Analysis of OEE improvements in Blow Molding Machines in the Plastic Packaging Manufacturing Industry using Six Big Losses and FMEA methods

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Abstract

The plastic packaging manufacturing industry is a downstream industrial sector, so far it has become the supply chain of customer products, especially being part of the food industry, pharmaceutical industry, cosmetics, and medical devices. With the increasing demand for plastic packaging, industry players are required to maintain the productivity and quality of the products they produce. In order to maintain product performance, control over the production process must be carried out, including maintaining engine performance. The effectiveness for measuring the performance of production machines is the OEE (Overall Equipment Effectiveness) indicator. The OEE value is influenced by 3 variables, namely availability, performance, and quality. These variables are translated into six big losses which consist of breakdown losses, set up and adjustment, start-up, idle and minor stoppage, speed losses, and defect losses. The purpose of this research is to analyze six big losses on blow molding machine units in plastic packaging manufacturing companies. The analytical method used in this study is to use a fishbone diagram and why why analysis to find out the cause of the low OEE value and use FMEA (Failure Mode and Effect Analysis) in determining corrective actions. Based on the results of the analysis, it was found that the first largest losses were breakdown losses with a value of 36.4% or 15,849 hours from. While the second losses are setup and adjustment losses with a value of 20.1% or 8,752 hours of machine operating time. Improvement efforts made are by performing autonomous maintenance, changing the frequency of PM (Preventive Maintenance), and making spare part stock planning by determining the minimum stock of spare parts. From the results of the improvements that have been made, it can be declared quite effective because the OEE value increased by 10.6%.

Keywords
Overall Equipment Effectiveness, Blow Molding Machine, Six Big Losses, Fishbone Diagram, FMEA

1. Introduction
The industrial sector is the largest contributor to the national economy with a contribution of more than 20%. In the National Industrial Development Master Plan (RIPIN) for 2015-2035, it is stated that there is an increase in industrial development targets every five years. The RIPIN 2015 – 2035 is stipulated by Government Regulation No. 14 of 2015 and compiled as an implementation of the mandate of Law No. 3 of 2014 concerning Industry, as well as being a guide for the government and industry players in industrial planning and development.

Based on the qualitative and quantitative criteria of the national industry, RIPIN sets 10 priority industries which are grouped into 3 types of industry, namely the mainstay industry, the supporting industry, and the upstream industry. The two main industrial sectors are the food industry and the pharmaceutical, cosmetic & medical device industry. The plastic packaging industry, which is the downstream chemical sector, has so far been a supply chain for consumer products, especially being part of the two major industrial sectors mentioned above.

With the increasing demand for plastic packaging, industry players are required to maintain the productivity and quality of the products they produce. In order to maintain product performance, control over the production process must be carried out, including maintaining the reliability of the production machine's performance. The effectiveness of the production machine can be evaluated from the OEE (Overall Equipment Effectiveness) measurement indicator. The use of OEE is a method used as an indicator to keep production equipment in a reliable condition. The size of the OEE value is influenced by three variables, namely Availability, Performance, and Quality. The three types of variables are translated into Six Big Losses which consist of Breakdown Losses, Set up and Adjustment, Start up, Idle and Minor Stoppage, Speed Losses, and Defect Losses.

To be able to achieve the OEE target, TPM (Total Productive Maintenance) must first be applied. TPM is a method/system used to maintain and improve the quality of production through maintenance of work equipment and equipment such as machinery, equipment and work equipment. The application of TPM to increase productivity has been studied in several industries. According to Mwanza & Mbohwa (2015), currently the TPM concept has been widely accepted and applied but it is still possible to find industries that face maintenance challenges. Patidar et al. (2017) reveal that maintenance tools and techniques (MTT) are increasingly being applied by many Indian SMEs to improve performance and gain competitive advantage with long time stability in the harsh global market in terms of productivity, cost and quality. However, proper implementation of MTT is not an easy task. Of course, manufacturing companies are more focused on increasing production performance in terms of productivity output in order to survive in a competitive market, because high productivity performance has a direct relationship with equipment efficiency and process control.

The focus of this research is to develop an effective TPM model to improve the Preventive Maintenance system in plastic packaging companies. Currently, the plastic packaging company has not used OEE indicators to measure how effective the performance of existing machines is. There are 2 types of machines, namely Blow Molding machines and ISB machines. The company has monitored performance availability, performance and quality, but has not set measurable targets that can be used as KPIs (Key Performance Indicators). Figure 1 present the actual OEE performance data of the two types of machines in the company.

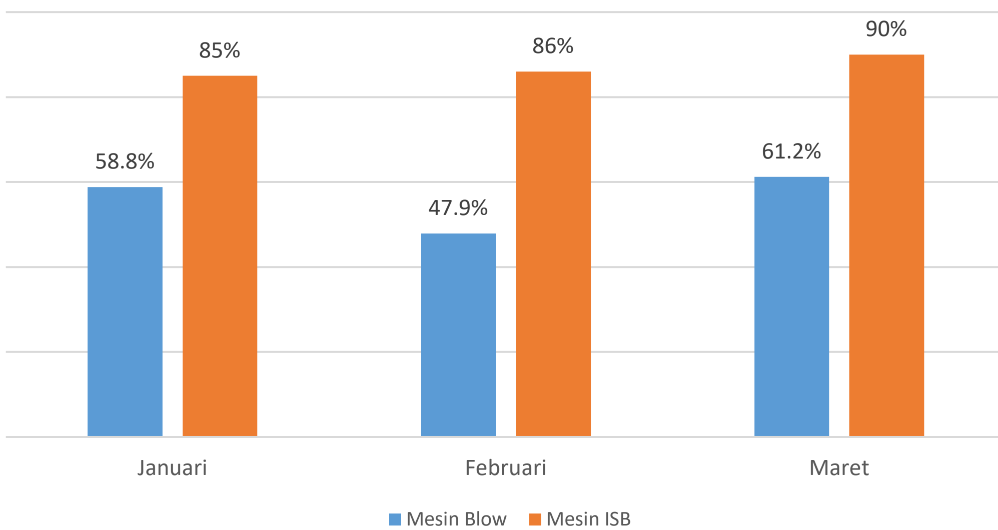

Figure 1. OEE Blow Machine and ISB Machine for January – March 2020 periode
(Source: Processed data)

Based on the data above, it can be seen that the engine performance measured using the OEE parameter indicates that the OEE of the Blow Machine is lower than the OEE of the ISB Machine. The average OEE of blow machines is 56% while the OEE of ISB machines is 87%. With the implementation of OEE, it is hoped that the effectiveness of engine performance can be measured so that with a reliable engine, it is able to meet product sales targets to meet market demand. With regard to the absence of OEE target setting in the company, and the actual average achievement of the blow machine's OEE value is still below the world-class company target of 85%, the researcher proposes to set OEE as an indicator to measure equipment efficiency, productivity and quality. Efficiency analysis and improvement is carried out by implementing TPM, where this method can be applied to plastic packaging industry companies that have not used this method through analysis of Six Big Losses improvement and application of FMEA (Failure Mode and Effect Analysis).

The research conducted has two objectives including:

1. Identify and analyze the causes of losses that affect engine performance through the application of TPM
2. Establish a corrective action plan through improvements that can be set, namely by FMEA (Failure Mode and Effect Analysis)

2. Literature Review

This research is supported by several previous studies that are relevant to the problems being discussed, the results of these previous studies can be used as supporting data or as reference material in this study. The following are a number of previous studies that the researcher considers relevant to be used as references in the research that the author will carry out.

The successful implementation of TPM depends on the implementation of several pillars such as 5S, Planned Maintenance, Jihsu Hozen, Quality Maintenance, Kaizen, Office TPM, SHE. Overall equipment effectiveness increased from 63% to 79%. Most of the damaged components are in the casting process. The key factors for TPM implementation are employee involvement and support from top management Singh et al. (2013). Mwanza & Mbohwa (2015) developed an effective TPM model to improve the quality of the maintenance system in a chemical manufacturing company in Zambia. The result is that 70.5% of employees are aware of the TPM concept, 14.7% of employees agree that the TPM concept helps improve the current maintenance system, 14 ,7% unsure. Of the 29.5% of employees who are not aware of TPM, 64.3% are not sure that the TPM concept can help improve the current maintenance system. Researchers propose knowledge and information sharing, operator involvement and training. Researchers design a TPM model that will result in an effective TPM implementation for higher competitiveness in a dynamic business environment. Kigsirisin et al. (2016) Implementation of the Eight pillars Strategy (EPS), to reduce equipment damage, reduce water loss, and increase equipment effectiveness. Failure rate (FR), availability (A), performance efficiency (PE), quality level (QR) are determined by evaluating the effectiveness of the equipment through OEE. As a result, the plant can produce a higher quantity of quality water for customers by monitoring the final water treatment process through profit cost (PC). The ISM framework is used to look at the interaction of various maintenance tools and techniques for performance improvement in Indian SMEs. MTT is organized into 6 levels. The network model establishes a reciprocal relationship between MTTs. The MICMAC analysis yielded the relative importance and interdependence among MTTs. The ISM-based model provides a better understanding of the linkages between MTTs to improve SME performance. However the ISM methodology is based on expert opinion, this framework requires further validation with empirical data and detailed case studies (Patidar et al. 2017). Through a comparison of the literature and actual cases in companies that have successfully implemented TPM, this research helps to understand the steps in implementing TPM (Shen 2015).

Raza & Ulansky (2017) apply Predictive Maintenance (PM), which is the most promising maintenance strategy to implement in the production line. The researcher succeeded in proposing a predictive maintenance mathematical model based on prognostic and health management. A new approach has been proposed to determine the optimal periodic predictive maintenance, which is based on the use of PDF of random errors in measurements. Numerical calculations have shown that predictive maintenance is more efficient than corrective maintenance because it provides a higher Availability Rate on a smaller number of checks. Azizi (2015) suggested SPC as a monitor function to evaluate process quality performance and seven basic tools were used to deal with variations in the manufacturing process. AM is implemented in the glazing production line to increase machine efficiency by giving more responsibility and authority to operators to perform more upgrades and precautions for their own machines. Defect rate data and machine performance in line glazing depend on each other. SPC contributed to the reduction of defects from 14.61% to 6.12% and the reduction of machine breakdown time from 2502 minutes to 1161 minutes, increasing the OEE value from 22.12% to 28.61%. Production productivity performance has been increased by implementing AM and reducing defect rates. Strong integration of SPC, OEE and AM is recommended to increase production productivity performance for the tile manufacturing industry.

Purba et al. (2018) implemented TPM in a manufacturing company for air conditioner filters for four wheels. The object of research is the cutting jig in the blow molding department. The need for the provision of spare parts and equipment supplies in term maintenance and maintenance is very important so that maintenance activities are not disrupted which will then harm the company itself. The company must pay more attention to the condition of the machine/equipment by estimating the time of damage through the calculation of the operating period to anticipate damage to the machine/equipment or replacement of components before damage occurs to the machine/equipment. Companies need to instill awareness in all employees to actively participate in increasing efficiency and productivity for themselves and the company. Esa & Yusof (2016) Knowing which variables have a significant correlation with the company's OEE that have an impact on company sustainability. There is a need for organizations to conform to world-class OEE standards. Managing OEE is one approach to ensure that production operations are reliable and able to satisfy customers and/or end users in general and ultimately, become a first-rate supplier to Proton and Perodua. This will be a way to ensure the company is competitive in the market as well as to comply with world standards.

Pascal et al. (2019) provides care management indicators that can assess the relevance of the actions taken and readjustment of the planned maintenance program. TPM is necessary to maximize equipment lifecycle and productivity. It is important to involve all relevant employees. The main point of the TPM policy is that various maintenance tasks are delegated to the operator and the resulting effect on the condition of the machine is then assessed. Another perspective of this research is to add other indicators of management, productivity, costs, spare parts. The goal is to offer experts all the information needed to make effective decisions. Rimawan et al. (2017) analyzed the implementation of TPM in order to determine the OEE value on the Komatsu PC200-8 Magnet Excavator heavy equipment and the type of grab in the company. The results of the study concluded that in each tool with different models of assistive devices can affect the OEE value in each instrument and of course this is influenced by other factors. Before and after repair, especially on one of the tools (P200-8 Excavator no 4) which has the lowest OEE value and steps are taken to increase the OEE value using the TPM, SMED and 5W1H methods, there is an increase in the OEE value of 6.61% for PC200 -8 Excavators no 4.

Jauregui Becker et al. (2015) conducted an analysis and measurement of OEE in a semiconductor industry company. No method for the High-Mix-Low-Volume (HMLV) job shop machining environment is present in the literature. The engine performance indicator as a substitute for OEE in this type of industry is by measuring the EEC. The test results for this method applied in the machining department of VDL ETG Almedo show that the EEC can be applied. The flow chart is provided to assist in determining the best areas for improvement. Maletič et al. (2012) The results of the study noted that 3.22% of profits were generated from weaving machines, due to an increase in productivity, the quality level will be increased by about 2%. The findings show that maintenance has an impact on product quality and company profitability. The researcher proposes further study of the mathematical model by adding more variables that can provide more information about the impact of maintenance on quality.

Hedman et al. (2016) identify critical factors and when to operate OEE measurements. The study identified critical factors that directly affect the accuracy and applicability of OEE measures when operating systems for automated measurement of manufacturing data. When measurements are automated, it is more important for companies not to shy away from managing the detailed characteristics of the manufacturing process. It remains to be seen the level of awareness among decision makers about OEE and how it affects policy decisions. Domingo & Aguado (2015) analyzed the combination of two indicators, namely between OEE and the concept of sustainability based on environmental impacts calculated from the complete product life cycle to Overall Environmental Equipment Effectiveness (OEEE). OEEE metric is presented as a solution to answer questions regarding green manufacturing and Lean and it is concluded that 1) OEEE is a new parameter that allows companies to include sustainability in business decisions; 2) OEEE shows the compatibility between green manufacturing and Lean, 3) OEEE provides new technologies to integrate sustainability practices into business decisions, 4) OEEE compares the environmental impactof the two aspects, and corrective actions have been made.

Based on previous research and various methods used, there is no method used, namely analysis and improvement of Six Big Losses through improvement and application of FMEA in the plastic packaging manufacturing industry which aims to improve machine/equipment performance in order to achieve the targets set by the company.

3. Methods

The research method in conducting this research, the author uses descriptive and verification methods. Descriptive research is research conducted to determine the value of independent variables, either one or more variables without making comparisons, or connecting with other variables studied and analyzed so as to produce conclusions. While verification research is a research that is intended to test theories, and research will try to produce new scientific information, namely the status of hypotheses in the form of temporary conclusions of research.

Based on the method of acquisition, the data obtained can be grouped into two types, as follows:

1. Primary data
   Primary data is a source of data that directly provides data to data collectors, this is obtained from direct observation through interviews or asking questions to company employees, company leaders and parties related to company activities.
2. Secondary Data
   Secondary data is information obtained not directly to data collectors. The results of this secondary data in the form of further data from primary data. It is used to support information from primary data through interviews or from literature studies.

Data collection techniques are the methods used to collect data and other information in research on the problem that is the object of research. Data collection techniques used in this study are:

1. Field Research
   The field survey was conducted to the company as the object of research. The purpose of this field research is to obtain accurate data through:
   a. Interview
      Direct interviews were conducted to several employees in the company with the aim of gathering the information needed or related to research so that it is expected to obtain clearer data.
   b. Observation
      Namely data collection is done by reviewing or visiting the company concerned directly, to record information related to the problem to be studied.
   c. Documentation
2. Library Research
   Collecting data or information by studying literature or sources related to the problem under study. Library studies can be obtained from secondary data, namely literature, books, related to the object under study and aims to find out theories that have to do with the problem to be studied.

4. Results and Discussion

4.1 Numerical Results

Based on data from blow machine production during 2020, the good part ratio is at 97.7% with details of a total good product of 246,625,311 units out of a total production of 252,604,268 units. Meanwhile, the number of defective products was 5,978,957 or equivalent to 2.4%. After calculating the production results then measuring the effectiveness of the blow machine. Measurement of machine effectiveness is carried out using the overall equipment effectiveness (OEE) method using three variables in the overall equipment effectiveness (OEE) calculation, namely availability rate, performance rate, and quality rate.

Availability ratio is a ratio that describes the utilization of the available time to carry out production activities. From the calculations that have been made, the availability ratio during January – December 2020, the lowest availability ratio occurred in May 2020, which was 76.5%. Meanwhile, the highest availability ratio occurred in December 2020, which was 88.2%. From table 1, it is known that the availability ratio every month from January to December 2020 has not met the ideal standard based on the JIPM, which is > 90%, which means that the availability ratio for the Blow Machine has not been maximized.

Performance Efficiency is a ratio that describes the ability of equipment to produce a product. From the calculations that have been made, Performance Efficiency is obtained that the average Performance Efficiency during January – December 2020 is 62.6%. The lowest Performance Efficiency occurred in June 2020 at 46.2% and the highest occurred in May 2020 at 88.1%. Meanwhile, when compared to the Performance Efficiency target in accordance with the JIPM guidelines, that is > 95%. Conclusions based on these data, the level of achievement of Performance Efficiency on average is still far from the ideal value expected by the company.

Quality rate is the ability of machines/equipment to produce products according to standards. From the calculations that have been done, the Quality Rate is obtained that the average value of the Quality Rate is 97.62%. The lowest

Quality Rate occurred in May 2020 at 97.0% and the highest Quality Rate occurred in November 2020 at 98.6%. From table 1, it can be seen that the Quality Rate of the Blow machine in the period January - December 2020 did not meet the JIPM standard, which is > 99%, meaning that the Quality Rate on the Blow Machine has not yet reached the ideal value.

To measure the effectiveness of the machine, especially the blow machine, it consists of 3 OEE variables, namely the Availability Rate x Performance Rate x Quality Rate value according to the OEE formula. From the calculations that have been carried out, it can be seen that the OEE value on the Blow Machine for the January - December 2020 period can be said to have not met the World Class Company. The highest OEE value is 65.4% in May 2020 and the lowest OEE value is 39.5% in June 2020. If it meets the following ideal criteria: Availability Rate > 90%, Performance Efficiency > 95%, Quality Rate > 99% and for the OEE indicator value > 85%.

Table 1. Data OEE Blow Machine January – December 2020

No.	Month	*Availability Rate*	*Performance Efficiency*	*Quality Rate*	OEE
1	January	83,4%	72,3%	97,4%	58,8%
2	February	83,4%	59,2%	97,0%	47,9%
3	March	82,0%	76,2%	97,9%	61,2%
4	April	85,6%	53,1%	97,3%	44,3%
5	May	76,5%	88,1%	97,1%	65,4%
6	Juny	87,8%	46,2%	97,5%	39,5%
7	July	82,1%	74,7%	97,3%	59,7%
8	August	82,8%	60,3%	97,7%	48,8%
9	September	84,1%	54,1%	97,8%	44,5%
10	October	83,6%	60,4%	98,2%	49,6%
11	November	85,1%	61,8%	98,6%	51,9%
12	December	88,2%	55,4%	98,2%	48,0%

4.2 Graphical Results

The next stage is to analyze the causes of the low OEE value. The calculation of six big losses is done to find out what factors cause the low OEE value of the blow machine. Six Big Losses consist of: Breakdown Losses, Setup and adjustment Losses, Startup Losses, Idle and Minor Stoppages Losses, Speed Losses and Defect Losses.
Breakdown Losses are categorized as downtime losses due to machine and equipment damage to unscheduled maintenance resulting in a lot of wasted production time. Breakdown Losses is a situation where machinery and equipment in production are damaged and cannot be used. Based on the calculation that the highest breakdown losses occurred in May 2020, which was 15.7%, while the lowest breakdown losses occurred in December 2020, which was 7.5%. With a total Breakdown Time during the January - December 2020 period of 15,849 hours.
Set up and adjustment losses are categorized as downtime losses due to time losses caused by preparation before the machine is operated. In general, this is done for product changeovers, or adjustments to ensure settings on the machine. Based on the calculation of Setup and Adjustment Losses that the highest value occurred in May 2020, which was 7.5%, while the lowest Setup and Adjustment Losses occurred in June 2020, which was 3.3%. The average Setup and Adjustment losses during January – December 2020 is 5.6% with a total setup time of 8,752 hours.

Start up losses are categorized as downtime losses due to time losses caused by preparation before the machine starts to be used for the production process. This activity is often referred to as Run in, which is a time lag for the engine warm-up process. Usually done after the engine stops for a long time / long holidays. Based on the results of the Start up Losses calculation that the highest value occurred in July 2020, which was 0.81%, while the lowest Start up Losses occurred in April 2020, which was 0.16%. The average Startup Losses during January - December 2020 is 0.45% with a total start up time of 715.32 hours. One of the losses caused by the waiting period or because the machine stops momentarily and occurs repeatedly is referred to as Idling and Minor Stoppages losses. Based on the calculation results of Idling and Minor Stoppages losses, on average, Idling and Minor Stoppages losses during January – December 2020 are 1.15% with a total Minor Stop time of 1,807.20 hours.

Categorized as speed losses due to a decrease in process speed caused by several things, for example, the engine is thirsty, engine performance is below the expected capacity and operator inefficiency when working. Based on the results of the reduced speed losses calculation, the average reduced speed losses during January – December 2020 was 6.89% with a total time of 10,851 hours.

Defects in the process will be related to the cost of rework or rework in the blow machine process. Based on the results of the calculation of the number of defects, the average rework losses during January - December 2020 is 2.3% with a total defect of 15,502 units.

To determine the selection of improvement priorities, Pareto diagram tools are used. The first step is to make a Pareto diagram of the six big losses. Then a Pareto diagram for the breakdown of each machine and the last is a Pareto diagram for the type of problem on the machine whose damage is dominant. Based on the Pareto diagram, it can be seen that Brekdown Losses is the dominant factor, which is 36.4% of the total six big losses, so it is necessary to further analyze which machines experience the most dominant breakdown losses.
The next step is to analyze using a fishbone diagram, with a cause-and-effect diagram to trace the causes of breakdown losses on the blow machine. The causes of breakdown losses consist of 5 elements: man, machine, method, environment, material.

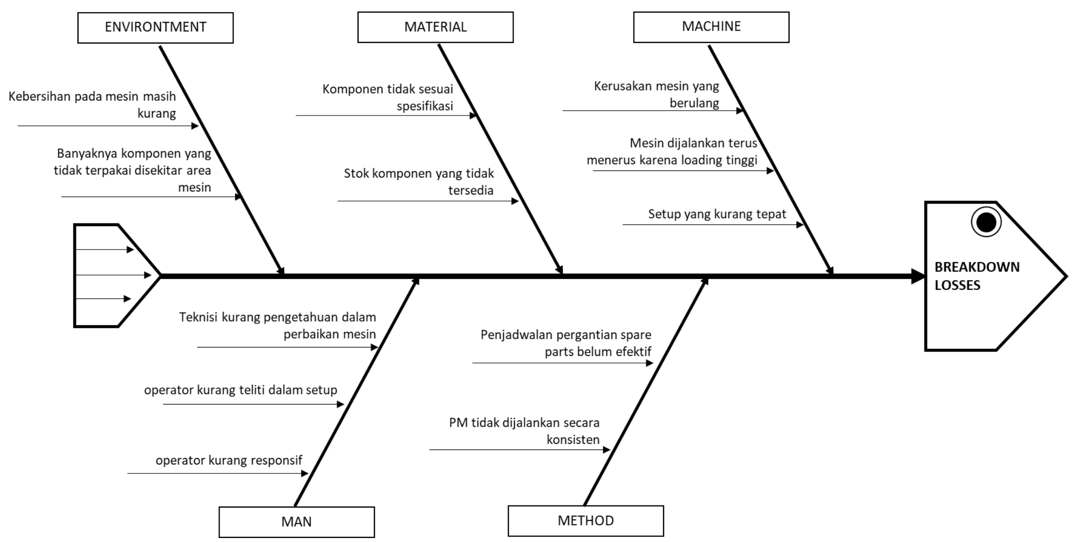

Figure 2. Fishbone Diagram Possible Root Cause

The following is an explanation of the causal analysis based on the cause and effect diagram (fishbone) above (figure 2)

1. Man/operator
   a. Operators are less responsive in carrying out maintenance on engine cleanliness which results in engine disruption or engine stopping suddenly (breakdown).
   b. The operator is not careful in setting up the machine so that the machine stops while operating for re-setup.
   c. An error occurred in repairing the blow machine because the technician did not understand how to deal with damage to each component.
2. Machine/equipment
   a. Machines often experience breakdowns due to lack of maintenance carried out, this can be seen in the Planned Maintenance Cycle data, which is not carried out every month, only once every 3 months. And adapted to the existing loading in the production section.

b. The machine is still operated even though it is known that there is a minor damage which requires immediate maintenance or component replacement.
c. Set up the machine is not correct, this can cause some components to wear out quickly.

3. Environment
   a. Cleanliness on the machine is less visible on components such as tie rods and mold dies, it seems that there is still lack of maintenance so that clamping compression is reduced.
   b. The large pile of unused components around the blow machine results in inefficient operator work due to poor location arrangements.
   c. The rest of the product cutting is scattered inside the machine.
   d. There is oil seepage/splatter around the bottom of the engine.

4. Methods
   a. Preventive Maintenance (PM) is carried out often not according to the procedures, tools and materials used to perform PM.
   b. Scheduling for component replacement has not been effective, usually the replacement of engine components is carried out when only the engine components are damaged.
   c. There are still some check points that are lacking in the PM checklist, so that some components cannot be detected in their condition.
   d. There is no implementation of Autonomous Maintenance by production operators, so the responsibility for machine maintenance is only the Maintenance department.

5. Material/Spare Part
   a. The engine specifications are not correct to maintain engine performance and do not waste raw materials, in this case the Tie Rod. Because at the time of change order, material replacement on the blow machine is in accordance with the product specifications requested by the customer.
   b. Seals and O-rings often have minimal stock of raw materials where it takes 1-2 weeks to order these spare parts.

From the various root causes of the breakdown problem that have been found, it is then necessary to determine the priority level in taking corrective actions. The method used to determine the priority level is FMEA (Failure Mode and Effect Analysis).

4.3 Proposed Improvements

Corrective actions were taken on the four highest sources of problems, namely the stock of components that were not available which became the main priority for the following corrective steps:

1. Stock of spare parts that are not available
   Based on maintenance data, seal/o-ring needs are the most widely used during the Blow engine repair process or during the Preventive Maintenance (PM) process. This damage generally occurs in the compression engine where there are many seals/o-rings that are no longer suitable for use or have been decompressed.
   The need for the seal/O-Ring used is calculated by determining the Safety Stock using the Seal/O-ring for one year. Type seals/O-Rings are grouped into 4 groups. Data usage for 8 weeks with a service level of 95%, the value of Z = 1.64, with a lead time of order is 2 weeks.
   With the stipulation of the safety stock, the need for seals/o-rings during the PM period per 3 months can be met so that there is no shortage of spare parts, which are mostly needed for blow machines, mainly on the compression part of the engine as the main tool.
   Using the seal/o-ring recommendation from the manufacturer or OEM product so that the service life of the seal/o-ring is in accordance with the manual book so that it can be predicted when the seal/o-ring must be replaced without waiting for engine damage. The seal/O-ring used is standardized using the Viton type with a shore value of min. 80 units.

2. PM is not conducted consistently

PM is not carried out consistently because the functions and responsibilities of implementing PM are only charged to the maintenance department. There is no involvement of production operators as machine users, so the corrective steps taken are:

a. Autonomous Maintenance implementation
Immediate steps taken for the implementation of autonomous maintenance by making rules that include:
First phase: In this phase the team will carry out maintenance on the machine and keep it in excellent condition by carrying out restoration and eliminating the causes of damage/machine failure and sources of engine contamination. At this stage, the team should be introduced to the standards governing cleaning, inspection, tightening and lubrication activities to ensure the machine is in good condition..

Second phase: In this phase the team will receive detailed training on operational principles so that their knowledge and skills regarding machine repair will increase. After passing this phase, the team is expected to understand how to improve the condition of the engine to keep it at standard performance.

b. The Maintenance Department revises the procedures and work instructions in coordination with the Planner and Production so that the PM implementation can be carried out according to the PM schedule. Where the PM schedule is changed from per 3 months to per month.
PM schedule changes from 3 months to monthly so as not to interfere with the production targets set by the planner. Taking into account the number of technicians and the PM time required. So the change to monthly is expected to be able to optimize PM results because they are not in a hurry in the process.

c. Planner and Production department recalculate production capacity by considering PM time which is scheduled at the end of the year to be implemented in the following year.

3. Spare parts replacement scheduling has not been effective
   a. Replacement of spare parts is carried out according to the PM schedule given by the maintenance party.
   b. Maintenance ensures the availability of spare parts stock by determining the Safety Stock spare parts that are most often used and have a service life in accordance with the blow machine manufacturer's recommendations.
   c.
4. Components do not meet specifications
   a. All spare parts or components of the blow machine must use OEM products from the manufacturer, especially the main engine components.
   b. Spare parts or components that are general in nature are ordered from local suppliers by considering the quality, duration of order and price. The appointed local supplier has passed the assessment process as the company's Approved Vendor List (AVL).
   c.

After the improvement step, the OEE value is calculated again by multiplying the availability x performance efficiency x quality rate. Where these values are the accumulated percentage of each parameter during July - October 2021 as in Table 2. It can be seen in Table 2 that the average value of OEE for 4 months (July – October 2021) is 62.2% with details of the average value of Availability = 86.4%, Performance Efficiency = 73.9% and Quality Rate = 97,4%.

Table 2. OEE After Improvement

Parameter	July	August	September	October	Average
Availability	90,4%	83,4%	86,0%	85,6%	86,4%
Performance Efficiency	73,0%	73,2%	75,6%	73,8%	73,9%
Quality Rate	97,4%	98,2%	97,0%	97,1%	97,4%
OEE	64,3%	60,0%	63,1%	61,3%	62,2%

Meanwhile, when compared between the OEE values before and after repairs can be seen in the table 3. The OEE value before repair was 51.6% and after improvement was 62.2%. It can be seen that there is an increase in the OEE value even though it still cannot reach the ideal OEE value according to the World Class Company, which is 85%.

Table 3. Comparison of OEE Before and After Improvement

Parameter	Before Improvement	After Improvement	World Class Manufacturing
Availability	83,7%	86,4%	90%
Performance Efficiency	63,5%	73,9%	95%
Quality Rate	97,7%	97,4%	99.9%
OEE	51,6%	62,2%	85%

These findings have analyzed the impact of root causes on the achievement of OEE scores. As well as corrective steps taken to eliminate Six Big Losses as an effort to improve the performance of the blow machine. That the corrective steps taken were able to increase the value of the availability rate on the blow machine. It is known that the availability value achieved has increased but is still below the World Class Manufacturing Standard. Availability value achieved is 86.5% where the availability value according to World Class Manufacturing Standard is 90%. This shows that the occurrence of downtime on the blow machine has not been completely resolved and further corrective action is needed. The performance efficiency value achieved is still below the World Class Manufacturing Standard. The value of performance efficiency achieved is 73.9% where the availability value according to Standard World Class Manufacturing is 95%. This shows that the blow machine is still often idle and the engine speed is below the specified cycle time standard. This affects the low achievement of the value of performance efficiency. The quality rate achieved is still below the World Class Manufacturing Standard. The quality rate value achieved is 97.4% where the quality rate value according to Standard World Class Manufacturing is 99.9%. This shows that quality problems are still found in the products produced by the blow machine. However, on average the defects that occur tend to be constant both before and after the repair step. So that the corrective steps have not been focused on handling non conformance products.

Based on the three OEE parameters above, the current OEE value is 62.2%. The achievement of this OEE value is still below the World Class Manufacturing Standard of 85.4%. This shows that the blow machine performance is still low after the repair step even though there has been an increase before the repair step. The most influential factor on the achievement of the OEE value is performance efficiency. This illustrates that the use of the blow machine is not maximized because breakdowns are still found.

5. Conclusion

The conclusions of this research activity are:

1. The low OEE value is caused by high losses in the blow machine and the root causes of the problems found include:
   a) Stock of spare parts that are not available
   b) PM is not conducted consistently
   c) Spare parts replacement scheduling has not been effective
   d) Spare part components do not meet specifications
2. Improvement efforts made are by performing autonomous maintenance, changing the PM frequency from 3 months to 1 month and making good spare parts stock planning by determining the minimum spare part stock that must be met.

Based on the results of the research that has been concluded above and in an effort to improve the performance of this blow machine, several suggestions are submitted for further research:

1. The implementation of Total Productive Maintenance (TPM) is very important to maintain machine performance in accordance with the initial design of the factory. This will be able to reduce losses on the machine such as breakdown losses. TPM must be run with a high commitment from the maintenance department.
2. The blow machine operator is advised to be able to run the machine optimally according to the work instructions that have been made. In addition, the blow machine operator must carry out autonomous maintenance consistently so that the engine performance is better.

3. Companies must carry out regular monitoring and control of engine performance indicators through achieving OEE values and their implications for Six Big Losses.
4. For further research, this research is to improve performance efficiency by looking at other factors that may still have not been explored in this study as a result of the limited time of the study and the object of the research itself.

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