Analysis of Total Productivity Maintenance to Increase Batching Plant Machine Productivity at Moving Plant PT Adhi Persada Beton in Yogyakarta

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Abstract. This study was conducted on a batching machine at the movable plant of PT Adhi Persada Beton in Yogyakarta. The purpose is to determine the productivity level of a batching plant machine and analyze what factors that can decrease the machine's productivity. Source of data used in this study are secondary data, collected from the machine's performance history that was recorded from July 2023 to January 2024. The methods of analysis of this study are using the Overall Equipment Effectiveness (OEE) method and Six Big Losses. Based on a calculation of these two methods, we obtained the OEE value of the batching plant of PT Adhi Persada Beton is above the JIPM standard value of about 88.3%, and the calculation results of six big losses describe that set-up and adjustment losses are the main cause of the decreased OEE value of the machine that about 6.49%. Based on fishbone diagram analysis, the causes of decreased OEE value are environmental factors, humans, machines, methods, and materials. Based on Total Productivity Maintenance (TPM) analysis, the improvement can be carried out by training the employees, conducting periodic evaluations, forming SOPs that are related to the maintenance of the machine, and increasing employee awareness.

Keywords: *OEE, PT Adhi Persada Beton, Six Big Losses, TPM*

1 INTRODUCTION

Technology developments have a significant impact on the industrial world in Indonesia, where companies compete to increase their productivity by making updates in the field of technology. As a result of technological developments, the production process at the company can increase due to the influence of the level of human expertise and the productivity of related machines. Technology is applied to achieve high efficiency with minimum labor [1].

Machine capability is a determining factor in the production process, where machine capability is an important part that affects the smooth production process and the products produced. In addition to machine capability, an important factor for smooth production and to achieve organizational success is good performance from employees [2]. Companies must carry out regular machine maintenance to minimize

S. Musa et al. (eds.), *Proceedings of the 5th International Conference on Global Innovation and Trends in Economy 2024 (INCOGITE 2024)*, Advances in Economics, Business and Management Research 302,
https://doi.org/10.2991/978-94-6463-585-0_24

the occurrence of downtime which can inhibit the production process [3]. Maintenance includes all activities that synergize in keeping equipment in the production system working, with the aim of eliminating deviations and achieving performance in accordance to the standards [4].

One maintenance method that is useful for increasing productivity is Total Productivity Maintenance (TPM). TPM is an approach to the maintenance of production components that aims for companies to have continuous work, improve product quality, and avoid deviations that can cause losses [5]. The selection of TPM in this study is to minimize losses from

machine downtime due to repairs, because TPM is included in preventive maintenance which aims as a preventive measure so that machine damage does not occur. The application of TPM can be supported by the Overall Equipment Effectiveness (OEE) method to measure the level of machine effectiveness and minimize damage. Analysis using the Overall Equipment Effectiveness (OEE) method aims to eliminate Six Big Losses on the machine so as to optimize the value of availability, performance, and quality. Six big losses are six failure factors that describe the cause of the machine working less efficiently or less than optimal [6].

PT Adhi Persada Beton is a subsidiary of PT Adhi Karya (Persero) Tbk. which is specialized in the manufacturing industry. To fulfill the needs of demand, PT Adhi Persada Beton established plants in several areas, one of which is a movable plant or a non-fixed plant in Yogyakarta that produces ready-mix concrete. However, when experiencing an increase in demand, the company often experiences delays in the supply of goods, where the company exceeds the deadline agreed with consumers. The factor causing delays in demand fulfillment is that the machine experiences downtime when production is in progress so that production stops to carry out machine repairs. Therefore, to avoid delays in demand fulfillment, the company must implement a routine maintenance system so that the machines work optimally.

The most significant and most frequent cause of production constraints is machine downtime during production, which can be seen in the following table.

Table 1 Machine Downtime and Working Hours Data

Period	Downtime (hour)	work hours available (hour)	Total Production (m^3)
Jul-23	43	496	12761
Aug-23	40	496	11121
Sep-23	44	480	11050
Oct-23	49	496	12298
Nov-23	40	480	10442
Dec-23	39	400	7344
Jan-24	26	320	5006

Source: PT Adhi Persada Beton, 2024

In this study, researchers analyzed the production of ready-mix concrete, where ready-mix concrete is the main product produced by PT Adhi Persada Beton. To produce ready mix concrete, PT Adhi Persada Beton utilizes a batching plant machine to streamline the production process. A batching plant is a machine used to produce ready mix concrete which is equipped with pugmill mixing components, aggregate feeding system, vibrating screen, conveyor, water tank, wet mix storage silo, and other components. However, the use of a batching plant that is not balanced with maintenance will also cause new problems, where in the PT Adhi Persada Beton Yogyakarta plan the maintenance system has not been established regularly, causing downtime during production so that the production process stops.

Based on the description that has been explained, maintenance of the machine is highly important factor to increase the effectiveness of the machine in the production process. As a result, researchers want to conduct research on the application of Total Productivity Maintenance (TPM) to the batching plant of PT Adhi

Persada Beton to increase the productivity value of the machine. This research is expected to determine the level of effectiveness of the batching plant at PT Adhi Persada Beton and the factors that cause the decline in the efficiency value of the machine so that it can be used for maintenance recommendations to improve the effectiveness of the machine.

Based on the background of the problem and empirical studies related to this research. So, in this research, the author wants to know, and analyze the efficiency and effectiveness values of batching plant machines and find out how to implement total productive maintenance to increase the work effectiveness of batching plant machines at PT Adhi Persada Beton.

2. METHODOLOGY

The authors in this study use the concept of quantitative descriptive methods, where quantitative descriptive methods are a detailed description of an event with quantitative measures using predetermined methods, so as to describe the condition of the object being studied. This research is also classified as action research, where researchers go directly to the field to take measurements of objects that have been determined. The purpose of action research in this study is to obtain data on loading time, failure and repair, Set-up and adjustment, ideal cycle time, and Operation time to help researchers measure OEE values.

This research is a study that uses quantitative data. Whereas quantitative data is data in the form of absolute numbers that are systematically calculated so that its magnitude can be determined [7]. Data processing carried out in this study comes from secondary data. Secondary data according to [7] is data obtained by researchers from all parties who have knowledge of the topics discussed but can be obtained from journal references, and books that are relevant to machine maintenance management at PT Adhi Persada Beton, including Machine downtime data, Production quantity data, Machine operational data, Machine working hours data, and Production target data.

In this study, processing of observation data using the OEE (Overall Equipment Effectiveness) method and six big losses with the following steps:

a. Data collection
The data needed in this study are data related to the production process carried out by machines such as working hours data, machine rest hours data, machine damage hours data, and defective product data produced by machines.

b. Calculating the OEE value
OEE according to [8] is a value used to measure the effectiveness of the machine used for the production process, where the OEE calculation consists of 3 factors:

- Availability Rate
Availability Rate is a depiction of the time available for machine operation, can be calculated by the formula:

$$AR = \frac{OT}{LT} \times 100\% \quad \text{..... (1)}$$

Description:
OT = Operation time LT = Loading time

- Performance Efficiency
  Performance Efficiency is a ratio that shows the ability of a machine to produce an item, can be calculated by the formula:
  $PF = \frac{TPP \times ICT}{OT} \times 100\%$ ..... (2)
  Description:
  OT = Operation time ICT= Ideal cycle time TPP= Total production
- Quality Rate
  Quality Rate is a calculation that describes the ability of the machine to produce goods in accordance with the specified standards, can be calculated by the formula:
  $QR = \frac{TPP \times Defect}{TPP} \times 100\%$ ..... (3)
  Description:
  TPP= Total production

  Defect= Total defective products
- OEE (Overall Equipment Effectiveness)
  The calculation of the OEE value can be calculated using the formula:
  $OEE = AR \times PF \times QR$ ..... (4)

c. Identification of six big losses
   Production machine productivity that is not maximized certainly causes the company to experience losses. Losses associated with reduced machine productivity in OEE can be analyzed from six factors called six big losses [6]. The six factors that make up the Six Big Losses are:

- Breakdown losses
  Breakdown Losses, which are losses caused by production machines that experience damage or interference so that they require maintenance or replacement of components to be used for production again, can be calculated by the formula:
  $Breakdown = \frac{Breakdown}{Loading\ Time} \times 100\%$ ..... (5)
- Set-up and adjustment losses

  Set-up and adjustment losses, which are losses caused by changes in production conditions such as installation, adjustment, and readjustment of machines to obtain maximum efficiency during production, can be calculated by the formula:
  $Set\ up\ losses = \frac{Set\ up}{Loading\ Time} \times 100\%$ ..... (6)

- Idling and minor stoppages

  Idling and Minor Stoppages Losses, which are losses in the form of a momentary stoppage of the machine and the machine working without load during the production process, can be calculated by the formula:

$$Idling\ losses = \frac{(JPK - JPB) \times ICT}{Loading\ Time} \times 100\% \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Description:
JPK= Gross production quantity JPB= Net production quantity ICT= Ideal cycle time

- Reduced speed losses
  Reduced Speed Losses, which are losses in the form of decreased machine speed in the production process. This loss can be measured by calculating the difference between the ideal speed of the machine and the actual speed of the machine, which can be calculated by:

$$Reduced\ speed\ losses = \frac{(ACT - ICT) \times TPP}{Loading\ Time} \times 100\% \ldots\ldots\ldots (8)$$

  Description:
  TPP= Total production ACT= Actual cycle time ICT= Ideal cycle time

- Defect in process losses
  Defect in Process, which is a loss in the form of product defects produced in the production process, so that the defective product needs more time used for the repair process so that the product produced is in accordance with the desired quality, which can be calculated by:

$$Reduced\ speed\ losses = \frac{TRW \times ICT}{Loading\ Time} \times 100\% \ldots\ldots\ldots (9)$$

Description:
TRW= Total reject and rework ICT= Ideal cycle time

- Reduced yield losses

Reduced Yield Losses, which are losses in the form of differences in the quality of products produced at the beginning of production until the machine works stably, which can be calculated by the formula:

$$Reduced\ yield\ losses = \frac{RAP \times ICT}{Loading\ Time} \times 100\% \ldots\ldots\ldots (10)$$

Description:
RAP= Early production rejects ICT= Ideal cycle time

d. Analyze with Pareto diagram

A Pareto diagram is a diagram used to determine the highest problems to be addressed quickly through ranking. Pareto diagrams are also used to identify problems aimed at quality improvement and show the allocation of resources needed.

. e Analyze with a cause-and-effect diagram

A cause-and-effect diagram is a fishbone diagram used to analyze the causes of a problem. This diagram is a tool for analyzing the sources of process deviations using a graphical description of the process elements. The main causal factors according to
[4] can be divided into five factors, namely the environment, raw materials, methods, machines, and people.

3. RESULT & DISCUSSION

The ready-mix concrete production line at PT Adhi Persada Beton plant in Yogyakarta uses 7 equipment components. The components used in the batching plant for the production of ready-mix concrete are arranged in series, which has an impact when one of the components is damaged, the production process cannot be carried out. In calculating the batching plant effectiveness value using the OEE method, the batching plant efficiency value for the period July 2023-January 2024 was obtained with an average of 88.7% with a description of the average availability rate value of 90.8%, performance efficiency of 97.7%, and quality rate 100%.

Table 2 OEE Calculation Table

Period	AR	PE	QR	OEE
Jul-23	91,0%	98,2%	100%	89,3%
Aug-23	91,6%	96,7%	100%	88,6%
Sep-23	90,5%	96,1%	100%	87,0%
Oct-23	89,5%	100%	100%	89,5%
Nov-23	91,5%	94,9%	100%	86,8%
Dec-23	89,8%	97,9%	100%	88,0%
Jan-24	91,6%	100%	100%	91,6%
Rata-rata	90,8%	97,7%	100%	88,7%

Source: Data processed, 2024

The reduction in the productivity of the batching plant machine itself in this study was caused by three six big loss factors, namely 11.3% with breakdown losses of 2.84%, set up and adjustment losses of 6.49%, and reduced speed losses of 2.34%.

Table 3 Recapitulation of Six Big Losses Calculation of Batching Plant

Period	Jul-23	Aug-23	Sep-23	Oct-23Nov-23	Dec-23	Jan-24
Breakdown Losses	2,51%	1,88%	3,02%	3,85%2,13%	3,65%	1,94%
Set Up and justment Losses	6,49%	6,47%	6,47%	6,62%6,38%	6,51%	6,45%
Idling and Minor Stoppages	0,00%	0,00%	0,00%	0,00%0,00%	0,00%	0,00%
Reduced Speed Losses	1,68%	3,02%	3,55%	0,00%4,65%	1,87%	0,00%
Defect in Process	0,00%	0,00%	0,00%	0,00%0,00%	0,00%	0,00%
Reduced Yield Losses	0,00%	0,00%	0,00%	0,00%0,00%	0,00%	0,00%
Total	10,67%	11,37%	13,03%	10,47%13,16%	12,03%	8,39%

Source: Data processed, 2024

From the description of the results of the calculation of OEE and six big losses, further analysis as recommendations for solutions that will be given by researchers will focus on handling losses associated with high values of breakdown losses, set up and adjustment losses, and reduced speed. Due to the problems related to three losses having an impact on the production process, the related problems will be retrieved to make it easier to provide recommendations for improvement.

Based on the results of calculations and data analysis, this research is in line with research [9] where the level of machine productivity can decrease due to error factors called six big losses, and according to research [10] machine productivity can be increased by making improvements with the TPM concept.

After finding out that the recapitulation calculation of the six big losses batching plant for period of July 2023-January 2024, the next step is to compile the calculation results in a Pareto diagram. The following is the calculation of the percentage of each loss.

Table 4 Percentage of Six Big Losses of Batching Plant

Six big losses	*Time losses* (Jam)	Percentage (%)	Cumulative (%)
Breakdown Losses	68,05	24,2	24,2
Set Up and Adjustment Losses	163,23	57,9	82,1
Idling and Minor Stoppages	0	0	82,1
Reduced Speed Losses	50,47	17,9	100
Defect in Process	0	0	100
Reduced Yield Losses	0	0	100

Source: Data processed, 2024

From the calculations and analysis carried out, it is obtained that the factor that is the main focus in improvement, namely set up and adjustment losses worth 57.9% or 163, 23 hours.

Furthermore, the Pareto diagram is a tool that can be used to find out the main problems and can be the focus of improvement for the company. The following is a picture of the Pareto diagram of the batching plant for the period July 2023-January 2024.

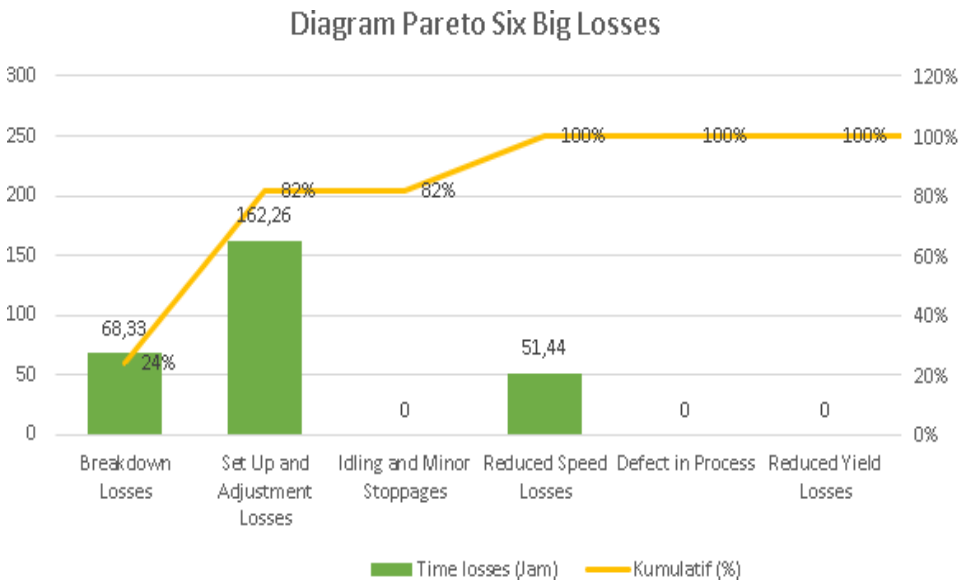

Figure 1 Pareto diagram of six big losses analysis of batching plant

From the three problems that the batching plant cannot produce according to its capacity, it can be analyzed the cause of the loss with a fishbone diagram by analyzing each aspect that is man, machine, material, method, environment. After analyzing using a fishbone diagram, improvements are made so that the production speed and usable time can increase as targeted. The following is an analysis of the causes of loss in the batching plant against the five aspects that have been mentioned.

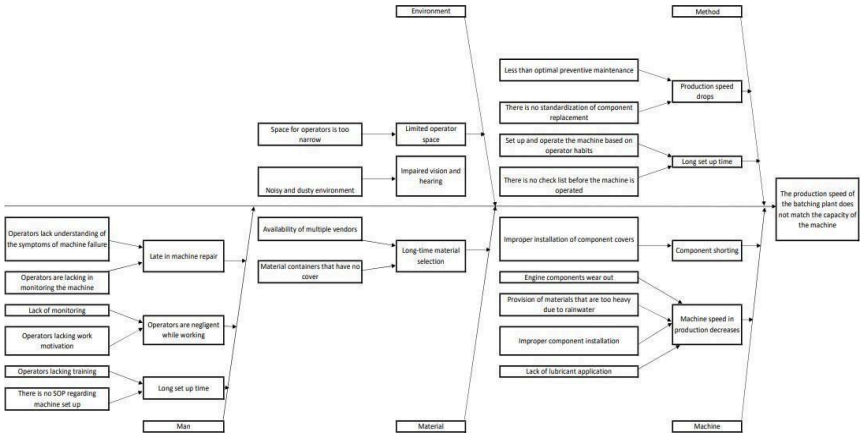

Figure 2 Fishbone diagram of six big losses of batching plant

From the description of the problems and causes of problems, the next is the preparation of improvement recommendations based on the TPM pillars by activity plan. TPM is a program that involves all human resources of a company to develop the equipment maintenance function in the company in the hope of achieving zero defects, zero accidents, and increasing the level of equipment productivity [8]. The TPM pillars consist of eight aspects; focused improvement, planned maintenance, education and research, autonomous maintenance, quality maintenance, office TPM, tools management, health and safety. In this study, improvement recommendations use five TPM pillars; autonomous maintenance, focused improvement, planned maintenance, training, health and safety. The following are the improvements given to overcome the six big losses that exist in the batching plant at PT Adhi Persada Beton plant Yogyakarta.

Table 5 Recommended Improvement Activities Based on TPM Pillars

Type of TPM	Activities
Autonomous Maintenance	Conduct daily and weekly meetings before the production process takes place which was previously only done when trouble occurred. Ensure that all machine components that need to be lubricated are well-lubricated. Conduct a check list of component conditions which includes the actual condition of components such as early damage that can be discussed during the meeting. Performing machine cleaning before and after the production process which was previously only done only at the end of production.
Focused Improvement	Supervised by the head of production in the production section and provided a daily report form on machine usage. Provide incentives and punishments to employees for the quality of their work. Establish an SOP that includes pictures of components, and how to operate them. Routinely conduct evaluations for employees aimed at improving the quality of work. Standardize standard working time for workers and operators to determine the maximum daily production capacity and the optimal time to perform work.
Planned Maintenance	1. Creation of an SOP regarding component cleaning and lubrication schedule 2. Scheduling preventive maintenance and predictive maintenance based on the problem analysis of components 3. Perform overall maintenance within the specified interval
Training	1. Provide training to technicians and operators on the knowledge of the machines being operated. 2. Provide training to contract employees so that job rotation can be carried out 3. 3. Training on machine SOP standards and optimum working hours.

	Training and sharing with experts in the field of machines used for production so that autonomous maintenance runs effectively.
Health and Safety	1. Provide additional PPE in the form of safety glasses, masks and earmuffs that must be worn in the production zone. 2. Provide PPE to vendor drivers who unload cargo.

4. CONCLUSION

From the results of data processing and analysis of the application of TPM with the OEE method to determine the value of machine productivity and eliminate six big losses, it can be concluded that in the period July 2023 - January 2024 the OEE value of the batching plant machine is 88.7% with details of availability rate 90.7%, performance efficiency 97.4%, and quality rate 100%.

With the OEE value of 88.7%, it can be concluded that the OEE value is above the JIPM standard value of 85%. This shows that the OEE value has good productivity, but if it is not balanced with good maintenance, the value can decrease, so the company must make improvements and keep doing better evaluations so that the OEE value of the batching plant increases and the machine effectiveness value becomes more optimal.

The factors that cause the decrease in OEE value of batching plant machines due to six big losses are % breakdown losses of 2.84%, set up and adjustment losses of 6.49%, and reduced speed losses of 2.34% with a total value of six big losses of 11.3%.

From the results of the analysis using the fishbone diagram, the authors can recommend improvements to the TPM concept, namely autonomous maintenance, focused improvement, planned maintenance, training, and health and safety.

5. SUGGESTIONS

The company is expected to implement improvement recommendations with the TPM method, and continue to review the results of implementing recommendations to create a good work system, and can increase productivity levels by calculating the OEE value of batching plant machines so that there are no delays in delivery when production levels increase.

For academics and further research, it is expected to be able to compare the results before and after improvements using the TPM concept on a machine in a company.

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