American International Journal of Business Management (AIJBM)
ISSN- 2379-106X, www.aijbm.com Volume 2, Issue 9 (September- 2019), PP 23-37

Analysis of Total Maintenance Productivity on Ships/Fleet To Increase Performance Using Overall Equipment Effectiveness (OEE) Method and Analysis of Six Big Losses (Case Study of PT. XYZ)

Ade Caswito[1], Ahmad hidayat Sutawijaya[2]

[1.2]*Program Studi Magister Management, Universitas Mercu Buana Jakarta*
**Corrosponding Author: Ahmad hidayat Sutawijaya[2]*

ABSTRACT:- Overall Equipment Effectiveness (OEE) is a method of measuring the use of equipment. OEE is known as one of the Total Productive Maintenance (TPM) program applications.The ability to clearly identify the root of the problem and its causes so as to make the improvement effort focused is the main factor. This method is applied thoroughly by many companies in the world. for example the engine stops suddenly, declining machine production speed,the duration of setup and adjusment time, when the machine operates but does not produce products with the specified work standards.During the period January 2018 - December 2018 the value of Overall Equipment Effectiveness was obtained, still below the world class or below the ideal word.This is what underlies PT. XYZ to make improvements in its production activities.To overcome these problems in an effort to increase production efficiency is done by Total Productive Maintenance using the Overall Equipment Effectiveness (OEE) method as a tool used to measure and determine the performance of machines / equipment.After making the process of improvement and improvement, the Overall Equipment Effectiveness value increased above 85%, in M169 it was 87.1% and in M269 it was 92.8%.This research was conducted to get a picture of the suitability of the factors that determine the need for implementing Total Productive Maintenance with company conditionsand see which of the six big losses is the dominant factor affecting the decline in ship / fleet effectiveness. Thus the writing of this research will provide a proposal to improve the effectiveness of the ship / fleet in an effort to increase production efficiency in the company through the application of Total Productive Maintenance.

Keywords:- TPM, OEE, Six Big Losses

I. INTRODUCTION

Today performance improvement is very important for companies to obtain operating or production cost efficiencies and to benefit the company itself. One example of increasing productivity is to evaluate the performance of production facilities or operations in the company.In general, problems originating from production facilities can be caused by human factors, engine and environment, these three factors are very influential for each other.

Based on the problems that arise in the manufacturing environment above, Japan has developed and launched the concept of Total Productive Maintenance (TPM) in 1971, the system is described by Nakajima (Nakajima 1998) which includes the synergy between improving product quality, operational efficiency, engine capacity. (Amit Kumar, 2012).

Maintenance is currently considered as a strategic part and an integral part of business processes and provides that fact"This creates added value". Because understanding of the strategic importance of maintenance has increased, then a company must try to control, properly measure and manage maintenance functions (Baluct et al., 2012).

Steps to prevent or overcome these problems in an effort to increase production efficiency is done by TPM that uses the Overall Equipment Effectiveness (OEE) method as a tool used to measure and determine the performance of machines/ equipment.With the application of TPM that uses the Overall Equipment Effectiveness (OEE) method to find a picture of the suitability of the factors that determine the need for implementing Total Productive Maintenance with company conditions and see which factors of the six big losses are dominantly affecting the decline in the effectiveness of the machine/ equipment.

The Research Questions to be examined, what is the main cause of the low performance of the ship/ fleet, Breakdown Time, Idle minor stoppage, is the main factor that influences it?, What is the value of OEE vessels in January 2018-December 2018?., what is the achievement of OEE value after making improvements?., And finnaly How to make improvements and improvements that are appropriate to improve the performance of the ship/ fleet?

II. THEORY STUDY

2.1. Maintenance

According to Assauri (2008), Maintenance is an activity to maintain facilities or equipment by carrying out repairs or adjustments or replacements needed in order to create a satisfactory operational production condition in accordance with what has been planned. From the above definition, maintenance is all activities so that the equipment is maintained or returned to certain conditions and fit conditions to carry out its functions.

a. Total Productive Maintenance (TPM)

According to Nakajima TPM (Total Productive Maintenance) is a program for the fundamental development of maintenance functions within an organization, TPM will be able to increase productivity,quality, and minimize costs (Kurniawan, 2013).

The machine operator is responsible for maintaining the machine, apart from being responsible for its operations.The application of TPM can realize enormous cost savings through the process of increasing productivity realized by TPM (Azwar, 2014).

Total Productive Maintenance (TPM) aims to maximize the effectiveness of the equipment used in the industry, which is not focused on maintenance but on all aspects of the operation including to increase the motivation of workers in the company (Iftari, 2015).

The TPM component generally consists of 3 parts,that is:

1. Total Approach.In implementing TPM all involved are responsible and maintain all company facilities.

2. Productive Action. All employees involved are required to be proactive about the conditions and operations of the production facility. 3. Maintenance. Implementation of care and maintenance in increasing the effectiveness of facilities in production operations.

b. Overall Equipment Effectiveness (OEE)

Overall Equpment Effectiveness (OEE) is a metric that focuses on how effectively a production operation is carried out. The results are stated in a general form so as to allow comparisons between manufacturing units in different industries. OEE calculation values are as follows:

OEE (%) = Availability (%) × Performance Rate (%) × Quality Rate (%)

Availability is knowing the ratio of operating time to loading time. Loading time is the time available days or monthly reduced by the planned engine downtime.

Loading Time = Total Available Time – Planned Down Time, Operation time is the total effective processing time. In this case the operation time is the result of reducing loading time with engine downtime.Down Time = Breakdown + Set Up. Operation Time = Loading Time – Down Time. Availability value = Operation time / Loading time.

c. Perhitungan Performance Efficiency

Performance efficiency is the ratio of the quantity of products produced multiplied by the ideal cycle time to the operation time.

Performance Efficiency = Total Process X Ideal Cycle Time / Operation Time X 100 %

Rate of Product Quality is the ratio of good products (good products) in accordance with predetermined product quality specifications to the number of products processed.

Rate of Quality Product = Procesed amount – Defect amount / Procesed amountX 100 %.

Table 1. Standard Overall Equipment Effectiveness

Availability (Ketersediaan)	≥ 90%
Performance (Kinerja)	≥ 95%
Quality Yield (Kualitas)	≥ 99%
Overall Equipment Effetiveness (OEE)	≥ 85%

d. Cause and Effect Diagrams

Fishbone Diagram or Cause and Effect Diagram is one of the tools of QC 7 tools that are used to identify and show the relationship between cause and effect in order to find the root cause of a problem. Fishbone Diagrams are used to show the causative factors and the quality caused by these causative factors. Prof. Kaoru Ishikawa from Tokyo University in 1953. (Budi kho, 2016)

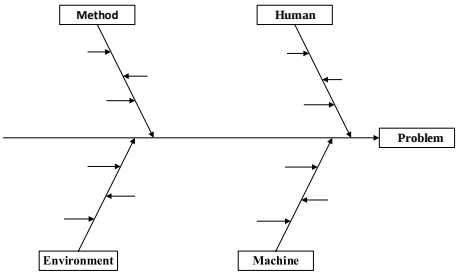


Figure 1 Cause - Effect Diagram

e. Repair With 5 W 1 H

5W - 1H is one method for making repairs,with analysis or investigation methods:

1) What, what is the main target of improvement?
2) Why, why such a plan of action is needed?
3) Where, where the plan is implemented?
4) Who,who will work on the plan activities?
5) *When,* when this action will be carried out?
6) *How,* how to work on the plan.

III. METHOD

The research methodology describes the procedures regarding research steps that are arranged systematically. Systematic steps are needed so that research can be carried out properly and research objectives that have been planned can be achieved. This research refers to the formulation of the problem.

1.1. Population and Sample

The population that will be discussed is about the equipment that will be analyzed related to OEE, so in this

company the population that will be used is the engine on the ship / fleet.

The sample used in this study is the performance of the ship engine / fleet using only the type/ has the same capacity.

1.2. Method of collecting data

1.2.1. Primary data

Is data directly obtained from direct research observations in the maintenance area.

1.2.2. Secondary data

Secondary data is data in the form of company documentation such as the Daily report, *Monthly report*and others. his secondary data is obtained from company documents, especially reports on ship performance.

IV. DATA ANALYSIS

4.1. Calculation of Availability Rate

Calculation of Availability can be seen in Table 4.5 (Table of Availability Rate values in 2018). *Availability is the level of operation time ratio to loading time.*To calculate the availability of M269 vessels in February 2108, the formula is as follows:

Availibility =Operationtime/Loadingtime X 100 %. (15.0 /21.0) x 100 % = 70.8 %.

Table 2. Availability of Vessels Period January to December 2018

Bulan	LoadingTime		Downtime		Operating Time (day)		Availability (%)	
	M169	M269	M169	M269	M169	M269	M169	M269
Jan	31.0	-			31.0		100.0	
Feb	28.0	21.7		6.3	28.0	15.3	100.0	70.8
Mar	31.0	31.0		-	31.0	31.0	100.0	
Apr	30.0	4.0		26.0	30.0		100.0	-
Mei	28.0	6.0	3.0	25.0	25.0	8.8	89.3	146.0
Jun	30.0	30.0		-	30.0	30.0	100.0	100.0
Jul	27.0	31.0	4.0	-	23.0	31.0	85.2	100.0
Agst	29.0	28.0	2.0	3.0	27.0	21.1	93.1	75.3
Sept	30.0	27.0		3.0	30.0	15.6	100.0	57.8
Okt	31.0	31.0		-	31.0	31.0	100.0	100.0
Nop	26.0	27.9	4.0	2.1	22.0	21.0	84.6	75.0
Des	24.4	31.0	6.6	-	17.8	31.0	73.0	100.0
Total							93.76	82.49

Source: Daily and Monthly Reports processed, 2018

a. Performance Rate Calculation

Performance rate is the level of the ratio of the quantity of product produced to an ideal cycle time to the time available to carry out the production process (operation time).To calculate the performance value of the January 2018 ship M169 used the following formula:

Performance Rate = Total Process X Ideal Cycle Time / Operation Time X 100 %

Performance Rate= (2 trip x 8.3)/ 31.0 x 100% = 53.8%.

Table 3. Performance Rate for the period of January to December 2018

Bulan	Processed Amount (Trip)		Ideal Cycle Time		Operation Time		Performance Rate	
	M169	M269	M169	M269	M169	M269	M169	M269
Jan	2.0		8.3	-	31.0		53.8	
Feb	2.0	1.0	8.3	14.8	28.0	15.3	59.5	96.7
Mar	3.0		8.3	-	31.0	31.0	80.6	
Apr	3.0		8.3		30.0		83.3	
Mei	2.0	1.0	8.3	8.3	25.0	8.8	66.7	95.1
Jun	2.0	2.0	8.3	8.3	30.0	30.0	55.6	55.6
Jul	4.0	3.0	8.3	8.3	23.0	31.0	144.9	80.6
Agst	3.0	3.0	8.3	8.3	27.0	21.1	92.6	118.6
Sept	2.0	2.0	8.3	8.3	30.0	15.6	55.6	106.7
Okt	3.0	3.0	8.3	8.3	31.0	31.0	80.6	80.6
Nop	2.0	3.0	8.3	8.3	22.0	21.0	75.8	119.3
Des	3.0	2.0	8.3	8.3	17.8	31.0	140.4	53.8
Total							82.5	89.7

Source: Daily and Monthly Reports processed, 2018

b. Calculation of Rate of Quality Product

The Rate of Quality value of the ship code M169 for data in February 2018 isas follows:

Rate of Quality Product = Procesed amount – Defect amount / Procesed amountX 100 %

Rate of Quality =(1(trip) – 0.3)/2(trip) x 100% = 67.0 %.

Table 4. Rate of Product Quality for the period of January to December 2018

Bulan	Processed Amount (Trip)		Defect Amount (day)		Rate of Quality (%)	
	M169	M269	M169	M269	M169	M269
Jan	2.0				100.0	
Feb	2.0	1.0		0.3	100.0	67.0
Mar	3.0				100.0	
Apr	3.0			2.0	100.0	
Mei	2.0	1.0	1.0	0.7	50.0	30.0
Juni	2.0	2.0			100.0	100.0
Juli	4.0	3.0	1.0		75.0	100.0
Agst	3.0	3.0	2.0	1.0	33.3	66.7
Sept	2.0	2.0	1.0	1.0	50.0	50.0
Okt	3.0	3.0			100.0	100.0
Nop	2.0	3.0	1.0	0.1	50.0	97.3
Des	3.0	2.0	1.6		46.7	100.0
Total					75.42	79.00

Source: Daily and Monthly Reports processed, 2018

c. Calculation of Overall Equipment Effectiveness (OEE)

After the value of the availability rate, performance rate, and rate of quality of the product what the ship is obtained, then the overall equipment effectiveness (OEE) value is calculated to determine the effectiveness of the use of ships at PT. XYZ. Standard Overal Equipment Effectiveness (OEE) Ideal Value. OEE calculation is the result of multiplying the value of availability rate, performance rate, and rate of quality products that have been obtained. The OEE M169 value in January 2018 uses the following formula :

OEE (%) = Availability (%) × Performance Rate (%) × Quality Rate (%)× 100%

OEE= A x P x Q = 1.00 x 0.53 x 1.00 x 100,00 = 53.0 %

Table 5. Overall Equipment Effectiveness of the January to December 2018

Bulan	Availability		Performance Rate		Rate of Quality		Overall Equipment Effectiveness	
	M169	M269	M169	M269	M169	M269	M169	M269
Jan	1.00	-	0.53	-	1.00		53.0	-
Feb	1.00	0.70	0.59	0.96	1.00	0.67	59.0	45.0
Mar	1.00	-	0.80	-	1.00	-	80.0	-
Apr	1.00	-	0.83	-	1.00	-	83.0	-
Mei	0.89	1.46	0.66	0.95	0.50	0.30	29.4	41.6
Jun	1.00	1.00	0.55	0.55	1.00	1.00	55.0	55.0
Jul	0.85	1.00	1.44	0.80	0.75	1.00	91.8	80.0
Agst	0.93	0.75	0.92	1.18	0.33	0.66	28.2	58.4
Sept	1.00	0.57	0.55	1.06	0.50	0.50	27.5	30.2
Okt	1.00	1.00	0.80	0.80	1.00	1.00	80.0	80.0
Nop	0.84	0.75	0.75	1.19	0.50	0.97	31.5	86.6
Des	0.73	1.00	1.40	0.53	0.46	1.00	47.0	53.0
Average							55.5	44.2

Source: Daily and Monthly Reports processed, 2018

It is known that the highest OEE value is found on the M169 ship in July at 91.8%,M269 in November worth 86.6%and in October worth 80.0%.the lowest OEE value occurred in M169 in September at 27.5%,M269 in September valued at 30.2%.If you take the average value of OEE between January to December, each ax worth M169 worth 55.2%, and M269 worth 44.2%.

d. Six Big Losses

From OEE calculations to improve ship performance, as a supporter, Six Big Losses is carried out to make it easier to analyze the root causes of the most dominant problems resulting in suboptimal vessel performance.

e. Calculation of Equipment Failure (Breakdown) Losses

The breakdown loss value for M269 vessels for February 2018 data is as follows:

Breakdown Loss = Total Breakdowns / Loading TimeX 100 %

Breakdown Loss = 6.3 / 21.7 X 100 % = 29.2%.

Table 6. Ship Breakdown Loss for the period January to December 2018

Bulan	Total Waktu Kerusakan/Breakdown (Day)		Loading Time (Day)		Breakdown Losses (%)	
	M169	M269	M169	M269	M169	M269
Jan			31.0	-	-	
Feb		6.3	28.0	21.7	-	29.2
Mar		-	31.0	31.0	-	-
Apr		26.0	30.0	4.0	-	650.0
Mei	3.0	25.0	28.0	6.0	10.7	416.7
Juni		-	30.0	30.0	-	-
Juli	4.0	-	27.0	31.0	14.8	-
Agst	2.0	3.0	29.0	28.0	6.9	10.7
Sept		3.0	30.0	27.0	-	11.1
Okt		-	31.0	31.0	-	-
Nop	4.0	2.1	26.0	27.9	15.4	7.4
Des	6.6	-	24.4	31.0	27.0	-
Total					0.52	9.30

Source: Daily and Monthly Reports processed, 2018

f. Calculation of Setup & Adjustment Loss

To find out the percentage of downtime loss caused by the setup and adjusment time, the following formula is used, the M269 ship setup & adjusment values for data in February 2018 are as follows:

Setup dan Adjustment Loss = Total Setup dan Adjustment / Loading Time X 100 %

Setup dan Adjustment Loss = 2.3 / 21.6 X 100 % = 10.75 %.

Table 7. Equipment Failure (Breakdown) for the period January to December 2018.

Bulan	Setup Time (day)		Loading Time (day)		Set up & Adjusment Losses (%)	
	M169	M269	M169	M269	M169	M269
Jan			31.00	-	-	
Feb		2.3	28.00	21.67	-	10.75
Mar			31.00	31.00	-	-
Apr		2.0	30.00	4.00	-	50.00
Mei	1.0	3.0	28.00	6.00	3.57	50.00
Juni			30.00	30.00	-	-
Juli	1.0		27.00	31.00	3.70	-
Agst	2.0	1.0	29.00	28.00	6.90	3.57
Sept	1.0	1.0	30.00	27.00	3.33	3.70
Okt			31.00	31.00	-	-
Nop	1.0	0.1	26.00	27.92	3.85	0.29
Des	1.6		24.40	31.00	6.56	-
Rata - Rata					2.33	10.76

Source: Daily and Monthly Reports processed, 2018

g. Calculation of Idling and Minor Stoppage

Idling and Minor Stoppage occurs if the ship stops repeatedly. To find out the percentage of idle loss caused by the Idling and Minor Stoppage time the following formula is used, the value of the M169 Idling and Minor Stoppage for the January 2018 period is as follows:

Idling and Minor Stoppage = Nonproductive Time / Loading Time X 100 %

Idling dan Minor Stoppages = 2.0 / 31 X 100 % = 6.5 %.

Table 8. Idling and Minor Stoppage Vessels Period January to December 2018

Bulan	Loading Time (day)		Non Productive Time		Minor Stoppage Losses	
	M169	M269	M169	M269	M169	M269
Jan	31.0	-	2.0	-	6.5	
Feb	28.0	21.7	-	2.3	-	10.8
Mar	31.0	31.0	1.0	-	3.2	-
Apr	30.0	4.0	2.0	2.0	6.7	50.0
Mei	28.0	6.0	3.0	3.0	10.7	50.0
Juni	30.0	30.0	2.0	-	6.7	-
Juli	27.0	31.0	3.0	2.0	11.1	6.5
Agst	29.0	28.0	8.0	3.0	27.6	10.7
Sept	30.0	27.0	4.0	3.0	13.3	11.1
Okt	31.0	31.0	4.0	1.0	12.9	3.2
Nop	26.0	27.9	2.0	0.1	7.7	0.3
Des	24.4	31.0	2.6	-	10.7	-
Average					9.75	12.96

Source: Daily and Monthly Reports processed, 2018

h. Reduced Speed Calculation

Reduced Speed is the difference between the actual production speed and the ideal machine production speed. To find out the percentage of Speed loss caused by the time Reduced Speed is lost, then the following formula is used.

Reduced Speed Ship values for M169 data in January 2018 are as follows:

Reduce Speed Loss = Actual Production Time – (IdealCycletime xTotal Product Proses / Loading Time X 100 %. = 31.0 – 8.33 x 2 / 31 X 100 % = 0,46 %.

Table 9. Reduced Speed of Vessels Period January to December 2018

Bulan	Total Product Prosess		Actual Productive Time		Ideal Cycle Time (day)		Loading Time		Reduced Speed Losses	
	M169	M269	M169	M269	M169	M269	M169	M269	M169	M269
Jan	2		31.00		8.33		31.00	-	0.46	
Feb	2	1	28.00	15.34	8.33	14.83	28.00	21.67	0.40	0.02
Mar	3		31.00	31.00	8.33	8.33	31.00	31.00	0.19	1.00
Apr	3		30.00		8.33	8.33	30.00	4.00	0.17	-
Mei	2	1	25.00	8.76	8.33	8.33	28.00	6.00	0.30	0.07
Juni	2	2	30.00	30.00	8.33	8.33	30.00	30.00	0.44	0.44
Juli	4	3	23.00	31.00	8.33	8.33	27.00	31.00	(0.38)	0.19
Agst	3	3	27.00	21.08	8.33	8.33	29.00	28.00	0.07	(0.14)
Sept	2	2	30.00	15.61	8.33	8.33	30.00	27.00	0.44	(0.04)
Okt	3	3	31.00	31.00	8.33	8.33	31.00	31.00	0.19	0.19
Nop	2	3	22.00	20.95	8.33	8.33	26.00	27.92	0.21	(0.15)
Des	3	2	17.80	31.00	8.33	8.33	24.40	31.00	(0.30)	0.46
Rata - rata									0.18	0.19

Source: Daily and Monthly Reports processed, 2018

i. Rework Loss Calculation

Rework Loss is the difference between the actual production speed and the ideal machine speed. To find out the percentage of Defect loss caused by lost Rework Loss time, the following formula is used, M169 Vessel Rework Loss values for data in January 2018 are as follows:

ReworkLoss = IdealCycleTime X Rework/Loading Time X 100 %=8.33 X0/31 X 100 % = 0 %.

j. Yeild / Scrap Loss Calculation

Yield / Scrap Loss is a loss arising during an operational process that has not yet reached a stable state. To find out the magnitude of the percentage of Defect loss caused by Yeild/ Scrap Loss time lost, M169 Yeild / Scrap Loss value for data in January 2018 is as follows:

Yield / Scrap Loss = Ideal Cycle Time X Scrap / Loading Time X 100 %= 8.33 X 0 / 31 X 100 % = 0 %.

k. Analysis of Discussion

Overall Equipment Effectiveness Calculation analysis is performed to see the level of effectiveness of the use of ships during the period January - December 2018. Measurement of Overall Equipment Effectiveness is a combination of time factor, the quality of the operation of the ship and the speed of the operational process of the ship.

During the January s.d December 2018 period, OEE values obtained by vessels operated by PT. XYZ is:

1. During the January to December 2018 period, the Availability Rate value on M169 vessels was around 93.76%,M269 around 82.49% the average value is 88.1%. This proves that the ship has been operating optimally. Seen from the value obtained is higher than the ideal standard that is ≥ 90%.

2. During the January to December 2018 period, the Performance Rate value for the M169 ship was around 82.5%,M269 is around 89.7% with an average value of 86.1%.This proves that the ship is still far from the ideal word. Seen from the value obtained is lower than the ideal standard 95%.

3. During the January to December 2018 period, the Rate of Quality Product on the M169 ship was around 75.42%, M269 is around 79.0% with an average value of 77.2%. This proves that the ship is still far from the ideal word. Seen from the value obtained is lower than the ideal standard ≥ 99%.

4. During the January to December 2018 period, the Overall Equipment Effectiveness value ranged from M169 to 55.5%,M269 is around 44.2%with an average value of 49.8%.This proves that vessels in 2018 have still not operated in an ideal state. Seen from the value obtained is lower than the ideal standard 85%.

l. Analysis of Calculation of Six Big Losses before improvement (January to December 2018)

i. Analysis Identifies the source and root cause of the problem

so that repairs can be done immediately, then an analysis of the six big losses factors that result in low effectiveness of the engine in OEE calculations, by using a causal diagram. The analysis will be more efficient if only applied to the dominant factors. From Table 8 it can be seen that the dominant ones are idling and minor stoppage with an average influence on M169 vesselswith a value of (9.75) and M269 worth (12.9),while the breakdown losses with an average affect the value on the M169 ship with a value of (6.24)and M269 worth (10.29).

Table. 10. The value of big losses

Four Big Losses	Total TimeLoss (day)		Persentase %	
	M169	M269	M169	M269
Breakdown Loss (BL)	6.24	102.29	33.78	80.99
Set Up and Adjustment Loss (SAL)	2.33	10.76	12.59	8.52
Reduced Speed Loss (RSL)	0.15	0.29	0.83	0.23
Idling Minor Stoppage Loss (IMSL)	9.75	12.96	52.80	10.26
Total	**18.47**	**126.29**	**100.00**	**100.00**

m. Analysis of Idling and Minor Stoppages Losses & Analysis of Breakdown Losses

The low performance of the ship due to idling and minor stoppages losses & breakdown losses caused by sudden and unexpected damage occurs so that the ship cannot operate. The cause and effect diagram of breakdown losses can be seen in Figure 4.5 for details of the effect of the low productivity of the ship caused by, among others :

1. Human / Ship Crew

➢ Crew less responsive in supervising ship engines when operating. Not careful in treating andrarely clean boat engines which can cause the engine to stop suddenly.

2. Machine

➢ Sudden interference often occurs, due to unstable temperatures. Age of old shipengine.

3. Method

➢ Maintenance process is not standard in ship engine maintenance, the crew only makes repairs when damage has arisen.

4. Environment

➢ Effects of fluctuating waters, dangerous during bad weather.In the estuary waters large logs often hamper the trip and sometimes get into the ship's engine. And often the tides of the river water when mooring so that resulted in ships demolished.

5. Material

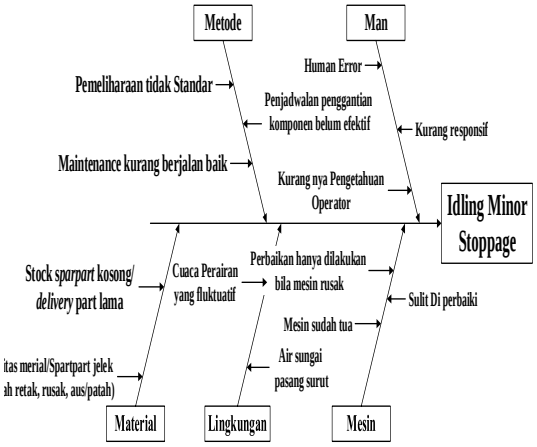
➢ Stock spare parts are often empty / sparpart delivery for too long. Poor materia parepart quality (easily cracked, damaged, broken or broken)

n. Cause / Fishbone Diagram

Through the Pareto diagram it can be seen that the factor that gave the biggest contribution from the six big losses factor is Idling minor stoppage M169 of (9.75%)and M269 (12.96%)

followed by M169 Breakdown Loss factor of (6.24%) and M269 of (10.29%).

According to the Pareto Rule (80% rule), the cumulative percentage value close to or equal to 80% becomes a priority issue that will be discussed next.Therefore, these two factors will be analyzed using cause and effect diagrams.



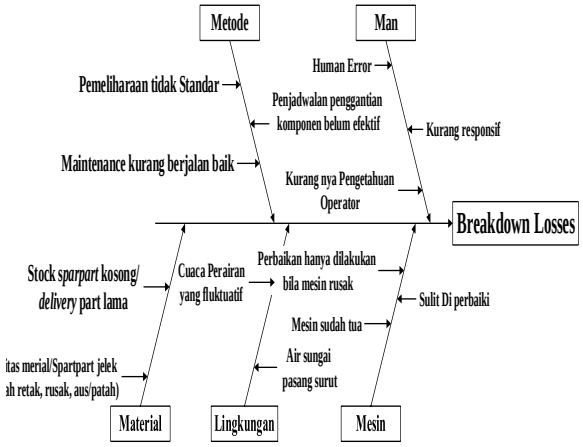


Figure 2 & 3. Fishbone Diagram for Ship / fleet Losses Breakdown Analysis

Source: Qualitative Data, 2018

o. Recommended Improvements for Reduced Speed Losses & Breakdown

Recommendations for improvement are given to increase the OEE value of the ship, after analyzing the causes of the problem using a fish bone diagram, then the next step is to propose improvements for the causes of problems with the 5W and 1H methods based on the analysis of downtime losses and so on as shown in the table. 13 as follows.

Table 11. 5W 1H

What	Why	Who	Where	When	How
Machine					
Difficult to fix	Sudden interference often occurs, due to unstable temperatures.	Supervisor & Teknisi	Ship function (Workshop)	January and so on. 2018	Provide sparpart and establish good relations with sparpart suppliers that are difficult to find
The age of the engine is old					Engine or boat replacement
Method					
Maintenance is not standard	Maintenance process is not standard, in the maintenance of ship engines, the crew only carries out maintenance when damage has arisen.	Crew kapal & Staff Maintenance	Production / Ship function	January and so on. 2018	Make a standard implementation of maintenance which if not done crew will give sanctions
Maintenance is not going well					Koordinasi dalam monitoring keadaan kapal
Material					
Poor Material / Sparpart quality (easily cracked, damaged)	Reduced efficiency	Supervisor & Teknisi	Production / Ship function	January and so on. 2018	Modifying parts or replacing parts with other materials

p. OEE Calculation after Improvement (January 2019 to April 2019)

OEE calculation is the result of multiplication of the availability rate value,performance rate, and the rate of product quality that has been obtained.OEE M169 value in January 2019 uses the following formula:

OEE (%) = *Availability (%) × Performance Rate (%) × Quality Rate (%)*

OEE M169 Jan 2019 = A x P x Q = 0.93 x 0.83 x 0.97 x 100% = 74.5%.

OEE M269 Jan 2019 = A x P x Q = 100.0 x 0.81 x 1.00 x 100% = 80.7%.

Table 12. Overall Equipment Effectiveness of Vessels for the period January s.d April 2019

Bulan	Availability		Performance Rate		Rate of Quality		Overall Equipment Effectiveness	
	M169	M269	M169	M269	M169	M269	M169	M269
Jan	0.93	1.00	0.83	0.81	0.97	1.0	74.5	80.7
Feb	0.83	1.00	1.25	0.89	1.03	1.0	106.9	89.3
Mar	1.00	0.93	0.81	1.23	1.00	1.0	81.0	119.0
Apr	0.93	0.97	0.96	0.89	0.96	1.0	85.8	82.3
Average							87.1	92.8

Source: Daily and Monthly Reports processed, 2019

q. Discussion

Based on the calculation of Overall Equipment Effectiveness and six big losses,and analysis to find the cause of the problem, both with pareto diagrams,fishbone diagram that has been presented in several main findings that affect the value of Overall Equipment Effectiveness (Availability and Performance with 100% Quality)and also against the six big losses. In this chapter there is discussion to explain some of the findings and data processing and try to evaluate the improvements that have been made.

r. Obtaining Overall Equipement Effectiveness Value

Achievement of OEE value after improvement has increased, in Table 5 and Table 12. from M169 (62%) to M169 (91%), from M269 (41%) to M269 (100%).OEE M169 (91%), M269 (100%)is a value that has already passed world-class OEE companies on services. The detailed details of OEE namely the availability and performance values are as shown in Figure 3 in the form of a comparison between overall equipment effectiveness in 2018 (before repairs) and 2019 (after repairs).

The OEE value of XYZ companies has an upward trend since OEE measurements were carried out in 2018 until the end of April 2019. Even the last two months from March 2019 to April 2019 OEE values have increased, OEE value was originally (50.11%) to (91.00%). In detail, OEE parameters.

Achievement of OEE value after improvement has increased,seen in previous OEE values Table 5.in the original M169 ship code (55.5%) and OEE values thereafter Table 12.in the ship code M169 becomes (87.1%).Table 12 in the original M269 ship code was (44.2%) which was (92.8%). OEE M169 (87.1%) and M269 (92.8%) are values that have exceeded world-class OEE companies in services. The detailed details of OEE namely the availability and performance values are as shown in Figure 4. which is a comparison between overall equipment effectiveness in 2018 (before repairs) and 2019 (after repairs).

The OEE value of XYZ companies has an upward trend since OEE measurements were carried out in 2018 until the end of April 2019. Even the last two months from March 2019 to April 2019 OEE values have increased, the OEE value was (55.5%) to (87.1%). In detail, OEE parameters can be seen in figure 4.

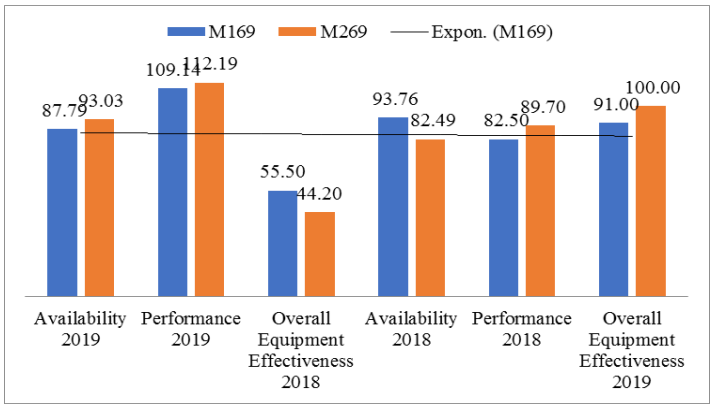


Figure 4. Comparison graph of OEE 2018 and 2019 values

Source: Processed report data. 2018 & 2019

s. Repair Details

To make improvements, a risk based priority strategy is conducted through a 5W 1H analysis conducted with interviews and discussions with all related crew both the technical part, Maintenance staff, crew members etc.,to do repairs is related to the machine,related to the environment and related to the material both on the causes of idling minor stoppage,reduced speed losses and set up losses as well as on the causes of breakdown losses.

Table 13. Problem Resolution

NO	Factors	Problem solving
1	Human / Ship Crew	
	Less responsive crew to supervise the ship's engine when operating.	Crew Training Periodically so that it has a very high concern
	Less careful in maintaining and cleaning the ship's engine which can cause the engine to stop suddenly.	Supervision of the crew must be improved
2	Machine	
	Frequent interruptions occur suddenly / difficult to repair.	Providing spare parts and establishing good relations with suppliers of spare parts that are hard to find.
	Age of old ship engine.	Engine or boat replacement.
3	Method	
	Maintenance process is not standard, in the maintenance of ship engines, the crew only carries out maintenance when damage has arisen.	Make ast andard of implementation (SOP) maintenance which if not done by the crew will be given sanctions.
4	Environment	
	The effect of fluctuating waters, dangerous during bad weather.	Collaborate with BMKG to report on Indonesian waters weather regularly. To avoid operation bad weather.
	In the estuary waters large logs often hamper travel and sometimes even enter the ship's engine.	Installation of filtering so that wood does not get into the machine ship.
	And there are often ups and downs when mooring, which causes the ship to crash.	Must measure the depth of water when mooring so that it does not occur.
5	Material	
	Frequent empty spare parts / slow spartart delivery.	Stock spare parts and look for spare parts suppliers that are easier to reach so delivery of spare parts is faster.
	Poor quality material/spare parts (easily cracked, damaged, broken).	Looking for very high quality spare parts and looking for a reliable supplier.

V. CONCLUSION

With the implementation of Total Productive Maintenance using the OEE method in an effort to improve the operational efficiency of the ship at PT. XYZ can be concluded as follows:

1. The main causes of low vessel / fleet performance are idling and minor stopagges because it is the main factor that affects it and is also caused by the factors of Human, Method, Machine, and Environment.
2. The results of the analysis of the achievement of Overall Equipment Effectiveness (OEE) value before making various improvements in January 2018 until December 2018, This OEE value is still below the world class or is still below the ideal in the manufacturing industry (minimum 85%) and continuous process industry (minimum 95%).After the process of repairs and improvements OEE values increase above the world class and are above the ideal word.
3. Losses are reduced so that the value of OEE increases made several improvements, including:

a. Actions for improvement to reduce breakdown losses periodically conduct Crew training so that they have a very high concern.

b. Running a maintenance system to improve machine effectiveness based on the concept of the eight pillars of Total Productive Maintenance, among others, making toolboxes for tools equipped with tool pallet, operator cleansed furiously, checking the oil indicator every time a work activity is started, and regulate air pressure.

Suggestion

Based on the results of the research concluded above and in an effort to improve the effectiveness of the ship, put forward several suggestions and can be given for further research as follows:

1. Conduct research on the effect of Continuous Improvement on reducing losses.In the ship maintenance system is a very important activity in order to extend the life of each ship sparpart so that it can reduce the frequency of brekadown.
2. Conduct research on the effect of automation and process data integration on losses. Abk crew was advised to be able to operate the engine and make settings to prevent damage due to misoperation.
3. Engineering is advised to always prepare and control critical and assembly-shaped sparts so that when one day a failure occurs can be repaired in a short time.
4. Examine the application of the Predictive Maintenance (PdM) system in maintenance activities and see its effect on losses.
5. Conduct research on improvement of quality problems and make improvements more thoroughly.

REFERENCES

[1]. Assauri, S. (2008). *Manajemen Produksi dan Operasi*. Jakarta: Lembaga Penerbit Fakultas Ekonomi Universitas Indonesia.

[2]. *Azwar*, Saifuddin. (*2014*). Metode Penelitian. Yogyakarta: Pustaka Pelajar. *Azwar*, Saifuddin. (*2014*). Penyusunan Skala Psikologi (Edisi II). Yogyakarta: Pustaka

[3]. Budi Kho. (2016, June 27). Ilmu Manajemen Industri. Retrieved June 27, 2016, From Manajemen Kualitas: Ttp://Www.Ilmumanajemenindustri.Com

[4]. *Daryus*, Asyari. *2008.* Diktat kuliah Proses produksi. Jakarta: Fakultas. Teknik Universitas Darma Persada. Hardi Yonathan, dan Iskandar Isdaryanto.

[5]. Denny Astrie Anggraini, Adi Saputra. (2018). Analisis Efektivitas Penggunaan Mesin Produksi Jendela Dan PintuDengan Menggunakan Metode Overall Equipment Effectiveness(Studi Kasus : Pt Metta Buana Sejahtera). *ISSN 2337-4349: Hal. 241-248.*

[6]. Deitiana, Tita. (2011). Manajemen operasional strategi dan analisa. Edisi pertama. Mitra wacana media, Jakarta

[7]. Elian Garin Bowo Kuncoro, Denny Sukma Eka Atmaja. (2018). Analisis Perawatan Dan Efektivitas Mesin Continuous Tandem Cold Mill (Ctcm) Dengan Menggunakan Metode Overall Equipment Effectiveness (Oee)(Studi Kasus: Pt. Krakatau Steel Tbk.) ISSN 2085-4218:136-139.

[8]. Gupta, Amit Kumar And Dr. R. K. Garg. (2012). Oee Improvement By Tpm Implementation: A Case Study. International Journal Of It, Engineering And Applied Sciences Research (Ijieasr) Issn: 2319-4413 Volume 1, No.1.

[9]. Harsha G. Hedge, N.S. Mahesh. Kishan Doss. (2009). Overall Equipment Effectiveness Improvement by TPM and 5S Technique in a CNC Machine Shop. Volume 8, Issue 2.

[10]. Haitham Mansour M. Munir Ahmad Nesreddin Dhafr Hussain Ahmed. (2013)."Evaluation of operational performance of workover rigs activities in oilfields", International Journal of Productivity and Performance Management, Vol. 62 Iss 2 pp. 204 – 218

[11]. Heizer, Jay, Barry Render . (2015). *"Manajemen Operasi: Sustainability and Supply Chain Management". Edisi Sebelas. Jakarta: Salemba Empat*.

[12]. Hermanto. (2016). Pengukuran Nilai Overall Equipment Effectiveness pada Divisi Painting di PT. AIMs. Vol 17, No 2.

[13]. Imam Sodikin, Cyrilla Indri Parwati, Agostinho Da Fonseca. (2017). Analisis Total Productive Maintenance Dengan Metode Overall Equipment Effectiveness Sebagai Solusi Six Big Losses Dan Cacat Produk. ISSN: 2337 – 4349: Hal.57-62.

[14]. Mohammad Faizal Hazmi, Anda Iviana Juniani, Ekky Nur Budiyanto. (2015). Analisis Perhitungan OEE dan Six Big Losses terhadap Produktivitas MesinTuber Bottomer Line 4 PT. IKSG Tuban. ISSN No. 2581 – 1770.Hal.161-166.

[15]. Nakajima, S. (1988). Intorduction To Total Productive Maintenance. Cambridge: Productivity Press.

[16]. Nayak, D. M., Viiaya Kumar, M. N., Naidu, G S., & Shankar, V. (2013). Evaluation Of Oee In A Continuous Process Industry On An Insulation Line In A Cable Manufacturing Unit. *Internantional Journal of Innovative Research in Science, Engineering and Technology, 2(5), 1629-1634.*

[17]. Osama Taisir R.Almeanazel. (2010). Total Productive Maintenance Review and Overall EquipmentEffectiveness Measurement. Jordan Journal of Mechanical and Industrial Engineering.*Volume 4, Number 4, September 2010ISSN 1995-6665Pages 517 – 522.*

[18]. Poerwanto, G. H. (2014, April 27). Kelola Kualitas Diagram Fishbone. Retrieved April 27.

[19]. Prof. A.Bangar, Hemlata Sahu, Jagmohan Batham. (2013). Improving Overall Equipment Effectiveness By Implementing Total Productive Maintenance In Auto Industry, Ijetae Vol. 3, Issue 6 June Issn: 2250-2459.

[20]. Riza Virdian, Endang P.W. dan Erlina. (2014). Evaluasi Efektivitas Mesin Coal Feeder Dengan Penerapan Total Productive Maintenance (Tpm) Di Pt. Pembangkitan Jawa Bali Services Pltu Paiton Unit Ix, Page 35-49.

[21]. Samad, M. A., & Hossain, M. R. (2012). Analysis of Performance by Overall Equipment Effectiveness of the CNC Cutting Section of a Shipyard. *ARPN Journal Of Science and Technology*, 2(11), 1091-1096.

[22]. Samsul Huda, Misbach Munir. (2015). Implementasi 5r+1s Sebagai Upaya Peningkatan Efektivitas Produksi Dengan Metode Overall Equipment Effectiveness (Oee) Di Pt. Coca-Cola Bottling Indonesia. Vol. 03/No. 03/2016:11-18.

[23]. Stamatis D. H. (2010). The Oee Primer: understanding overall equipment effectiveness, reliability, and maintainability. CRC Press.

Corrosponding Author: Ahmad hidayat Sutawijaya[2]
[2]Program Studi Magister Management, Universitas Mercu Buana Jakarta