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Over all Equipment Effectiveness (OEE) Measurement Analysis on Gas Power Plant with Analysis of Six Big Losses

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Abstract: *The purpose of this study is to determine the effectiveness of the gas turbine engine work through the value of OEE (availability, performance, quality) and identify losses affecting the OEE value of the gas turbine engine. The method used is a descriptive analysis, which exposes availability, performance and quality of gas turbine engines based on actual data and information by collecting, compiling, classifying and analyzing data and information about the effectiveness of gas turbine engines. The results of the OEE are analyzed using the six big losses method to find the loss factor, root cause analysis using the Fishbone diagram and make improvement recommendations using the 5 why analysis method. Based on the research results, the OEE value of two gas turbine affected by the loss factor which are reduce speed losses, rework losses and breakdown The root of the problem comes from various causes, among others, the setting of the production capacity poorly, the maintenance schedule is still not correct, the operator's competence and knowledge are still lacking, and the technical problems in the gas turbine engines.*

Keywords: *OEE, gas turbine, six big losses,*

I. INTRODUCTION

The power generation industry is an important sector in national development as a provider of electricity for the community, offices and industry. High competition in the manufacturing and service industries, the higher the demand for electricity. Therefore, every company must have continuous improvements in each department to be able to compete (Hermanto, 2016). PT Dian Swastatika Sentosa Tangerang unit is a private company engaged in the supply of electricity and steam where electricity and steam produced are distributed to the paper mill of PT. Indah Kiat Pulp & Paper Tangerang for the process of making paper.

In power generation, it has a requirement to produce electricity with the maximum capacity that can be reached and operates in high operational time. Declining power production occurs where the engine breaks down or fails to distribute. One concept that can be used to measure the level of effectiveness of production is the Overall Equipment Effectiveness (OEE) method. Achievement of OEE values is influenced by various factors, namely Availability, Performance, and Quality (Stamatis, 2010: 22).Sal

One of the performance values to be achieved by PT DSS is zero unplanned shutdown and zero restriction for electricity and steam production. Figure 1 shows the frequent failures in the electricity and steam production process which is a problem for companies where in 2015 there were 17 breakdowns, 2016 there were 22 breakdowns and 2017 there were 21 breakdowns. Gas turbine engines as the main engine in the process of electricity generation are often breakdown which inhibits the fulfillment of electricity needs and impact to production process of the customer (PT Indah Kiat Tangerang).

High loss in electricity production in a gas turbine engine (Figure 2) as a result of damage at the engine and electricity production being unable to achieve the performance value that is zero unplanned shutdown and zero restriction.

One way to improve engine performance to be more effective and product quality is to apply the concept of Total Productive Maintenance (TPM) (Boban & Joseph, 2013). In this case the tools used to measure engine performance are by using Overall Equipment Effectiveness (OEE) and six big loses analysis to determine the factors that cause failure (losess) in order to make improvements.

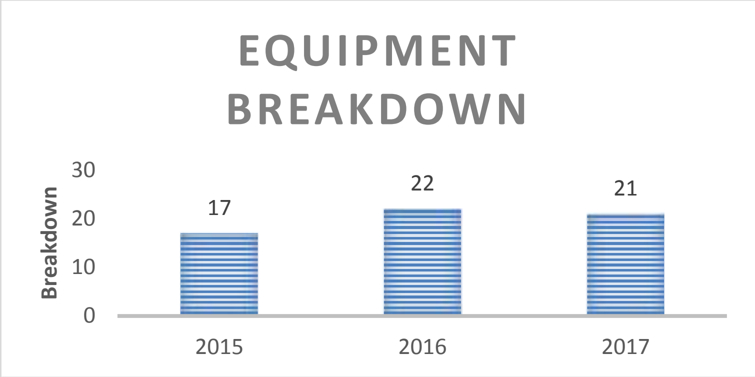

Fig. 1. Equipment Breakdown year 2015-2017

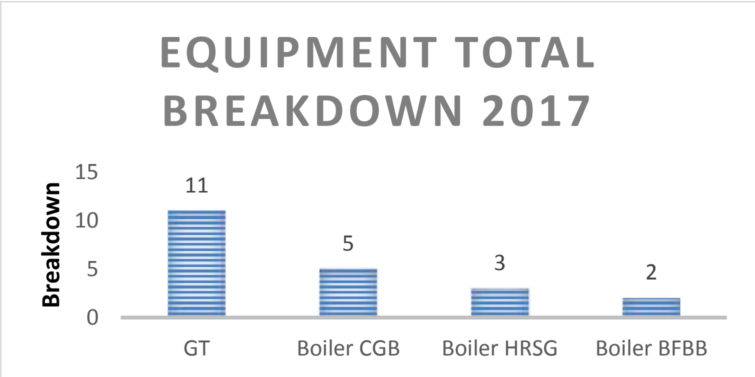

Fig. 2 Total Breakdown Equipment year 2017

II. LITERATURE REVIEW

Maintenance Management, According to Samat (2011), Maintenance includes all activities related to maintaining facilities and equipment in good condition and making necessary repairs when damage occurs so that the system can run as expected. Industrial maintenance management is an effort to regulate activities to maintain production sustainability, in order to be able to produce quality products and have competitiveness, through the maintenance of industrial facilities (Kurniawan 2013: 2).

Overall Equipment Effectiveness (OEE) is a comprehensive measure that indicates the level of machine / equipment productivity and performance in theory. This measurement is very important to know which areas need to be increased in productivity or efficiency of the machine / equipment and can also show the bottleneck area on the production line (Stamatis, 2010). OEE is also a measuring tool to evaluate and provide ways that can guarantee increased productivity of machinery / equipment (Azwar, 2014).

Total Production Maintenance (TPM) is a program for the fundamental development of the maintenance function in an organization, which involves all of its human resources. If applied as a whole, TPM will be able to increase productivity, quality, and minimize costs (Kurniawan, 2013). Total Productive Maintenance (TPM) aims to maximize the effectiveness of equipment used in the industry, which is not focused only on maintenance but on all aspects of operations including to increase the motivation of workers in the company (Iftari, 2015).

Six Big Losses. six major losses of Big Six Losses (Iftary, 2015) and (Rimawan & Raif, 2016) are as follows:

1. Equipment failure / breakdown losses, categorized as time losses due to decreased productivity and quality losses due to engine failure.
2. Set-up / adjustment time losses is the result of defects that occur when engine production must be reset.

3. Idling and minor stop losses occur when production is interrupted by a temporary malfunction or a machine that is stopping.
4. Reduced speed losses is the difference between design speed and actual operating speed.
5. Reduced yield is a loss that occurs during the initial stages of production when the engine starts up to reach stable conditions.
6. Quality defects and rework are losses in quality caused by malfunctioning production equipment.

III. RESEARCH METHODOLOGY

This research are focused on eliminating large losses, analysis with fishbone diagrams, and making corrective steps proposed to be carried out after getting the results of OEE calculations, six major losses and finding the root of the problem using 5 why analyzes.

Population and Sample, The population of this research is the gas turbine located at PT Dian Swastatika Sentosa unit tangerang is as many as 2 machines, while the sample taken is the type of saturated sample in which all populations become the sample under study.

Method of collecting data, Primary data collection is carried out directly with discussions with the maintenance, operational and PPIC departments as well as field observations with the production parties, especially the head of production and the head of maintenance, the engineer handling the gas turbine and field technicians. Discussion discusses the chronology (historical) during the operating machine, especially about the historical breakdown and analysis of the root causes of engine breakdown problems.

Method of Data analysis, The steps taken are as follows:

a. Calculates Availability

$$Availability\ Rate = \frac{Operating\ time}{Loading\ Time}\ x\ 100\%$$

b. Calculating Performance Eficiency

$$Performance\ Efficiency = \frac{processed\ amount\ x\ ideal\ cycle}{operation\ time}\ x\ 100\%$$

c. Calculate Quality Rate

$$Quality\ Rate = \frac{process\ amount - defect\ amount}{process\ amount}\ x\ 100\%$$

d. Calculating OEE

$$OEE\ (\%) = Availability\ (\%)\ x\ Performance\ (\%)\ x\ Quality\ (\%)$$

e. Calculation of Six Big Losses or six major factors: Downtime Losses (Equipment failure, setup and adjustment), speed losses (idling, minor stoppages and reduce speed), Defect losses (rework loss and scrap loss).

IV. RESULT AND ANALYSIS

Overall Equipment Effectiveness (OEE) calculation analysis is conducted with the aim of seeing the effectiveness of Gas turbine engines in the period of January 2017 – December 2017. This Gas turbine OEE measurement is based on time factor, speed and quality when operating the Gas turbine engine. The calculation results obtained in each unit of gas turbine can be seen in table 1 as follows: Based on Table 2. Discriminant Validity, it can be concluded that each indicator on the research variable has a cross-loading value on the variable that it forms greater than the cross-loading value on other variables. Based on the results obtained it can be stated that the indicators used in this study have good discriminant validity in preparing their respective variables.

Table 1. OEE Gas Turbine of PT Dian Swastatika Sentosa in 2017

Machine	Month	Availability	Performance	Quality	OEE
Gas Turbine Unit A	Jan-17	99.98%	90.54%	94.63%	85.66%
	Feb-17	98.92%	89.93%	94.54%	84.10%
	Mar-17	98.03%	84.96%	94.46%	78.67%
	Apr-17	100.00%	87.56%	94.69%	82.91%
	May-17	100.00%	91.48%	94.76%	86.68%
	Jun-17	99.93%	89.25%	94.69%	84.45%
	Jul-17	100.00%	90.05%	94.75%	85.32%
	Aug-17	99.45%	90.99%	94.73%	85.72%
	Sep-17	98.25%	91.54%	94.75%	85.21%
	Oct-17	99.58%	89.28%	94.62%	84.12%
	Nov-17	95.01%	85.55%	94.15%	76.53%
	Dec-17	90.33%	69.28%	91.79%	57.45%
Gas Turbine Unit B	Jan-17	98.99%	89.73%	94.52%	83.96%
	Feb-17	100.00%	88.95%	94.54%	84.09%
	Mar-17	98.39%	84.50%	94.50%	78.56%
	Apr-17	100.00%	86.57%	94.63%	81.92%
	May-17	99.93%	90.62%	94.71%	85.76%
	Jun-17	100.00%	88.57%	94.65%	83.83%
	Jul-17	99.90%	89.22%	94.69%	84.40%
	Aug-17	98.69%	90.04%	94.64%	84.09%
	Sep-17	99.86%	90.77%	94.79%	85.92%
	Oct-17	100.00%	88.56%	94.60%	83.78%
	Nov-17	100.00%	86.80%	94.52%	82.04%
	Dec-17	99.55%	76.02%	91.82%	69.49%

OEE gas turbines both unit A and unit B categorized do not meet the standards set. The average achievement of OEE for gas turbine unit A is 81.40% and the unit B gas turbine is 82.32%, where overall in January 2017 – December 2017 the gas turbine OEE value is at the range of 57.45%-86.68%. Attainable OEE value is influenced by the performance and quality values that are still under the value of world-class standards. While the availability value for both engines of PT DSS gas turbine in the period 2017 is already in world class standards.

Calculations and analysis of Six Big Losses. After knowing the OEE value in each gas turbine, then analyze the six big losses factor that affects the OEE. The result of the calculation of time losses on each factor can be seen in tables 2 and 3.

Table 2. Six Big Losses Turbine Gas Unit A PT DSS January – December 2017

No	Six Big Loss	Total Time Loss (hr)	Percentage (%)	Combative Percentage (%)
1	Reduce Speed Losses	7356.86	93.33%	93.33%
2	Rework Losses	403.74	5.12%	98.45%
3	Breakdown losses	103.30	1.31%	99.76%
4	Setup & Adjustment Losses	15.83	0.20%	99.96%

5	Idle & Minor stoppages	3.05	0.04%	100.00%
6	Scrap Losses	0	0.00%	100.00%
	Total	7882.78	100%	

Table 3. *Six Big Losses* Turbine Gas Unit B PT DSS January – December 2017

No	Six Big Loss	Total Time Loss (hr)	Percentage (%)	Combative Percentage (%)
1	Reduce Speed Losses	7454.97	94.35%	94.35%
2	Rework Losses	414.24	5.24%	99.59%
3	Breakdown losses	26.00	0.33%	99.92%
4	Idle & Minor stoppages	3.97	0.05%	99.97%
5	Setup & Adjustment Losses	2.57	0.03%	100.00%
6	Scrap Losses	0	0.00%	100.00%
	Total	7901.74	100%	

From the data obtained, it is known that the Reduce Speed Losses are the highest losses on the gas turbine units A and unit B in a year that is 7356.86 hours or 93.33% for the gas turbine Unit A and 7454.97 or 94.57% for the unit B gas turbine. Followed by another loss, for gas turbine unit A are: Rework Losses (403.74 hours/5.12%), Breakdown Losses (103.30 hours/1.31%). For gas turbine unit B is: Rework Losses (414.24 hours/5.25%), Breakdown Losses (26 hours/0.33%). The results of the percentages of these six big losses are described with Pareto diagram (Fig. 3 and 4) so it is apparent the sequence of the six factors affecting the effectiveness of gas turbines.

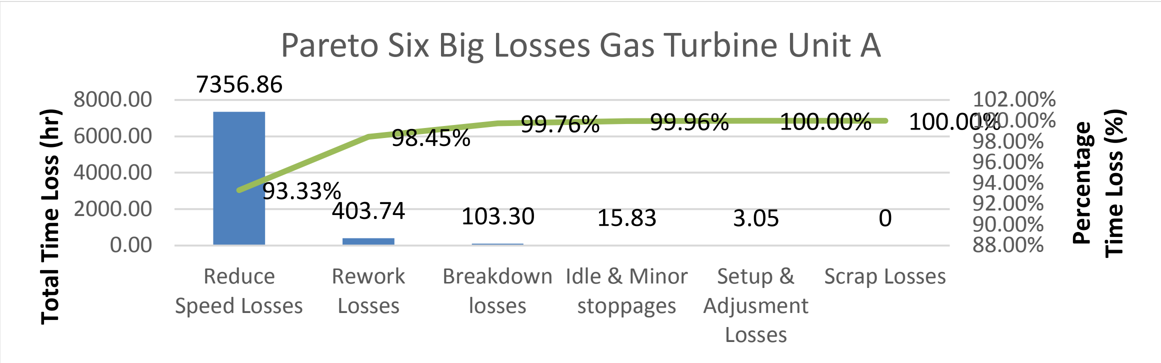

Fig. 3 Pareto Six Big Losses Gas Turbine Unit A PT DSS – 2017

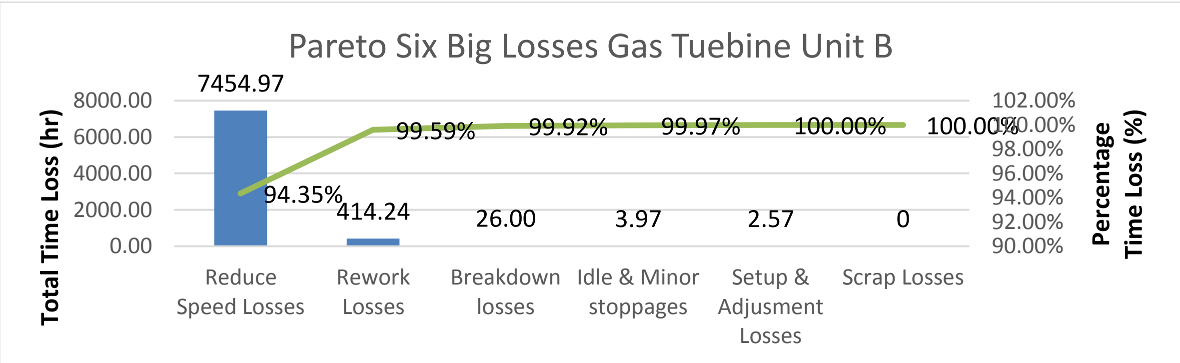

Fig. 4 Pareto Six Big Losses Gas Turbine Unit B PT DSS – 2017

The next step is to look for the root cause of the problem by conducting observations directly in the field and conducting interviews and discussions on employees related to the research that is part of the operation, engineering/maintenance, and PPIC. To obtain the results of the analysis in accordance with the purpose of the research and simplify the identifying causes of problems then create fish bone diagram for three major losses.

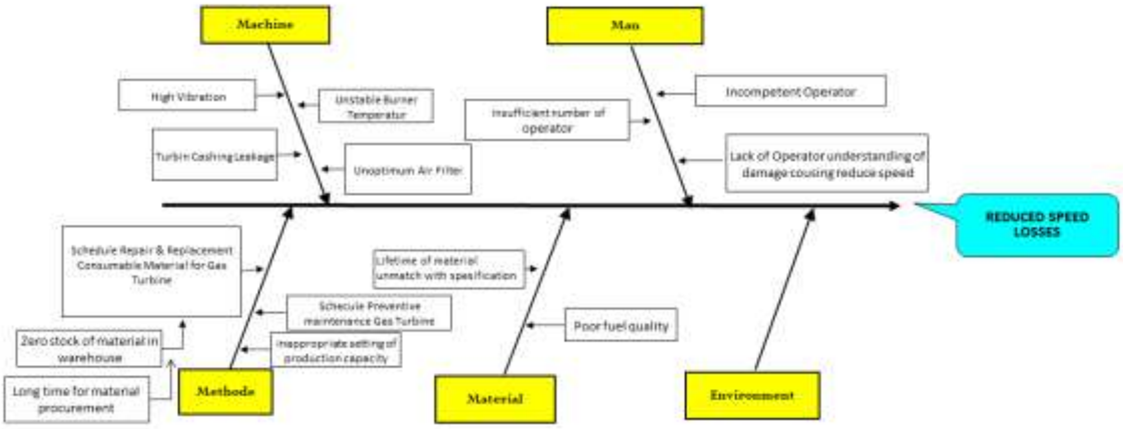

Fig. 5 Fish Bone Diagram Reduce Speed Losses

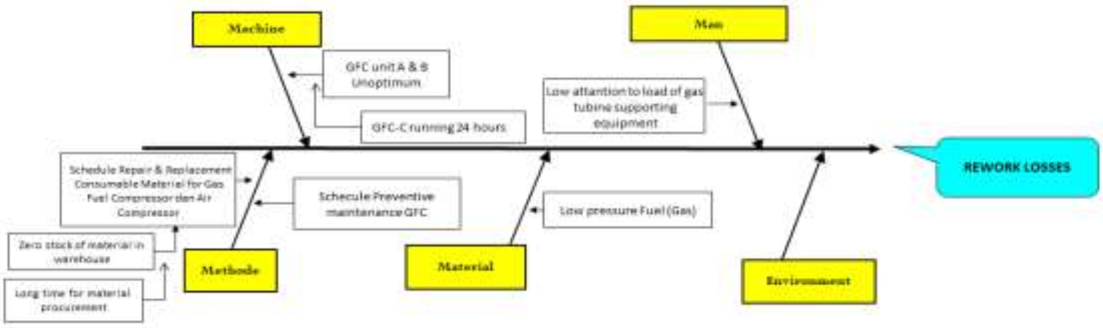

Figure 6 Fish Bone Diagram Rework Losses

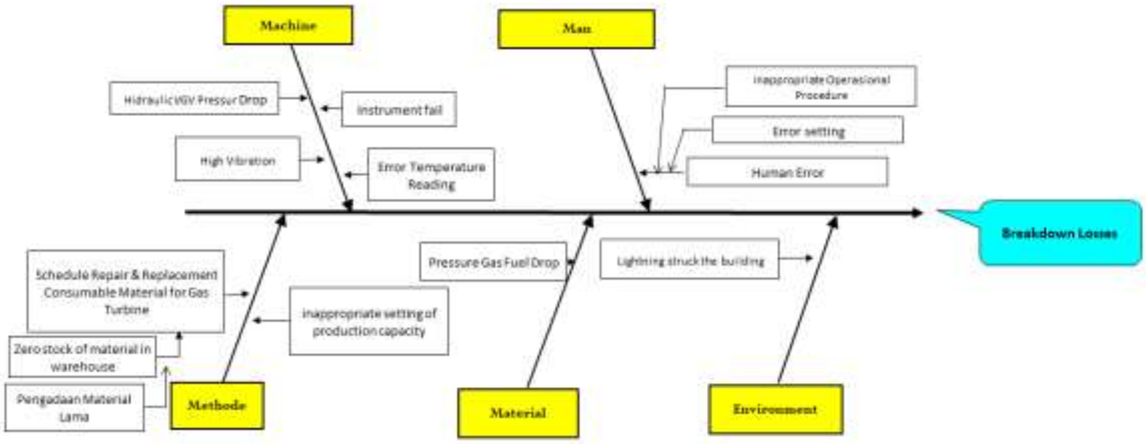

Figure 7 Fish Bone Diagram Breakdown Losses

The solution with the 5 why analysis method as a result of discussions with FGD and interviews are as follows:

Human factors. The problem of human factors is operator is less attentive and responsive to existing problems and lack of operator due to leave operator. To overcome this losses, can be done by making SOP (Standard Operating Procedure) and OPL (One Point Lesson) to provide guidance to the operator in order to know and resolve the problem, the addition of warning/alarm system to increase operator attention in the monitoring of the operation of the machine and need ongoing review and socialization related to leave regulations.

Machine factor. The problem of machine factor are vibration, VGV that does not fit the set point, error reading of thermocouple, high pressure of air filter due to blocked air filters and exhaust gas leaks in the turbine. Corrective action such as: Replacement of damaged parts and blocked filter replacement, spinning turbines to avoid unexpected expansion of turbine blade that can lead vibration, washing the turbine blade to eliminate the waste carbon from combustion firing that attached to the surface of turbine blade. Preventive Action: Scheduling the replacement and maintenance of gas turbine components to avoid oil leaks, unpredicted component damage and budget reviews for the replacement of the VGV drive system from the hydrolic system to motorize system.

Method Factor. The problem of method factor such as: schedule of repair of machine and replacement of material delayed because difficulty setting the Stop schedule with customer load needs, technicians from OEM originating from abroad, unavailability of substitute material due to unavailable stock, and unprecise Production load capacity setting. To resolve the problem, it can be done by routine coordination with customer and OEM for load arrangement and schedule stop, setting the feeder power panel or change over feeder power from PLN to gas turbine when low turbine load to obtaining a stable and optimum load, monitoring and monthly review of critical materials that require stock must be done in order to make sure availability of material.

Material Factor. The problem with the Material factor is the inconsistency of gas fuel quality and pressure from PT PGN causing gas turbine stop or reduce speed. To make sure gas turbine can run normally, it requires additional gas fuel compressor to maintain the gas supply to gas turbine.

Environmental factors. Problems in the environmental factor is the lightning strikes to the building. That can cause error reading of gas turbine instruments and sensors. It needs to be install a new lightning rod that is capable to protect the building and gas turbine exhaust stack from lightning.

V. Conclusion

1. The factor has not achieved the performance target of PT DSS is reduce speed losses by 93% or 7356.86 hours, rework losses 5.12% or 403.74 hours and breakdown losses 1.31% or 103.74

hours for gas turbine units A and for gas turbine unit B is reduce speed losses 94.35% or 7454.97 hours, rework losses amounting 5.24% or 414.24 hours and the breakdown losses 0.33% or 26.00 hours.

2. Improvement efforts by eliminating the six big loss factor : Increased performance of gas turbine can be done by setting the turbine load at low load time by setting arrangement electrical power distribution in the feeder panel, conducting training for operator and review of operator training requirements, routine review of machine maintenance program to be more precise and as needed, replacement of hydraulic to motorize system on VGV unit, creates specific and detail SOP/OPL on daily operational and maintenance of gas turbine.

Suggestion:

1. Gas turbine load distribution needs to be reviewed. The company should coordinate immediately with customers regarding the electricity load distribution to make sure gas turbine running at optimum conditions at all times. Proper load settings will reduce the Reduce Speed Losses as the dominant losses in this research.
2. SOP gas turbine load setting can provided for operator so each operator can perform load settings well.
3. Schedule of spare parts replacement and periodic inspections for gas turbine and support equipment should be more intensive reviewed considering the gas turbine and supporting equipment has been operating long enough.

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