Jurnal Teknologi dan Manajemen

ISSN (Print) 1693-2285 ISSN (Online) 2808-9995

Reseach Article

Evaluation of The Effectiveness of Die Casting Machines Using Overall Equipment Effectiveness (OEE)

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ARTICLE INFO

Received : 01 January 2024
Revised : 21 February 2024
Accepted : 23 February 2024

KEYWORDS

Fishbone Diagram, Overall Equipment Effectiveness, Pareto Diagram, Six Big Losses, Total Productive Maintenance

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A B S T R A C T

PT YKK Zipco Indonesia is a manufacturing company that produces zipper components, namely chains and sliders. The manufacture of slider products goes through several departments, namely die casting, assembling, painting and plating. The process of making slider products begins with the die casting department which carries out the production process using 17 machines. The problem that exists in the die casting department is that the level of productivity is quite low, so an analysis of the effectiveness of the die casting machine is needed. The aim of this research is to evaluate the performance of the production process in order to increase the efficiency and effectiveness of the company as a whole. The method used in this research is overall equipment effectiveness (OEE) and six Big Losses. The Overall Equipment Effectiveness (OEE) method is used to measure the effectiveness of production process machine performance in manufacturing companies using the parameters availability, performance and quality. In OEE there are six big losses which are categorized into 3 main categories, namely quality loss, downtime loss and speed loss. Then an analysis was carried out using the Pareto diagram and fishbone diagram to find the root causes of the problems that occurred. The results of this research, namely the results of OEE calculations on the C – 07 Die Casting machine, obtained an average OEE value of 78.6%. Based on the six big losses calculation, breakdown losses occupy the highest value with a percentage of 23.1%, making it the losses that most influence the value of machine effectiveness.

INTRODUCTION

Machine productivity can be increased and maintained by implementing a planned, regular and controlled maintenance program. Carrying out good maintenance will certainly increase the productivity and effectiveness of the machine, thereby avoiding losses caused by machine damage (Mubyarto & Sohibien, 2020).

Total Productive Maintenance (TPM) aims to increase the efficiency and effectiveness of the company as a whole (Dewi, 2014). In TPM, maintenance is very important to optimize the level of effectiveness of a machine, so that it can reduce or eliminate sudden damage (breakdown), while Overall Equipment Effectiveness (OEE) is a tool for measuring the performance of the production process. OEE can measure various types of production losses and determine areas where improvements can be made. OEE is a method that has been widely accepted for measuring company levels and the potential for production improvements (Widyadana, 2015).

PT YKK Zipco Indonesia is a manufacturing company with a focus on producing zipper components, namely chains and sliders. The manufacture of slider products goes through several departments, namely Die Casting, assembling, painting and plating. The Die Casting Department is the main department because the process of making slider products starts from this department. The Die Casting Department carries out the production process using 17 machines.

It is known that data on the production results of the Die Casting department during the period September 2021 - February 2022 can be seen in Figure 1. Figure 1 shows data on the production results of the Die Casting department which are still low during the period September 2021 - February 2022. This data is based on actual production quantities with targets that have been set.

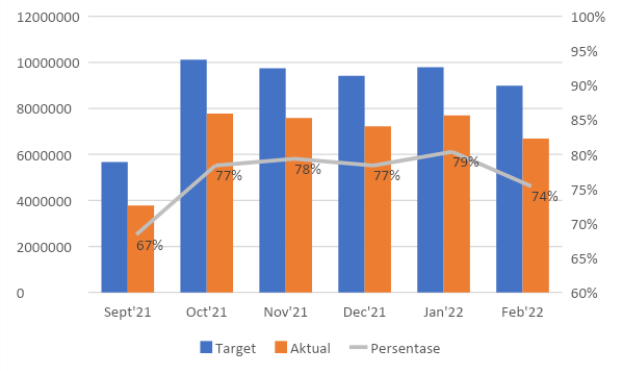

Fig 1. Production Result Data Die Casting Department

Table 1 presents a presentation of the performance of each die cast machine for the last 6 months in 2021 – 2022.

Tabel 1. Die Casting Machine Performance Percentage

Machine Number	Total Production Target 6 Months	Actual Total Production Results for 6 Months	Percentage of Performance
C-02	2,983,492	2,377,134	79.68%
C-03	2,862,213	2,111,548	73.77%
C-04	3,262,179	2,536,788	77.76%
C-05	3,055,030	2,212,606	72.43%
C-06	3,113,217	2,247,398	72.19%
C-07	3,173,314	2,243,856	70.71%
C-08	2,979,822	2,118,293	71.09%
C-09	3,068,806	2,570,265	83.75%
C-10	3,255,442	2,520,341	77.42%
C-11	3,126,689	2,410,221	77.09%
C-12	3,075,496	2,462,749	80.08%
C-13	3,572,506	2,608,135	73.01%
C-14	3,499,719	2,517,688	71.94%
C-15	3,384,488	2,590,088	76.53%
C-16	3,264,554	2,447,191	74.96%
C-17	3,038,623	2,275,614	74.89%
C-18	3,011,227	2,398,563	79.65%
Total	53,726,818	40,648,478	75.66%

(Sumber : Data Departemen *Die Casting*, 2022)

Table 1 shows that the C-07 Die Casting machine has the lowest average performance during the period September 2021 – February 2022. Therefore, this research will evaluate the effectiveness of the machine's performance. This evaluation was carried out to determine the causes of ineffectiveness that occurred on the C-07 Die Casting machine, so that it could be used as a recommendation for improvement to increase machine productivity in accordance with the TPM pillar.

OEE is a useful way to evaluate TPM implementation. OEE contributes to improved equipment performance and reliability. OEE also reduces the variability of schedule variations and product quality and increases product output. Preventive maintenance is the initial focus of TPM. As the TPM initiative progresses, an increase in OEE will be seen (Agustiady, 2016).

J. Yashini (2020) conducted research entitled An Analysis on Minimization of Product Error (Poka-Yoke) and Ongoing Overwork (TPM & OEE) in the Textile Industry. The research results show that the OEE value in the Tirupur textile industry is still very low, especially in the production line, namely 75.2%. In this research, the poka-yoke and TPM methods were applied to increase machine efficiency and reduce product damage

G. Pinto et al., (2020) conducted research entitled Implementing a maintenance strategic planning TPM methodology, in this research the problem found was the high breakdown time of lathe and machining sector machines, due to the machine stopping for too long when replacing parts. Recommendations for improvements made are that the company implements Autonomous Maintenance (AM), so that breakdown time is reduced by 23% for lathe machines and 38% for machining machines, and the OEE value increases by 5%.

METHOD

The type of research used in this research is quantitative research with a descriptive approach. This research uses a descriptive approach with the aim of describing the research object or research results. The aim of this research is to evaluate machine productivity performance. Performance measurement becomes more measurable if it is carried out using quantitative research. The data collection method used to obtain the data used in the research is as follows:

1. Observation Method: carried out by observing directly at the research location
2. Interview Method: carried out by answering directly to the informant or data source. In this case the researcher is interviewing the production operator and the head of the Die Casting department
3. Documentation Method: Data collection is carried out through recording company data or documents needed for research.

The first stage of this research begins with determining the research object, then conducting literature studies and field studies. The next step is to identify the problem which is divided into three consisting of formulating the problem, setting research objectives, and determining research boundaries. Based on the problem identification obtained, data was collected from the company needed for research. The company data collected is in the form of Machine Working Time, Breakdown and Setup, Planned Downtime, Processed Amount, Defect & Scrap, Ideal Production

DOI: 10.52330/jtm.v22i1.239

Amount. Data processing includes calculations of OEE and six big losses, from these calculations an analysis of the causes of problems and the roots of the problems that occur is carried out using Pareto diagrams and fishbone diagrams. From the results of the analysis carried out, improvement proposals for the Die Casting department are determined. The final stage is drawing conclusions and suggestions. Data processing and analysis was carried out using the Overall Equipment Effectiveness (OEE), Six Big Losses and Total Productive Maintenance (TPM) methods with the following stages (Miftahul Jannah et al, 2017):

1. Calculation of the Rate of Availability value using the formula:

$$Availability = \frac{Operation\ Time}{Loading\ Time}\ x\ 100\% \quad (1)$$

2. Calculation of the *Rate of Performance* using the formula:

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

3. Calculation of the *Rate of Quality Product* using the formula:

$$Quality = \frac{Processed\ Amount - Defect\ Amount}{Processed\ Amount}\ x\ 100\% \quad (3)$$

4. Calculation of the *Overall Equipment Effectiveness* (OEE) using the formula:
   OEE = *Availability x Performance x Quality* (4)

After carrying out an analysis of the calculations of Availability, Performance, Product Quality, and Overall Equipment Effectiveness (OEE), then look for the cause of the low OEE value using the Six Big Losses method to find out the types of losses that have an impact on the effectiveness of the C-07 Die Casting machine. The root of the problem of losses is sought using Pareto diagrams and fishbone diagrams, then conclusions and suggestions are drawn which will be submitted as recommendations for improvement using the Total Productive Maintenance (TPM) method.

RESULT AND DISCUSSION

The results of data processing carried out in this research are as follows:

1. Availability is a comparison between operating time and loading time. Data on machine uptime, planned downtime, breakdowns, and settings and adjustments are the data used to calculate availability levels. Table 2 shows the results of calculating the level of availability.

Table 2. *Availability Value Die Casting C-07 Machine*

Month	Loading Time (Hours)	Operating Time (Hours)	Availability (%)
Sep 2021	542	325	60.0%
Oct 2021	595	406	68.2%
Nov 2021	580	307	52.9%
Dec 2021	559	387	69.2%
Jan 2022	586	401	68.4%
Feb 2022	535	336	62.8%
Mean			63.5%

2. Performance Rate (Table 3.) is a comparison of the quantity of product produced using the ideal cycle time to the amount of time available for the production process.

Table 3. Performance Value Die Casting C-07 Machine

Month	Production Amount (*Shot*)	*Ideal Cycle Time* (Hours/ *Shot*)	*Operation Time* (Hours)	*Performance* (%)
Sept 2021	385,846	0.457	325	67,8%
Oct 2021	445,566	0.605	406	82,9%
Nov 2021	362,332	0.394	307	58,0%
Dec 2021	425,392	0.608	387	83,4%
Jan 2022	431,332	0.626	401	84,1%
Feb 2022	393,569	0.497	336	72,6%
Mean				74,8%

3. The ratio that shows the machine's capacity to produce products that meet standards is called the quality rate (Table 4.). The amount of production, defective products (including yield/scrap products and rework products) is used to calculate the quality rate. Data on production quantities, defective products (including yield/scrap products and rework products) is the data used to calculate the quality rate.

Table 4. *Quality Rate Die Casting* C-07

Month	Production (*Shot*)	Total Product *Defect* (*Shot*)	Quality Rate (%)
Sept 2021	385,846	11,395	97.0%
Oct 2021	445,566	10,062	97.7%
Nov 2021	362,332	12,000	96.7%
Dec 2021	425,392	7,750	98.2%
Jan 2022	431,332	10,392	97.6%
Feb 2022	393,569	4,550	98.8%
Mean			97,6%

4. Availability rate, performance rate and quality rate of the C-07 Die Casting machine can be used to calculate the Overall Equipment Effectiveness (OEE) value (Table 5.).

Table 5. *OEE Value Die Casting* C-07

Month	Availability Rate	Performance Rate	Quality Rate	OEE
Sep 2021	60.0%	67,8%	97,0%	74,9%
Oct 2021	68.2%	82,9%	97,7%	82,9%
Nov 2021	52.9%	58,0%	96,7%	69,2%
Dec 2021	69.2%	83,4%	98,2%	83,6%
Jan 2022	68.4%	84,1%	97,6%	83,4%
Feb 2022	62.8%	72,6%	98,8%	78,1%
Mean				78.6%

Based on World Class OEE standards, the average OEE value for the C-07 Die Casting machine is 78.6%, still below the OEE standard value of 85%. Therefore, improvements are needed by the Die Casting department to increase the OEE value of the C-07 Die Casting machine. The lack of an OEE value from the minimum world class standard value will certainly result in economic and financial losses for the company, the die casting department needs to increase work effectiveness, especially by paying attention to the performance of the machines used so that they can be maximized.

Breakdown losses and set up and adjustment losses are included in the OEE calculation as downtime losses. After calculating each loss, it can be seen which types of losses have the largest value during the research period from September 2021 to February 2022. Data from the six big losses calculations is presented. in a percentage table that summarizes all losses. The following is the percentage of the six losses which can be seen in Table 6.

Table 6. Percentage *Losses* Period September 2021 – February 2022

Month	*Breakdown Losses (%)*	*Set Up & Adjustment Losses (%)*	*Idling & Minor Stoppages Losses (%)*	*Reduced Speed Losses (%)*	*Reject /Rework Losses (%)*	*Scrap Losses (%)*
Sept 2021	24.2	15.9	17.2	19.3	1.2	0.8
Oct 2021	19.5	12.3	8.2	11.7	1.3	0.6
Nov 2021	35.0	12.1	3.8	22.2	1.0	0.4
Dec 2021	18.8	12.0	16.3	11.5	1.1	0.4
Jan 2022	19.3	12.3	10.6	10.9	1.4	0.9
Feb 2022	21.5	15.7	3.7	17.2	0.6	0.3

Pareto Diagram

A Pareto diagram is a graph that depicts a problem in terms of the sequence of the number of events that occur. The order is based on how many problems there are from most to least. The first step in creating a Pareto diagram is to determine the average losses and the cumulative percentage of the six big losses for the period September 2021 to February 2022 (Figure 2.).

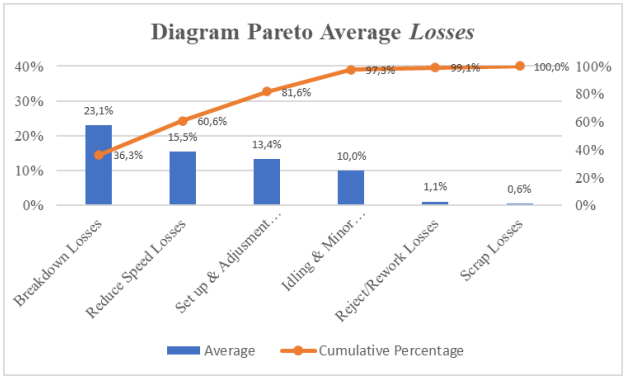

Fig 2. Pareto diagram for monthly losses

Based on the results of the Pareto diagram in Figure 2, it can be seen that the losses with the greatest value are breakdown losses, reduced speed losses, and set up and adjustment losses with a total cumulative percentage value of 81.6%. So these three losses can be analyzed using a fishbone diagram to determine the factors that caused these losses.

Fishbone Diagram

In carrying out an analysis using a fishbone diagram, researchers involve the company to ensure that the analysis carried out is in accordance with the company's conditions. The fishbone diagram analysis carried out includes Breakdown losses, Reduce speed losses, set up and adjustment losses. Breakdown losses are losses that occur when machine damage occurs frequently which results in production results below standard. So, the process of identifying the root causes that resulted in breakdown losses on the C-07 Die Casting machine was carried out (Figure 3.).

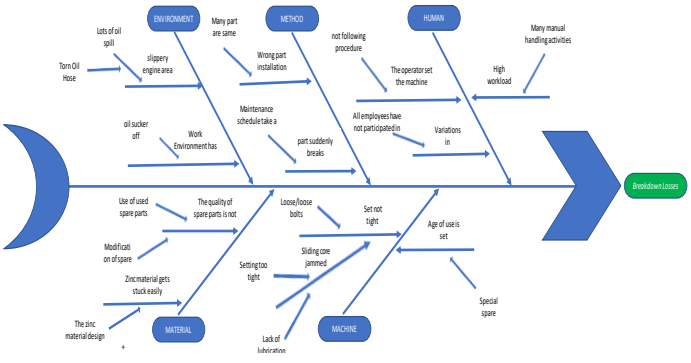

Fig 3. ***Fishbone Breakdown Losses***

The results of the fishbone diagram from field analysis show that machine factors, especially loose die set positions, are the main contributors to machine breakdown. This is the reason why machines often break down, thus directly affecting the occurrence of machine breakdowns. However, other factors that are supporting factors for the

DOI: 10.52330/jtm.v22i1.239

main cause also influence the occurrence of machine breakdown. Such as human factors in the form of variations in mechanical skills that influence repair results. If repairs are not carried out according to procedures, it can cause engine performance to not be optimal.

The method factor is that the part installation method is incorrect, causing the spare part to be easily damaged after being installed on the machine. The material factor is that the design of the zinc material is not suitable so that the liquid zinc produced after the melting process becomes thick. This causes zinc to easily get stuck in the die set, resulting in breakdown of the machine. Reduced speed losses are losses that occur as a result of the difference between the machine's design speed and its actual speed when it is operating.

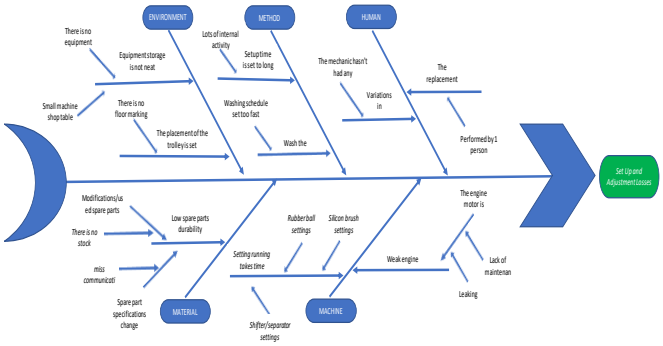

Fig 4. *Fishbone Reduce Speed Losses*

Based on the results of the field analysis shown in the fishbone diagram (Figure 4.), it can be seen that the main cause of reduced speed losses is machine factors, namely lack of maintenance on spare parts, especially the machine motor, which can make the machine pressure and hydraulics weak which directly affects the machine casting speed. However, the occurrence of reduced speed losses is also influenced by other factors which are supporting factors for the main causal factors. Such as the human factor in the form of the operator's lack of concern when there is a decrease in engine speed where the settings are not immediately reset which causes the engine performance to not be optimal. From the method factor, in the form of incorrect running settings due to not having implemented the SOP, this can cause the engine speed to decrease again even though the settings have been reset. From material factors, in the form of poor spare part material quality due to the use of used spare parts, which results in the lifespan of spare parts being low and easily damaged which can hamper the production process.

Set up & adjustment losses are disadvantage that occur when the die set up process on the machine lasts long enough so that the machine operating time is reduced by the die set up activity.

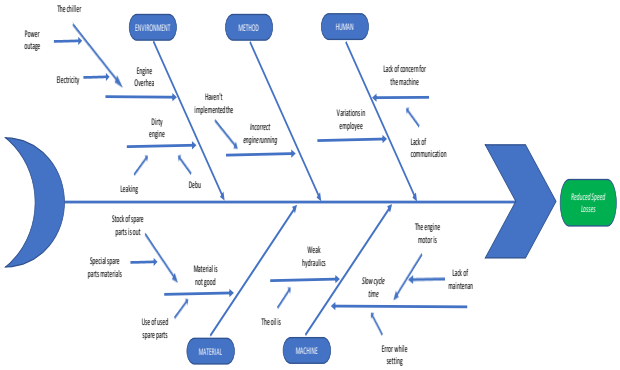

Fig 5. *Fishbone Set Up & Adjustment Losses*

Based on the results of the field analysis presented in the fishbone diagram, it can be seen that the main cause of set up & adjustment losses is machine factors (Figure 5.), namely lack of maintenance, which causes the machine motor to be damaged and the machine pressure to become weak. A damaged engine motor condition will hinder mechanics when changing over products. Weak engine pressure causes the engine running setting time to increase because the mechanic has to wait to ensure the die set is installed properly and the engine is ready to run again. However, the occurrence of set up losses is also influenced by other factors which are supporting factors for the occurrence of the main factors. Such as human factors in the form of variations in mechanical skills due to not having received training and the process of changing die sets taking a long time because it was done by one person. From material factors in the form of low durability of spare parts due to the use of used spare parts and miscommunication when the spare part specifications change. Meanwhile, environmental factors are due to untidy equipment storage such as careless placement of toolboxes and die set trolleys. This can hamper the preparation process and make product change over activities take longer.

The TPM pillar approach is used to carry out analysis of suggestions for improvement after identifying the causes of the three losses. Preparation of suggestions using the TPM (Total Productive Maintenance) pillar approach which aims to increase the effectiveness of facilities used in industry, which includes machine maintenance as well as all activities used in industry, including increasing motivation for company employees. The following are recommendations for improvements that have been suggested:

1. Breakdown Losses Improvements Recommendations
   Implementation of additional activities that can be implemented as preventive maintenance measures: recommendations for improvements made are in the form of improvements from planned maintenance. Carry out regular inspections of machine spare parts. Make a historical record of repair or replacement of machine components which contains the date the spare part was replaced, the type of spare part replaced and the date of the next component replacement. After repair or replacement activities are completed, historical records must be completed immediately

2. Reduce Speed Improvements Recommendations
   The recommended improvement is the implementation of autonomous maintenance. Light maintenance training material provided to machine operators includes: How to carry out simple checks when the machine cycle time is slow. Explanation of the characteristics of a motorbike that is in poor condition due to being too dirty. How to do simple cleaning of dirty engine motor components.
3. Set up & Adjustment Losses Improvements Recommendations
   In this step, internal activities are identified that can be converted into external activities. This change aims to shorten time. This is done so that the machine operator can help in arranging product changes for further production while the machine is in operation. The following are internal set up activities that can be converted into external set up: The activity of taking the shifter from the machine shop room should be carried out by the machine operator while the machine is operating so as to save set up time. The activity of replacing the rubber ball and silicon brush is carried out by the machine operator while the machine is operating so as to reduce the set-up time and prevent wasting time.

CONCLUSION

The results of calculating the OEE value on the C-07 Die Casting machine for the period September 2021 to February 2022, obtained an average OEE value of 78.6%. Referring to the world class standard for OEE values, the OEE value of the C-07 Die Casting machine is included in the medium category. This category means that the value of the machine in carrying out the production process is included in the normal category but improvements and improvements are still needed so that the production system can increase to world class category with an OEE percentage exceeding or equal to 85%. Based on the results of the Six Big Losses calculations, breakdown losses occupy the highest value with a percentage of 23.1% or contribute 36.3% of the total losses, making these losses the losses that most influence the value of machine effectiveness. Recommendations to improve this are implementing planned maintenance, Autonomous Maintenance as well as conducting training and education to improve production and maintenance operators capabilities.

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DOI: 10.52330/jtm.v22i1.239