, Seiton, Seiso, Seiketsu, dan Shitsuke) and autonomous maintenance method in the form of work instruction, inspection barcodes, preventive check sheets, and die labeling is proposed as an initial improvement steps to enhance the machine effectiveness, reduce the need for overtime, and support the achievement of daily production target at CV Reka Cipta Anugrah.

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