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# Analysis of Overall Equipment Effectiveness and Failure Mode of Boiler at PT. Indo Acidatama.

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***ABSTRACT :****PT. Indo Acidatama is a Go Public company engaged in the Agro Chemical Industry that produces hazardous chemicals, including Ethanol and Organic Fertilizers. Boiler engine is a closed vessel that can efficiently convert water into steam with the help of heat. The company has implemented preventive maintenance and predictive maintenance. The purpose of this study is to reduce downtime, determine the causes of losses, increase effectiveness and determine the factors that influence OEE on Six Big Losses. The Overall Equipment Effectiveness (OEE) method serves to identify by measuring the effectiveness of using an equipment or system. The Failure Mode and Effect Analysis (FMEA) method aims to identify and assess the risks associated with potential failures. Based on the results of data processing, the effectiveness of the machine using the OEE method on the Basuki boiler in 2019 and 2020 was 85.336% and 84.914%, while in the Alstom 1 boiler in 2019 and 2020 it was 89.738% and 87.507%, respectively. In the Basuki and Alstom 1 boilers, the results of the correlation analysis have a significant effect between Six Big Losses on the OEE value, the influencing factors of the value are Reduce Speed Losses, Equipment Failure Losses and Setup and Adjustment Losses. FMEA based on the analysis of the failure mode, there are 10 failure mode items on the Basuki boiler and 9 failure mode items on the Alstom 1 boiler. Evaluation on the Basuki boiler engine and the Alstom 1 boiler is carried out in the form of periodic maintenance, adding predictive maintenance lists, adding safety to the fire pipe, replacing gasket/seal on the FP, the addition of a control valve on the FWT and breakdown maintenance on the scrubber.*

***KEYWORDS: Failure analysis, Fishbone diagram, Overall equipment effectiveness, Six big losses***

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## I. INTRODUCTION

PT. Indo Acidatama is a Go Public company engaged in the Agro Chemical Industry that produces hazardous chemicals with modern and sophisticated equipment so that it is able to process molasses as a by-product of sugar factories into chemical products that have high economic value. The main products produced at PT. Indo Acidatama, including Ethanol and Organic Fertilizers. One of the causes of not optimal production is high equipment losses. The readiness of production machines is the main thing for production activities, with good machines the products produced will be in accordance with the quality standards and targets set [5]. The boiler engine is a closed vessel that can efficiently convert water into steam with the help of heat from the coal combustion process which will then be supplied to the steam produced to the production section. Machines that often work outside normal limits can reduce production capacity, reduce machine life and speed up replacement of spare parts due to damage [2].The results of interviews conducted at PT. Indo Acidatama, OEE data in 2018 for the Basuki Boiler engine was 87.571%, while the Alstom 1 Boiler engine had an OEE value of 86.331%. This research focuses on the two boiler machines which have been operating for approximately 15 years. The purpose of this study is to reduce downtime, determine the causes of losses, increase effectiveness and determine the factors that influence OEE on Six big Losses. The Basuki and Alstom 1 boiler engines have downtime due to damage and suddenly die when the boiler engine is in the process of producing steam. As a result of the cessation of the two boiler engines, the steam supply will decrease by 25 tons/hour due to damage or sudden death in both boilers.One way to prevent damage is to perform maintenance. Maintenance is a function that monitors and maintains factory facilities, equipment, and work facilities by designing, managing, handling, and inspecting work to ensure the function of the unit during uptime and minimize downtime caused

by damage as well as improvements [3]. PT. Indo Acidatama has implemented preventive maintenance and predictive maintenance for machine maintenance every month, but the preventive maintenance and predictive maintenance methods that do not eliminate downtime.

One method of measuring the performance of a machine that is widely used by companies, which is able to overcome the above problems is Overall Equipment Effectiveness (OEE). The OEE method serves to identify by measuring the effectiveness of using an equipment or system. The OEE value obtained later can be used as a reference for the implementation of maintenance policies where OEE has a standard value of 85%). The Failure Mode and Effect Analysis (FMEA) method is a method that aims to evaluate the system design by considering various types of failures from the system consisting of components, analyzing the effects on system reliability by tracing the effects of component failure in accordance with the following: the level of specific items of a critical system can be assessed and the necessary actions to improve the design and eliminate or reduce the probability of critical failure methods [1].

## II. MATERIAL AND METHOD

Maintenance is the conception of all activities needed to maintain or maintain the quality of the facility/machine so that it can function properly as in its initial condition [1]. The maintenance process as a concise transformation process in the company's system that is carried out will affect the level of availability of production facilities, production rates, end product quality, production costs and operating safety. The maintenance process carried out not only helps smooth production, but also keeps facilities and equipment in an effective and efficient manner with the aim of realizing zero breakdown (zero breakdown) on operating machines. Maintenance can be classified into planned maintenance, unplanned maintenance and autonomous maintenance. Planned maintenance is an organized maintenance that is carried out with forethought, control and recording according to a predetermined plan. The maintenance program carried out must be dynamic. Planned maintenance is divided into three forms of implementation according to [6], namely:

***Preventive Maintenance***

Preventive maintenance is an activity of periodic inspection of machines and equipment with the aim of knowing the conditions that cause damage, as well as to maintain machines and equipment that have been damaged by repairing and resetting them before they become more severe damage.

***Corrective Maintenance***

Corrective maintenance is an activity carried out to overcome the failure or damage found during the preventive maintenance period.

***Predictive Maintenance***

Predictive maintenance is a maintenance activity carried out on a predetermined date based on the results of predictive analysis and evaluation of operating data taken to perform predictive maintenance, which can be in the form of vibration data, temperature, vibration flow rate and others.

**Overall Equipment Effectiveness(OEE).**

Overall Equipment Effectiveness (OEE) is a method used as a measuring tool (metric) in the application of the TPM program to maintain equipment in ideal condition by eliminating the Six Big Losses of equipment. In addition to measuring the performance of a productive system. The ability to clearly identify the root of the problem and the contributing factors so as to make improvement efforts focused is the main factor that this method is applied thoroughly by many companies in the world [1]. OEE calculation is done by calculating the value of availability, performance efficiency and quality rate. The following is the calculation formula for the three ratios:

$$Availability = \frac{loading\ \ time - downtime}{loading\ \ time} x\ 100\% \quad (1)$$

$$\text{Performance} = \frac{total\ \ production\ \ x\ Ideal\ \ cycle\ \ time}{operation\ \ time}\ x\ 100\% \quad (2)$$

$$\text{Quality Rate} = \frac{total\ \ production\ \ - defect}{total\ \ production} x\ 100\% \quad (3)$$

The mathematical formula of the OEE concept is formulated as follows:

$$\text{OEE} = \text{Availability x Performance x Qualityx100\%} \quad (4)$$

**Six Big Losses**

Efficiency is a process characteristic that measures the actual performance of resources relative to a set standard. While effectiveness is another characteristic of the process that measures the degree of achievement of the production system output. Effectiveness is measured by the ratio of the actual output to the planned output.

There are six equipment losses that cause low performance of machines and equipment. The six losses are known as six big losses. The 6 (six) losses according to [1] are: equipment failure, setup and adjustment, idling and minor stoppages, reduced speed, defects in process and finally reduced yields.

**Fishbone Diagram**

Fishbone Diagram is a structured approach that allows a more detailed analysis to find the cause of a problem, discrepancies and gaps that exist. The factors that cause deviations in the quality of work results, people will always find that there are 5 significant main causes that need to be considered Human (men), work method (work method), machine/work equipment (machine/equipment), raw materials (material) and the work environment according to [4].

**Failure Mode and Effect Analysis (FMEA)**

Failure Mode and Effect Analysis (FMEA) is a method that aims to evaluate the system design by considering various types of failure of the system consisting of components, analyzing the effects on system reliability by tracing the effects of component failure according to the level Specific items of critical systems can be assessed and the necessary actions to improve the design and eliminate or reduce the probability of critical failure methods [1]. In FMEA, a risk priority number (RPN) can be calculated to determine the highest failure rate. RPN is the relationship between three variables, namely Severity (Severity), Occurrence (Frequency of Events) and Detection (Failure Detection) which indicates the level of risk that leads to corrective action.

Risk Priority Number = Severity x Occurrent x Detection (5)

**Boiler**

Boiler or commonly called a steam boiler is a closed vessel that is used to convert water into steam or in other words transfer the heat generated by the combustion of fuel (whether in solid, liquid, or gaseous form) so that it turns into steam. At PT. Indo Acidatama, boiler is in charge of providing steam by heating soft water to become steam to serve plant needs.

The steps carried out in this research are identification of problems to find out problems regarding the effectiveness of the boiler engine. Then carry out the process of collecting the necessary data in the form of total production data, planned downtime, loading time, downtime, ideal cycle time, actual cycle time, operating time, defect amount, Severity, Occurrence and Detectability values on the Basuki Boiler and Alstom 1 Boilers. in 2 (two) years, namely 2019 and 2020 related to the main issues discussed. After that, perform data processing by measuring the value of availability, performance efficiency and quality rate to calculate the OEE value. Furthermore, to find out the six equipment losses that cause the low performance of the boiler machine by calculating the six big losses and knowing what factors affect the OEE value, after knowing the value of the six big losses, it is analyzed using a fishbone diagram and to evaluate the maintenance method for the causes of losses, use the method FMEA.

## III. RESULTS AND DISCUSSION

***Availability***

Availability is a comparison between the actual machine operating time and the planned machine operating time. Availability is the relationship between how much loading time is available minus downtime. The higher the availability value, the better the OEE value of the machine. The formula in calculating Availability uses the formula in equation (1).

**Table 1. Data *Availability***

| *Boiler* | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| | *Loading Time* (Hour) | | *Downtime* (Hour) | | *Availability* (%) | |
| Basuki | 7844 | 8256 | 195 | 403 | 97.108 | 94.991 |
| Alstom 1 | 8184 | 8216 | 191 | 256 | 97.252 | 96.660 |

***Performance Efficiency***

Performance Efficiency is a ratio that shows the ability of equipment to produce goods. The data used in measuring Performance Efficiency are Output, Ideal Cycle Time and Operating Time. Performance efficiency

analysis is intended to determine the extent to which the efficiency of a machine used for the production process. The formula for calculating Performance Efficiency uses the formula in equation (2).

**Table 2. Data *Performance Efficiency***

| *Boiler* | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|
| | Total Production(Ton) | | *Ideal Cycle Time* (Ton/Hour) | | *Operating Time* (Hour) | | *Performance Efficiency* (%) | |
| Basuki | 81,499.1338 | 82,479.000 | 1.034 | 1.033 | 7649 | 7853 | 87.962 | 89.231 |
| Alstom 1 | 88,770.633 | 110,658.7964 | 1.086 | 0.817 | 7993 | 7960 | 92.268 | 90.502 |

***Quantity Rate***

Quality Rate is a ratio that indicates the ability of equipment to produce products that comply with standards. The data used in the calculation of the quality rate is the total production data and product defects. The formula in calculating the Quality Rate uses the formula in equation (3).

**Table 3. Data *Quality Rate***

| *Boiler* | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
|---|---|---|---|---|---|---|
| | Total Production(Ton) | | *Product Defect* (Hour) | | *Quality Rate* (%) | |
| Basuki | 81,499.1338 | 82,479.000 | 0 | 0 | 100 | 100 |
| Alstom 1 | 88,770.633 | 110,658.7964 | 0 | 0 | 100 | 100 |

***Value Calculation of Overall Equipment Effectiveness(OEE)***

After obtaining the values of availability, performance efficiency and quality rate, it can be calculated the value of effectiveness using the Overall Equipment Effectiveness (OEE) method. OEE calculation is multiplication data of availability, performance efficiency and quality rate. In the Basuki boiler and the Alstom 1 boiler, the OEE value is obtained using equation (4).

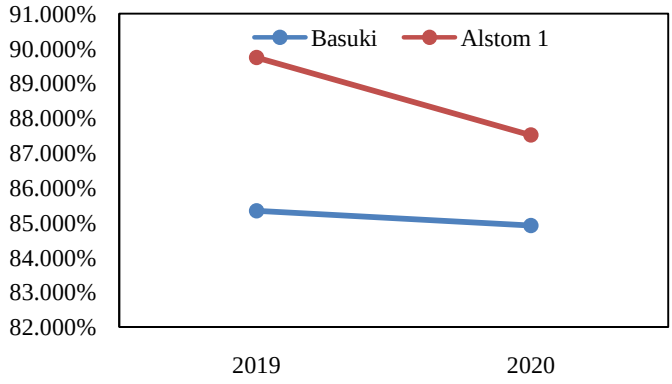


**Fig. 1. Basuki and Alstom 1 OEE Boiler**

***Analysis of Six Big Losses***

The calculation of Six Big Losses is useful for identifying losses, such as loss of equipment damage, loss of preparation or adjustment, loss of loss of speed, or loss of product damage. Six big losses analysis is used to determine the losses that occurred at PT. Indo Acidatama. The following is a picture of the six big losses in the Basuki boiler machine and the Alstom 1 boiler.

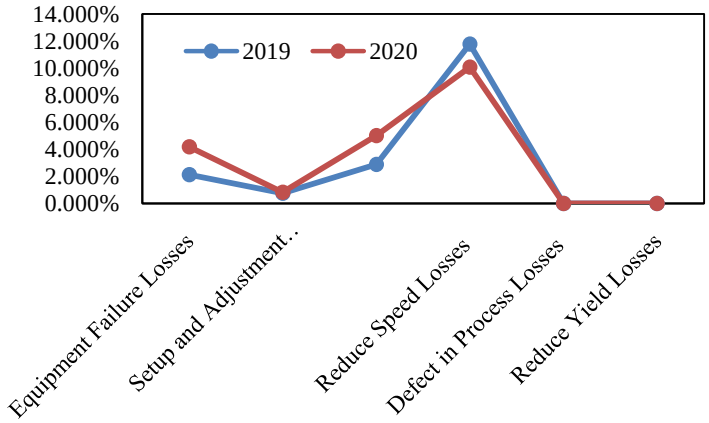


**Fig. 2, Basuki Six Big Losses Boiler**

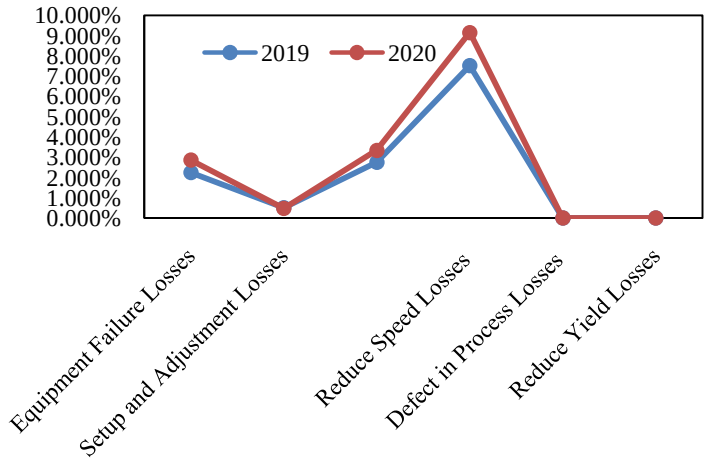


**Fig. 3. Alstom 1 Six Big Losses Boiler Machine**

***Failure Mode Analysis and Effect Analysis***

The results of Failure Mode Analysis and Effect Analysis show that the RPN value will then be ranked. The results of the RPN value ranking will be used for proposed improvements.

**Table 4. Rank ofRPN Basuki Boiler**

| Item | Failure Mode | RPN | Rank |
|---|---|---|---|
| Screw Feeding | Blocked by stones, bent threads and worn chains | 294 | 1 |
| Induced Draft Fan | Damaged motor, fan belt and bearing | 252 | 2 |
| Fire Pipe | Leaky pipe | 192 | 3 |
| Feed Water Tank | Over flow | 70 | 4 |
| Forced Draft Fan | Damaged motor, fan belts and bearing | 60 | 5 |
| Scrubber | Nozzle clogged, scrubber pump off | 60 | 6 |
| Feed Pump | Feed pump air intake | 48 | 7 |
| Water Pipe | Leaky pipe | 42 | 8 |
| Feed Water Tank | Limit water | 35 | 9 |
| Feed Pump | Feed pump is not working | 14 | 10 |

**Table 5 Rank ofRPN Alstom 1 Boiler**

| Item | Failure Mode | RPN | Rank |
|---|---|---|---|
| Induced Draft Fan | Damaged motor, fan belt and bearing | 216 | 1 |
| Chain Grate | Jamed/does not work. | 200 | 2 |
| Fire Pipe | Leaky pipe | 96 | 3 |
| Feed Pump | Feed pump is not working. | 90 | 4 |
| Guillotine Door | Broken steel rope | 72 | 5 |
| Feed Water Tank | Over flow | 70 | 6 |
| Feed Water Tank | Limit water | 35 | 7 |
| Feed Pump | Feed pump air intake | 16 | 8 |
| Forced Draft Fan | Damaged motor, fan belt and bearing | 8 | 9 |

In reducing the value of downtime and minimizing the occurrence of breakdown time, suggestions for improvement will be made to reduce the failure mode. Proposed improvements in the form of periodic maintenance before wear occurs on the chain and causes the thread to bend and spare parts are provided to replace if needed on screw feeding, re-check in predictive maintenance and repair/provided spare parts to replace damaged components in the IDF and FDF and feed pump , given safety on the fire pipe to make it thicker to minimize friction between the fire and ash pipes, added for sensors and accuators in the form of automatic control valves on the feed water tank, breakdown maintenance was carried out to clean clogged nozzles and repair/check the scrubber pump, replace leaking gasket/seal that causes air to enter the feed pump and periodic maintenance is carried out on the chain grate and guillotine door.

## IV. CONCLUSION

Downtime that occurred on the Basuki boiler machine in 2019 was 195 hours and in 2020 it was 403 hours. While the Alstom 1 boiler engine in 2019 was 191 hours and in 2020 it was 256 hours. So that the OEE produced on the Basuki boiler engine in 2019 was 85.336% and in 2020 it was 84.914%. While the Alstom 1 boiler engine in 2019 was 89.738% and in 2020 it was 87.507%. In the fishbone diagram, the cause of engine damage in the Basuki boiler is because the boiler's service life is more than 15 years so that there is a problem with the panel/error indicator, leaking water pipe, leaking fire pipe, screw feeding trouble, damaged IDF. Meanwhile, in the Alstom 1 boiler, due to the boiler's service life which is more than 15 years, there is a problem with the panel/error indicator, chain grate, leaking fire pipe, guillotine door, damaged IDF.

The Failure Mode and Effect Analysis (FMEA) method in the analysis of the mode of failure based on the results of the RPN value contains 10 failure mode items on the Basuki boiler machine. Then the analysis of the mode of failure based on the results of the RPN value, there are 9 failure mode items on the Alstom 1 boiler machine. Evaluation on the Basuki boiler engine and the Alstom 1 boiler is carried out in the form of periodic maintenance, adding predictive maintenance lists and re-checking, adding safety to the fire pipe, replacing gaskets/seal on the feed pump, adding a control valve to the feed water tank and performing breakdown maintenance on the scrubber. Factors that influence the value of Six Big Losses on the OEE value are Reduce Speed Losses, Equipment Failure Losses and Setup and Adjustment Losses.

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