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Predictive Maintenance Analysis In Predicting Equipment Damage In Balance Of Plant (BOP) Area (Pangkalan Susu Power Plant Case Study)

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Abstract

Along with the increasing demand for electricity use in Indonesia, especially north Sumatra, PT. PLN (PERSERO) built a coal-fired steam power plant. With the existence of this steam power plant, it can help the country's electricity supply, especially in Sumatra. As is known that steam power plants are plants that have a high potential for equipment damage, especially the Balance of Plant (BOP) area. Therefore, a team is formed that can overcome and identify equipment damage with certain tools, called the Predictive Maintenance team. Predictive Maintenance (PdM) techniques are designed specifically to help determine the condition of equipment assets used as a reference for predictions for when asset maintenance activities should be carried out. Predictive Maintenance (PdM) is a form of maintenance that directly monitors the condition and performance of equipment during normal operation to reduce damage or failures in the future. The main tools used for Predictive Maintenance are Vibration Meter and Infrared Thermography. And the equipment has standards or limits resulting from trending measurement data and also has international standards as a reference. There was damage to one of the Balance of Plant (BOP) equipment, which is Demineralized (DM) Pump that causes the supply of demineralized water to the unit to be reduced and the unit load cannot be increased to maximum. With predictive maintenance (PdM) analysis, it can be quickly identified that the damage was in the drive end (DE) motor bearing of the demineralized equipment (DM) pump. Replacement of bearing on the Demineralized motor (DM) can maximize the performance of the unit so as to make an electrical energy saving of 1,095,360 kWh. In addition, it also has financial benefits of Rp. 681,781,917,-

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1. Introduction

PT. PLN (PERSERO) constructed Pangkalan Susu coal-fired steam power plant to cope with the increasing demand for electricity in Indonesia, especially north Sumatra. With the existence of this steam power plant, it helps the country's electricity supply, especially in Sumatra. (University, 2015).

High vibration and temperature are among the factors causing damage to equipment that can result in severe damage if goes undetected in the early stage. Therefore, by using correct system and methods we can prevent equipment damage from happening.

Balance of Plant is a part of steam power plant that is known for having a high potential of equipment damage. Therefore, a team is formed that can overcome and indicate equipment damage with certain tools, called the Predictive Maintenance team (power, 2020).

With that, the author is interested in analyzing "Predictive Maintenance Analysis in Predicting Equipment Damage in Balance of Plant (BOP) Area (Pangkalan Susu Power Plant Case Study)".

2. Method

Every stage that will be done to analyze the effect of Predictive Maintenance Analysis in Predicting Equipment Damage in Balance of Plant (BOP) Area (Pangkalan Susu Power Plant Case Study)

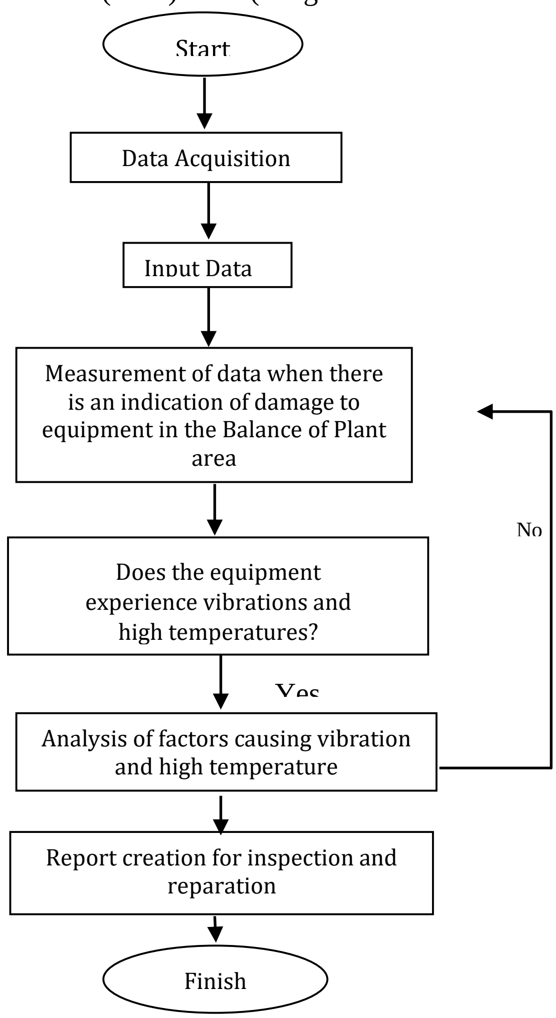

Figure 1. Flowchart Research Methods
Source: Author, *2020*

In August 2020 there was an increase in vibration and temperature in one of the Balance of Plant (BOP) equipment, Demineralized Motor (DM) Pump, which caused damage to the Drive End (DE) motor

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bearing that the author has obtained in the Predictive Maintenance History Report of Pangkalan Susu Power Plant. The vibration and temperature data that can be seen in tables 3 and 4.

Tables 1 . Chronology of vibrational disorders against DM Pump

		Titik No. 1			Titik No. 2			Titik No. 3			Titik No. 4		
11		V	H	A	V	H	A	V	H	A	V	H	A
12	5 Februari 2016	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	17-May-2016	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	10-Aug-2016	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	9-Sep-2016	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	9-Oct-2016	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	9-Nov-2016	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	29-Dec-2016	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	20-Jun-2017	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	21-Nov-17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	11-Dec-2017	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	31-Mei-18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	18-Jul-18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	15-Agu-18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	10-Okt-18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	20-Des-18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	02-Jan-19	1,610	1,880	0,480	1,590	1,680	1,590	1,590	2,270	0,390	1,800	1,100	0,470
28	29-Jan-19	3,380	1,820	1,590	1,590	1,590	1,590	1,590	2,760	0,690	2,610	1,090	0,390
29	25-Feb-19	3,540	2,280	0,760	1,590	2,270	1,590	1,590	1,590	1,590	1,650	1,390	0,480
30	25-Mar-19	6,930	2,590	0,980	1,590	2,270	1,590	1,590	1,110	0,896	1,990	1,310	0,526
31	25-Apr-19	0,568	3,000	0,346	1,590	3,010	0,561	1,590	2,270	0,696	2,390	1,750	0,480
32	21-Mei-19	0,657	2,650	0,346	0,689	2,780	0,796	1,590	1,120	0,796	1,650	1,490	0,380
33	20-Jun-19	0,703	2,260	0,343	1,590	2,250	1,590	1,530	1,620	0,661	1,800	1,260	0,426
34	19-Jul-19	1,270	2,510	0,419	1,590	2,760	1,590	1,590	2,250	0,696	1,750	1,470	0,506
35	17-Agu-19	1,140	2,470	0,288	1,590	2,250	1,590	1,500	1,590	1,590	0,895	1,170	0,584
36	11-Sep-19	1,590	2,130	1,590	1,590	1,580	1,590	1,590	1,590	1,590	0,924	0,988	0,130
37	05-Nov-19	1,590	2,700	1,590	1,590	2,270	1,590	1,590	1,590	0,682	0,821	0,874	0,343
38	03-Des-19	2,320	2,830	0,634	1,590	2,790	1,590	1,590	0,909	0,796	0,874	1,140	0,194
39	06-Des-19	1,590	3,780	1,590	3,810	2,130	1,410	1,590	1,210		1,100	0,853	1,980
40	28-Jan-20	8,570	5,200	3,990	1,590	2,270	1,590	1,590	2,610	0,796	1,260	1,030	0,388
41	28-Feb-20	0,499	1,260	0,356	1,590	1,150	0,756	1,590	2,050	0,568	1,180	0,877	0,376
42	24-Mar-20	0,718	1,380	0,796	1,590	1,590	1,590	1,590	1,590	0,575	0,817	0,947	0,286
43	21-Apr-20	0,531	1,360	0,331	0,796	1,500	1,590	1,590	1,590	0,561	1,590	0,913	0,327
44	18-Mei-20	1,050	2,330	1,590	1,590	2,250	1,590	1,590	1,590	0,368	1,410	0,988	0,369
45	16-Agu-20	1,460	2,260	1,590	5,820	5,410	3,020	1,590	2,250	0,368	0,881	1,070	0,341

Source: History Report Predictive Maintenance,2020

Tables 2. Chronology of temperature disturbances with DM Pump

		Titik No.1	Titik No.2	Titik No.3	Titik No.4
11	17-Mei-16	39,6	58,6	48,5	49,5
12	10-Agu-16	39,5	53,0	48,2	56,8
13	09-Sep-16	39,8	52,1	45,1	45,6
14	06-Okt-16	39,3	51,7	44,3	45,4
15	09-Nov-16	40,0	49,5	43,5	46,3
16	29-Des-16	37,8	54,1	43,6	40,0
17	20-Jun-17	47,9	55,1	49,0	48,9
18	21-Nov-17	46,9	57,0	47,0	46,0
19	11-Des-17	44,5	53,3	43,6	45,2
20	31-Mei-18	40,0	58,0	45,8	49,1
21	18-Jul-18	44,7	54,6	44,9	43,4
22	15-Agu-18	45,7	54,0	45,4	49,7
23	10-Okt-18	43,2	53,7	45,6	48,6
24	01-Jan-19	44,0	51,9	44,8	46,1
25	29-Jan-19	43,3	53,7	44,6	52,6
26	25-Feb-19	48,2	58,8	48,3	54,5
27	25-Mar-19	41,2	58,7	46,0	51,6
28	25-Apr-19	37,0	45,1	44,4	52,3
29	21-Mei-19	46,2	59,1	48,7	57,0
30	20-Jun-19	39,6	53,4	46,4	46,4
31	18-Jul-19	38,6	52,1	46,6	46,8
32	17-Agu-19	49,9	58,4	47,2	51,4
33	11-Sep-19	47,2	59,7	44,5	51,2
34	05-Nov-19	44,9	53,4	41,0	48,5
35	03-Des-19	40,7	57,3	45,2	51,7
36	04-Jan-20	50,7	60,3	47,4	56,1
37	28-Jan-20	49,6	56,5	47,2	57,3
38	25-Feb-20	48,7	63,6	50,1	51,7
39	24-Mar-20	44,5	65,6	34,9	54,6
40	21-Apr-20	47,1	66,8	51,1	57,8
41	18-Mei-20	45,3	61,6	50,3	60,5
42	16-Agu-20	42,2	80,5	44,5	49,4

Source: History Report Predictive Maintenance,2020

According a tables 4 and the result of the author's interview to several employees of the Pangkalan Susu power plant predictive maintenance technician, there are several problems that often occur on Demineralized Motor (DM) Pump of Balance of Plant (BOP), it can reduce the performance of the equipment because it cannot carry out its proper functions.

These are the condition of equipment performance when the problem occurs:

1. Demineralized (DM) Pump cannot be operated due to damage.
2. The process of producing demineralized water in Balance of Plant (BOP) is reduced because the Demineralized Motor (DM) Pump cannot be operated.
3. Load on power plants is reduced due to the absence of Balance of Plant (BOP) water supply.

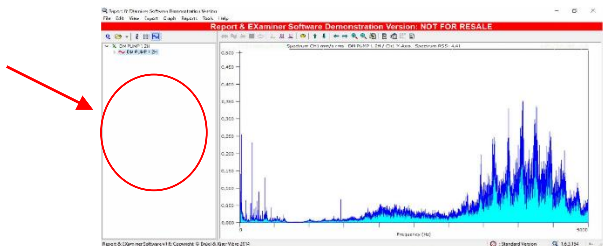
3. Result And Discussion

3.1 Predictive of Maintenance an Analysis Demineralized Pump Motors

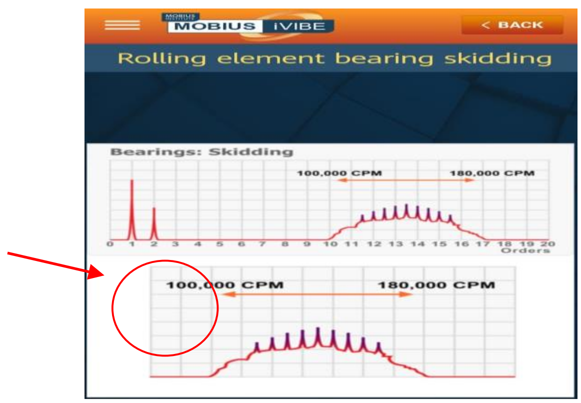
This analysis is based on the design of the system that obtained from the data collection process at Pangkalan Susu Power Plant.

1. Determination of Alternative Solutions

Based on the data obtained from the Pangkalan Susu Power Plant, the cause of the problem in the repair of the Demineralized Pump Motor can be solved by analyzing the root cause of the equipment. The following picture is the Analysis of Spectrum Vibration of Demineralized Pump Motor that suffered damage.



Figures 2. Analysis of Spectrum Vibration motor DM Pump that is problematic
Source: Maintenace Predictive Analysis and Report Application, 2020

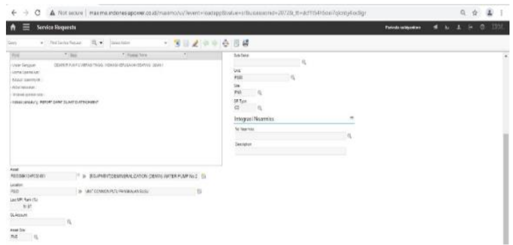


Figures 3. A Spectrum Of International Mobius iVibe Standard
Source : www.google.com, 2020

Based on the results of vibration spectrum analysis in the Maintenace Predictive Application and also the similarity between the Spectrum Motor Demineralized Pump (DM) and the International Standard Spectrum Mobius iVibe, it can be ascertained that the cause of the problem is damage to the Bearing Drive End (DE) of the Demineralized Pump Motor. Thus, it is necessary to make a service request for the replacement of the Bearing so that the performance of the Demineralized Pump Motor can be maintained within its best performance and can be operated normally.

2. Service Request (SR) Results of Predictive Maintenance Analysis

The creation of a Service Request (SR) report from The Maintenance Predictive analysis on the Maximo PT Indonesia Power is addressed to the field of Maintenance (HAR) for improvement, the replacement of Bearing Drive End (DE) Motor Demineralized Pump. This repair includes the replacement of grease or lubricant in the bearing house, on the motor so that repairs to the Demineralized Pump Motor are more maximal and reduce the same indication of damage. The repair schedule of the Service Request (SR) report can be set when the equipment is ready to be repaired and has also been discussed to the Maintenance (HAR) division related to the availability of bearings, supporting tools and technicians on duty. Based on the Service Request (SR) report on Picture 8.3, the repair was scheduled on Wednesday, August 26th, 2020.



Figures 3. *Service Request (SR) Analysis Results*
Source: Maximo PT. Indonesia Power, 2020

3. Demineralized Pump Motor Repair

Replacement of Bearing Drive End (DE) Motor Demineralized Pump carried out by the Maintenance division (HAR) according to Service Request (SR) from the predictive maintenance field using SKF bearings with code 6311-2Z / C3 which means that the bearing is single row deep groove ball bearing which has a medium series and a hole diameter of 55 mm and has protection from 2 sides.

3.2 Equipment a Performance After Repairing Demineralized Pump Motor

Tables 5 . Demineralized Pump production monitoring data

No.	Date	Production Expenses (Hour)	Demineralized Pump Condition	Description
1	27-Aug-20	96,4	Normal	Start Up unit
2	28-Aug-20	102,5	Normal	Start Up unit
3	29-Aug-20	99,2	Normal	Start Up unit
4	30-Aug-20	99,8	Normal	Start Up unit
5	31-Aug-20	105,9	Normal	Start Up unit
6	01-Sep-20	95,2	Normal	Start Up unit
7	02-Sep-20	97,9	Normal	Start Up unit
8	03-Sep-20	109,3	Normal	Start Up unit
9	04-Sep-20	102,1	Normal	Start Up unit

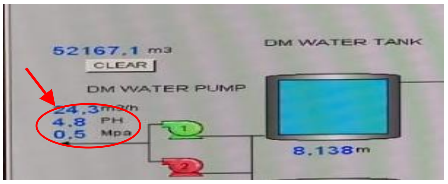
Source: BOP PNS OMU Database, 2020

Tables 5 shows water production in 2 weeks after the repair of the Demineralized Pump Motor. It can be concluded that the condition of the Demineralized Pump operates normally with an average rate of 100 m3 / h and proves that the performance of the equipment can be restored, thus maintaining the reliability of balance of plant (BOP) by reducing time and effort because it is quickly repaired.

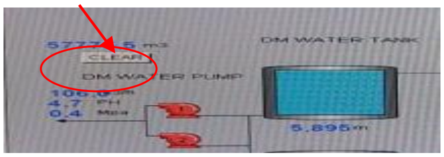
3.3 Comparison of Conditions Before and After Improvement

Before reparation of the Demineralized Pump Motor, problems such as noise and hot motor body occurred frequently during water production. Replacement of Bearing Drive End (DE) Motor Demineralized Pump has been implemented during the planned maintenance on July-October 2019. On August 27, 2019, the vibration and thermography check of the Demineralized Pump Motor gave good results and no more problems so that the water production process operates normally. From figure 8.5 it can be concluded that predictive maintenance analysis in the prediction of equipment damage in the BOP area is quite effective because it can restore equipment performance and maintain the reliability of balance of plant (BOP) in Pangkalan Susu power plant. Here is a comparison of the condition before and after the repair of the Demineralized Pump Motor:

1. Operating Process



(a)

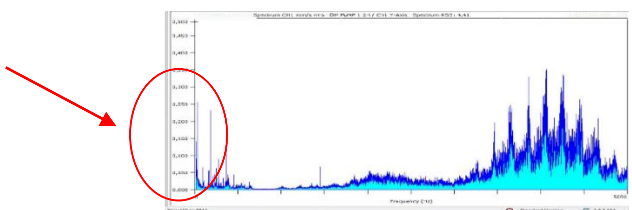


(b)

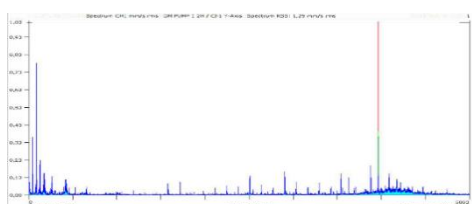
Figures 5 . (a) Load Before Replacement bearing drive end (DE) Motor Demineralized Pump (b) Load After Replacement Bearing Drive End (DE) Motor Demineralized Pump
Source: Author, 2020

Figures . 5(a) shows the water production load before the Replacement bearing drive end (DE) of the Demineralized Pump motor. Water production cannot be maximized and the water supply to the power plant is reduced to 24.3 m3 / h as shown in the picture. 5.(b) shows the water production load after the Replacement of Bearing Drive End (DE) Demineralized Pump Motor. Water production is up to 106.0 m3/h and the supply to the power plant is fulfilled.

2. Demineralized Pump Vibration Spectrum



(a)



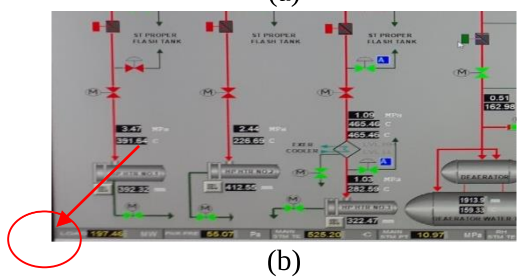
(b)

Figures 5 . (a) Vibration Spectrum Before Replacement of Bearing Drive End (DE) Motor Demineralized Pump (b) Vibration Spectrum After Replacement of Bearing Drive End (DE) Motor Demineralized Pump
Source: Author, 2020

Figures 5 . (a) shows the overall vibration before the Replacement bearing drive end (DE) Motor Demineralized Pump at 4.41 mm/s, which come into warning category. Figure 5 . (b) shows the overall vibration before the Replacement bearing Drive End (DE) Motor Demineralized Pump below the number 1.29 mm/s which come into the category of good or normal.

3. Pangkalan Susu OMU Power Plant unit load performance

(a)


(b)

Figures 7 . (a) Unit Load Performance When Water Supply Is Insufficient
(b) Unit Load Performance When Water Supply Is Sufficient
Source: Author, 2020

Figures 7.(a) shows the unit load when the water supply from Balance of Plant (BOP) is reduced due to damage to the Demineralized Pump Motor. The power plant unit can only produce 129 MW of electric load. Figures 7 . (b) shows the unit load after the water supply of the Balance of Plant (BOP) has been restored because the damage to the Demineralized Pump Motor has been repaired and the power plant unit can produce up to 197.46MW of electric load, which means an increase of approximately 68.46 MW.

3.4 Financial Benefits

The financial benefits obtained are the opportunity to minimize the loss of load production as in figure 4.8 due to the lack of water supply from Balance of Plant (BOP) due to damage to The Demineralized Motor Bearing Assuming the selling price of the electric power is Rp. 997 / kWh:
= 68,46 MW X 16 hour X Rp. 997/kWh)
= 1.095,36 MW X Rp. 997/kWh)
= 1.095.360 kWh X Rp. 997/kWh)
= Rp. 1.092.073.920

Production cost consist of fuel (coal) cost for 16 hours (32 tons/hour) with coal price of Rp.787,000/ton (Source: Pangkalan Susu Power Plant, 2020), electric power usage on Demineralized Pump which is 366.6 kWh and also the cost of Drive End (DE) bearing replacement of Rp. 1,500,000 (source:Maintenace Support Pangkalan Susu Power Plant):

1. Coal Cost:
= 16 hours X 32 tons/hour X Rp.787.000/tons
= 512 tons X Rp.787.000/tons
= Rp. 402.944.000
2. Cost of Demineralized Pump Electricity usage:
= 366,6 kWh X 16 hours X Rp.997/kWh= Rp. 5.848.003
3. Cost of Demineralized Pump Motor Bearing replacement:

= Rp. 1.500.000
Total A Production Cost
=Rp. 402.944.000 + Rp. 5.848.003 + Rp. 1.500.000 = Rp 410.292.003
Financial benefits =
Rp. 1.092.073.920 – Rp. 410.292.003 = **Rp. 681.781.917**

3.5 Non-Financial Benefits

The non-financial benefits of this implementation are:

1. Increased power plant reliability.
2. Reduced equipment maintenance time.
3. The equipment operation process of Balance of Plant (BOP) becomes easier because the Demineralized Pump has been repaired.

4. Conclusion

Predictive Maintenance analysis has been scheduled daily within 52 weeks or 1 year for different equipment. The difference in analysis time on each equipment is different, depending on the location and the number of equipment measurement points that can take up to 3 to 4 hours in 1 day. Predictive Maintenance analysis is able to optimize the performance of Balance of Plant (BOP) equipment so that the water supply is sufficient for the power plant unit to work optimally and save repair time up to 16 hours. Predictive Maintenance analysis has good financial benefits by minimizing potential losses of Rp. 681,781,917,-

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