



MAINTENANCE MANAGEMENT ANALYSIS OF INDUCE DRAFT FAN (IDF) EQUIPMENT OF COAL FIRE POWER PLANT (CFPP) LONTAR USING LIFE CYCLE COST ANALYSIS APPROACH

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ABSTRACT

To maintain the performance to optimalization operating at Coal Fire Power Plant (CFPP) the reliability of power plant equipment needs to be maintained especially on critical equipment. Based on CFPP failure data during 2012 – 2017, one of the critical equipment is the Induce Draft Fan (IDF).

The Journal will analyse the reliability, availability and maintainability for the IDF equipment with the approach of Life Cycle Cost Analysis (LCCA). Using the IDF equipment failure data during 2012 - 2017 which is processed using Minitab 17 application with Weibull Analysis method, the results obtained the mean value (μ) for MTTF and shape parameters (β) and scale parameters (η) for calculation MTTR. That data combined with the hours of annual routine maintenance periods for each unit, used to calculate the operating and maintenance (O&M) hours of IDF in a year and then combined with operational cost data so the total O&M costs for the IDF during 15 years period obtained. Consider with assumptions for the calculation, the final results can provide input for management to making appropriate maintenance decisions. The results of LCCA approach for 15 years obtained the lowest total maintenance cost is IDF unit 1 of 527.68 billion.

INTRODUCTION

To meet the growing needs for electricity in Indonesia, the government issued a policy of the 10,000 MW Fast Track Program Phase 1 (FTP-1). To achieve the energy needs in 2008 the government began to build power plants program and it is expected that the power plants will be ready to operate in 2009 (Admin, 2008).

Lontar CFPP is the one of the government Fast Track Program power plants that uses coal as the main fuel. At the coal fire power plant, coal is burned to heat the water in the boiler pipe

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until it turns into steam with a certain pressure. In the coal combustion process the air pressure is maintained at certain set points (under atmospheric pressure). To maintain the set-point, the combustion system is equipped with Force Draft Fan (FDF) and Induce Draft Fan (IDF) equipment. Under these conditions the reliability of the FDF and IDF equipment becomes very critical because if there is interference with the equipment it will have an impact on the loss of production opportunities.

In the CFPP generating system, IDF equipment is included in the Boiler Air and Gas System. The failure data equipment of Lontar CFPP from 2012 - 2017 as shown in Figure 1, Boiler Air and Gas System are in the top 5 causes of loss production, so to reduce the loss of production in the Boiler Air and Gas System in the next period the reliability of IDF equipment needs to be optimized.

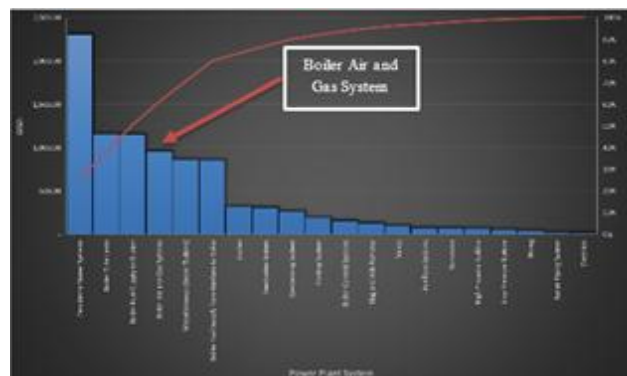


Figure 1. Lost production rank each CFPP system (GWh)

To maintain the reliability of the IDF equipment, maintenance must be optimal. In the study (Wardoyo, 2017) applying periodic maintenance interval optimization based on an analysis of Reliability, Availability and Maintainability (RAM) in the Saguling Hydroelectric Power Plant, while (Nugraha, Silalahi, & Sinisuka, 2016) implemented Reliability, Availability, Maintainability and Security (RAMS) for maintenance of 150-kV Power Transmission Submarine cables. (Bhakti & Kromodihardjo, 2015) designed a maintenance system using the Reliability Centered Maintenance method on medium pulverized (Eliyus, Alhilman, & Sutrisno, 2014) to estimate maintenance costs and determine machine life and number of maintenance personnel using the Life Cycle Cost method and (Madiyansah, 2018) conduct an economic analysis on the pulverizer equipment at the power plant with the Life Cycle Cost Analysis approach.

There is still not much research for the reliability of IDF equipment. Therefore, researchers try to make a study of the reliability, availability and maintainability for the Induce Draft Fan (IDF) with a Life Cycle Cost Analysis (LCCA) approach. The final result of this analysis is to provide an input to management for making appropriate decisions in optimizing the maintenance costs of Induce Draft Fan (IDF) equipment.

RESEARCH METHOD

This research was conducted with literature studies and field studies to determine the condition of the Induce Draft Fan (IDF) equipment in the Lontar CFPP so that data obtained for research from the year of operation during 2012 to 2017, then the data is processed using Minitab 17 application with Weibull analysis until we get the value of shape parameter (β), scale parameter (η) and mean (μ).

From the above parameters then used to calculate the Mean Time to Failure (MTTF) and Mean Time to Repair (MTTR) values for each IDF equipment. The data processing then performed to calculate the costs for each IDF equipment's in accordance with the life cycle cost analysis (LCCA) approach to obtain the total value of the operating and maintenance costs for the IDF equipment's during the operating period. From the total cost, it is obtained that the most

optimal Maintenance Management between each IDF equipment by considering the assumptions that exist.

The research can be described as shown in Figure 2.

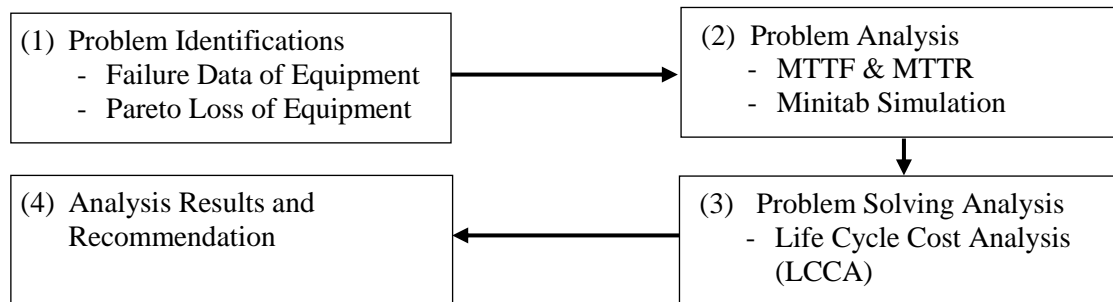


Figure 2. The Research process flowchart

Generally, Life-Cycle Cost (LCC) is the total cost during an asset operating from research, planning, design, testing, production processes, certification, operation, maintenance, until disposal of asset. The general formula for calculating the Life Cycle Cost for an equipment/system can be formulated as follows:

$$LCC = CI + CO + CM + CF + CD \quad (1)$$

Where's:

CI: Investment Cost; CO: Operational Cost; CM: Maintenance Cost; CF: Failure Cost; CD: Disposal Cost.

RESULTS AND DISCUSSION

1. The Calculation of Mean Time to Failure (MTTF)

From the data of failures that occur on each IDF equipment from starting to operate (2012) until 2017 can be recap in table 1 as follows:

Table 1. Failure data of IDF

No.	Unit 1		Unit 2		Unit 3	
	A	B	A	B	A	B
	Hour	Hour	Hour	Hour	Hour	Hour
1	28.560,00	33.970,00	11.536,63	11.616,83	1.968,00	1.968,00
2	10.301,63	4.128,87	10.882,01	10.882,01	7.535,28	8.613,78
3	1.946,97	159,72	81,00	81,00	1.022,73	84,17
4	139,20	801,62	11.786,72	14.316,87	11,50	6.369,65
5	10.952,18	862,62	2.520,30	1.808,67	84,17	19.302,65
6		1.915,28	3.538,95	6.161,38	10.665,67	6.414,70
7		179,40	767,82	4.534,53	1,00	
8		3.387,37			0,63	
9		2.694,93			13.362,38	
10					318,23	

From the above data then processed to get the MTTF value on each unit of IDF equipment using Minitab 17 software. In this study the distribution analysis used is Weibull Analysis. From the results of the software analysis, the data for each IDF equipment obtained as follows:

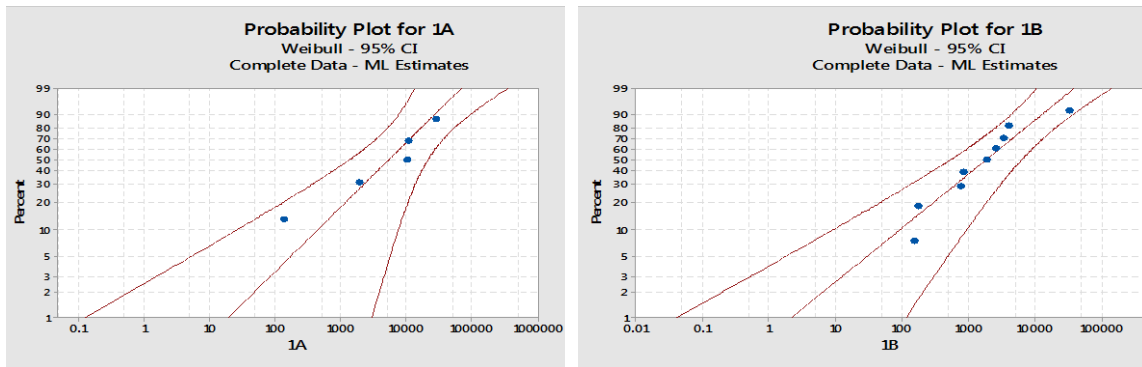


Figure 3. Failure data simulation for IDF unit 1 (IDF 1A & 1B)

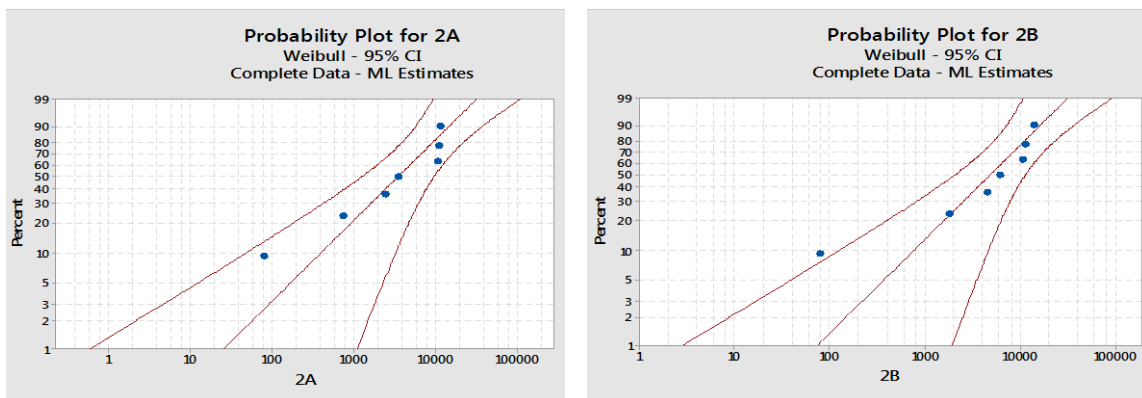


Figure 4. Failure data simulation for IDF unit 2 (IDF 2A & 2B)

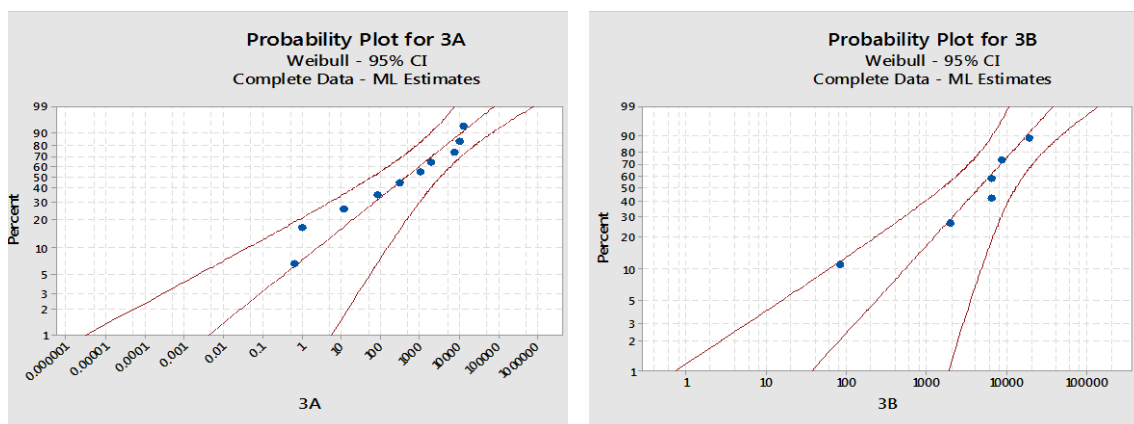


Figure 5. Failure data simulation for IDF unit 3 (IDF 3A & 3B)

From the simulation results of the IDF equipment using software, the value is obtained shape parameter (β), scale parameter (η) and mean (μ) which can be recapitulated in table 2 as follows:

Table 2. Simulation data result of MTTF

Unit IDF	MTTF			
	μ (Hour)	μ (day)	η	β
1A	10.726,60	447,00	9.009,66	0,75
1B	4.891,07	204,00	3.432,47	0,63
2A	5.961,44	248,00	5.520,46	0,86
2B	7.047,26	294,00	7.084,28	1,01
3A	5.059,77	211,00	1.843,91	0,43
3B	7.218,89	301,00	6.799,36	0,89

From table 2 above, the MTTF (μ) value is obtained for each IDF equipment. For IDF 1A machines, the time span for disruption is 10,726.6 hours or 447 days, for IDF 1B machines it is 4,891.07 hours (204 days), for IDF 2A machines it is 5,961.44 hours (248 days), for IDF 2B machines are 7,047.26 hours (294 days), for IDF 3A machines it is 5.59.77 hours (211 days) and for IDF 3B machines is 7218.89 hours (301 days).

2. The Calculation of Mean Time to Repair (MTTR)

The time data used to repair IDF equipment during the specified period is summarized in table 3 as follows:

Table 3. Repair data of IDF

No.	Unit 1		Unit 2		Unit 3	
	A	B	A	B	A	B
	Hour	Hour	Hour	Hour	Hour	Hour
1	206,67	0,15	729,86	649,66	8,72	8,72
2	19,63	6,15	8,00	8,00	9,63	65,50
3	2,48	0,80	0,93	0,93	34,63	592,18
4	4,63	19,63	9,85	9,30	65,50	0,75
5	6,07	0,90	9,30	6,65	762,55	4,10
6		0,87	1,38	4,20	214,22	9,05
7		11,13	1,08	486,97	594,43	
8		7,00			332,92	
9		1,57			13,20	
10					4,10	

From the above data then processed to get the MTTR value on each unit of IDF equipment using Minitab 17 software. In this study the distribution analysis used is Weibull Analysis. From the results of the software analysis, the data for each IDF equipment obtained as follows:

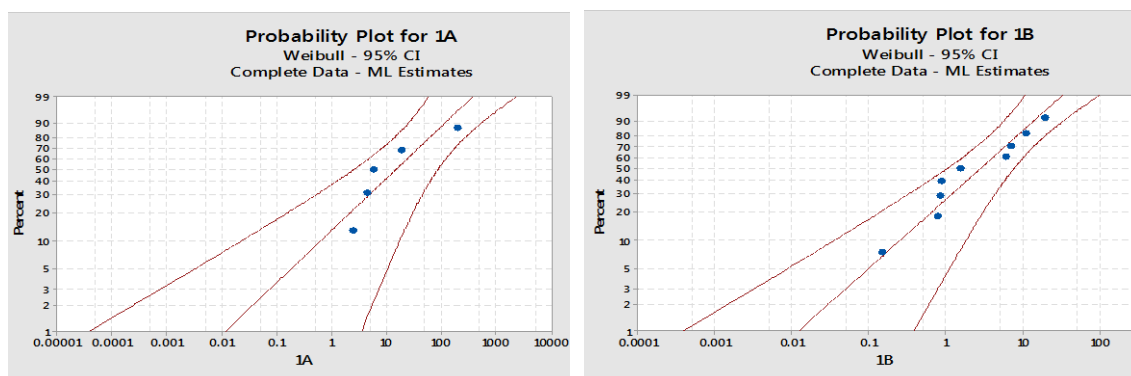


Figure 6. Repair Data IDF Unit 1 (IDF 1A & 1B)

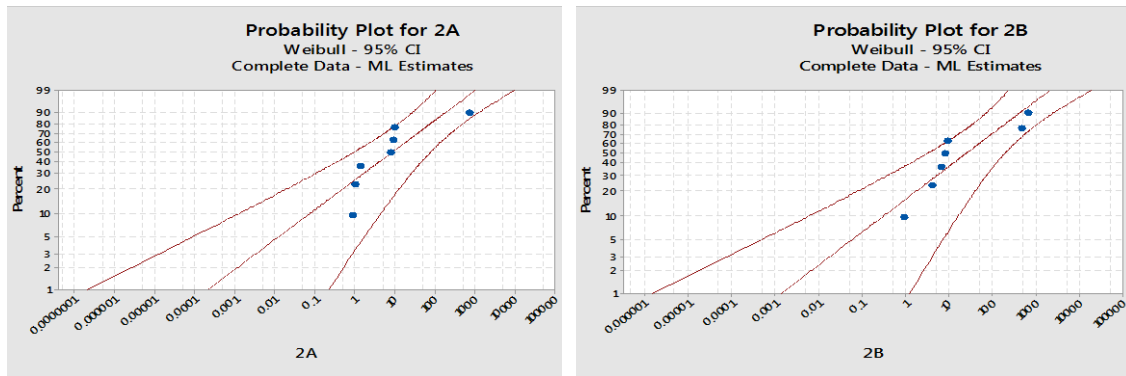


Figure 7. Repair Data IDF Unit 2 (IDF 2A & 2B)

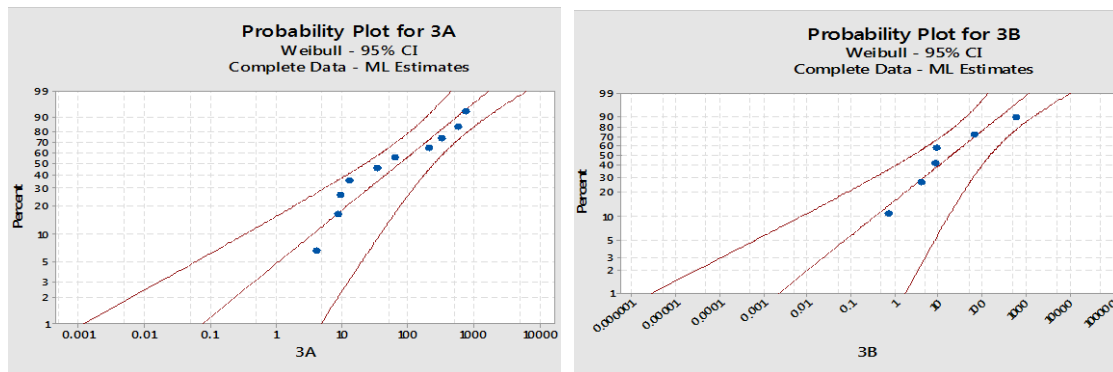


Figure 8. Repair Data IDF Unit 3 (IDF 3A & 3B)

From the simulation above obtained data shape parameter (β) and scale parameter (η) in table 4.

Discription	Unit 1		Unit 2		Unit 3	
	A	B	A	B	A	B
Shape Parameter (β)	0,59	0,78	0,40	0,43	0,61	0,46
Scale Parameter (η)	28,56	4,62	22,45	60,09	140,68	43,72

Furthermore, from the above data table then processed using the MTTR formula of Weibull distribution, the calculations for IDF 1A units can be obtained as follows:

$$\begin{aligned}
 MTTR &= \eta \Gamma \left(1 + \frac{1}{\beta} \right) & (2) \\
 &= 28,56 \times \Gamma \left(1 + \frac{1}{0,59} \right) \\
 &= 28,56 \times \Gamma (2,69) \\
 &= 28,56 \times 1,5353 = 43,84 \text{ hour}
 \end{aligned}$$

For other IDF equipment's, can be calculated using the same method so that the results of the each IDF equipment calculations can be recapitulated in excel as in table 5.

Table 5. Recapitulation of simulation data MTTR for IDF

Unit IDF	MTTR			
	η	$(1+1/\beta)$	$\Gamma(1+1/\beta)$	MTTR (Hour)
1A	28,56	2,69	1,5353	43,84
1B	4,62	2,29	1,1586	5,35
2A	22,45	3,51	3,3611	75,45
2B	60,09	3,31	2,7244	163,70
3A	129,02	2,82	1,7119	220,86
3B	43,72	3,15	2,3134	101,14

From table 5 above, for the IDF 1A, the time to repair for each time a failures occurs is 43.84 hours or 1.83 days, the IDF 1B is 5.35 hours (0.22 days), the IDF 2A is 75.45 hours (3.14 days), IDF 2B is 163.70 hours (6.82 days), IDF 3A is 220.86 hours (9.2 days) and IDF 3B is 101.14 hour (4.21 days).

3. Cost Analysis

a. Investment Cost (CI)

The initial investment costs for processing the initial contract data during the construction of the plant for the installation for unit #1 of IDF equipment can be calculated as follows:

- Price 1 Unit IDF (a) = Rp. 2.977
- Assurance Unit (b) = Rp. 81
- Transport Cost (c) = Rp. 7
- Install Cost (d) = Rp. 168
- Total = Rp. 3.255

(All calculated in Million)

The calculation assumptions:

- Units made abroad (China)
- The price of goods includes tax
- Goods are purchased using US Dollars and when purchasing goods, the exchange rate of rupiah used (KURS) is Rp. 9.000.

b. Operational Cost (CO)

Operating Costs are routine operating costs occurred in accordance with operating hours reduced by annual routine maintenance hours according to the power plant maintenance cycle. One unit consists of 2 IDF equipment so each IDF equipment operates 50% of the maximum capacity of the equipment. The operational cost analysis for 1 IDF machine is as follows:

- Power Consumption(a) = 215 kW
- Operating efficiency(b) = 50%
- Electricity cost (c) = 680 (Rp/kWh)
- Hourly production costs per unit = Rp. 4,386 million

c. Maintenance cost (CM)

Maintenance costs are routine maintenance costs occurred every year to maintain the performance of IDF equipment in normal conditions. Routine maintenance schedule (periodic inspection) for each unit in table 6 as follows:

Table 6. Maintenance time duration

Unit	Year														
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Unit 1	FYI	SI	ME	SI	SE	SI	ME	SI	SE	SI	ME	SI	SE	SI	ME
Duration (day)	60	30	45	30	60	30	45	30	60	30	45	30	60	30	45
Unit 2	-	FYI	SI	ME	SI	SE	SI	ME	SI	SE	SI	ME	SI	SE	SI
Duration (day)	-	60	30	45	30	60	30	45	30	60	30	45	30	60	30
Unit 3	-	FYI	SI	ME	SI	SE	SI	ME	SI	SE	SI	ME	SI	SE	SI
Duration (day)	-	60	30	45	30	60	30	45	30	60	30	45	30	60	30

The duration of FYI (First Year Inspection) maintenance is 60 days, SI (Simple Inspection) is 30 days, ME (Mean Inspection) is 45 days and SE (Serious Inspection) is 60 days. From the routine maintenance we get operating hours for each unit as shown in table 7.

Table 7. Operation hour for each IDF

Unit	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Unit 1 (Hour)	7.344	8.040	7.680	8.036	7.343	8.040	7.680	8.040	7.344	8.040	7.680	8.040	7.344	8.040	7.680
Unit 2 (Hour)	8.784	7.291	8.040	7.680	8.063	7.310	8.040	7.680	8.064	7.320	8.040	7.680	8.064	7.320	8.040
Unit 3 (Hour)	8.784	7.288	8.016	7.680	8.064	7.320	8.040	7.680	8.064	7.320	8.040	7.680	8.064	7.320	8.040

The maintenance costs for each work each IDF equipment are as follows:

Table 8. The maintenance costs for FYI

First Year Inspection (FYI) Works				
No.	Description	Unit	Vol	Total
1	Labor	Mandays	60	114.300.000,00
2	Tools	Days	60	15.210.000,00
3	Consumable	Set	1	48.921.000,00
4	Safety Tools	Set	1	410.000,00
5	Administration	Set	1	10.700.000,00
Total Cost				189.541.000,00

Table 9. The maintenance costs for the SI

Simple Inspection (SI) Work				
No.	Description	Sat	Vol	Total
1	Labor	Mandays	30	57.150.000,00
2	Tools	Days	30	7.605.000,00
3	Consumable	Set	1	48.921.000,00
4	Safety Tools	Set	1	410.000,00
5	Administration	Set	1	10.700.000,00
Total Cost				124.786.000,00

Table 10. The maintenance costs for ME

Mean Inspection (ME) Works				
No.	Description	Sat	Vol	Total
1	Labor	Mandays	45	85.725.000,00
2	Tools	Days	45	11.407.500,00
3	Consumable	Set	1	48.921.000,00
4	Safety Tools	Set	1	410.000,00
5	Administration	Set	1	10.700.000,00
Total Cost				157.163.500,00

Table 11. The maintenance costs for SE

Serious Inspection (SE) Works				
No.	Description	Unit	Vol	Total
1	Labor	Mandays	60	114.300.000,00
2	Tools	Days	60	15.210.000,00
3	Consumable	Set	1	48.921.000,00
4	Safety Tools	Set	1	410.000,00
5	Administration	Set	1	10.700.000,00
Total Cost				189.541.000,00

d. Failure Cost (CF)

Represents the costs occurred to repair damage that occurred on the IDF machine in each unit during 15 years' operation. From the simulation results of MTTF calculations for each IDF equipment, an estimated time of the damage occurrence for each IDF equipment was obtained. Then from the time of the incident the simulation of the damage event time was carried out for 15 years to obtain the damage event for 15 years as shown in table 12.

Table 12. Failure event simulation for IDF

Time of Failure Simulation for IDF																
Unit IDF	n- Year															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1A	0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	12
1B	1	2	2	2	1	2	2	2	2	1	2	2	2	2	1	26
2A	1	1	2	1	2	1	2	1	2	1	2	1	2	1	2	22
2B	1	1	1	1	2	1	1	1	1	2	1	1	1	1	2	18
3A	1	2	2	1	2	2	1	2	2	2	1	2	2	1	1	24
3B	1	1	1	1	2	2	1	1	2	1	1	1	1	1	1	18

From the simulation of failure events for 15 years as in the above table, the total incidence for each IDF equipment is obtained. For IDF 1A machines, 15 times of damage occurred 12 times, damage for IDF 1B engine occurred 26 times, damage for IDF 2A engine occurred 22 times, damage for IDF 2B engine occurred 18 times damage, for IDF 3A engine occurred 24 times damage and for IDF 3B engine occurred 18 times failures.

The duration of failure repair time for each IDF equipment accordance with the simulation of Mean Time to Repair (MTTR) calculation in table 5. The cost for repairing an IDF equipment per day is as shown in table 13.

Table 13. Repair cost calculation of IDF equipment each day

Repair Cost IDF				
No.	Description	Unit	Days	Total
1	Labor	Mandays	1,00	1.905.000,00
2	Tools	Days	1,00	253.500,00
3	Consumable	Set	1,00	48.921.000,00
4	Safety Tools	Set	1,00	410.000,00
5	Administration	Set	1,00	10.700.000,00
Total Repair Cost per days				62.189.500,00

For labor calculations in table 13 the number of days adjusts to the MTTR value each IDF equipment's according to table 5. For example, for IDF 1A equipment's, according to table 12 there was failures in the second year and then the repair time for IDF 1A according to table 5 was 43.84 hour or 1.83 days. The calculation of repair costs for IDF 1A is as shown in table 14. In the same way used to calculate the engine IDF 1B, IDF 2A, IDF 2B, IDF 3A and IDF 3B so that the cost of repairing IDF machines is obtained as shown in table 15.

Table 14. Repair Cost Calculation of IDF 1A

Repair Cost IDF 1A				
No.	Description	Unit	Days	Total
1	Labor	Mandays	1,83	3.479.799,88
2	Tools	Days	1,83	463.059,98
3	Consumable	Set	1,00	48.921.000,00
4	Safety Tools	Set	1,00	410.000,00
5	Administration	Set	1,00	10.700.000,00
Total Repair Cost IDF 1A				63.973.859,87

Table 15. Total Repair Cost Calculation of each

Description	Cost
Repair Cost IDF 1A	63.973.859,87
Repair Cost IDF 1B	60.512.039,16
Repair Cost IDF 2A	66.817.019,71
Repair Cost IDF 2B	74.754.109,10
Repair Cost IDF 3A	79.895.044,97
Repair Cost IDF 3B	69.127.578,83

e. Life Cycle Cost Analysis

From the calculations per component investment costs, operating costs, routine maintenance costs, repair costs and depreciation costs are then recapitulated in excel and continued with the LCC analysis as shown in table 16.

Table 16. LCCA for IDF unit 1 (in billion)

No.	Description	ID	Year -															Total			
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14		15		
1	Investation Cost	CI	6,51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,51	
2	Operation Cost	CO	-	32,21	35,26	33,68	35,24	32,20	35,26	33,68	35,26	32,21	35,26	33,68	35,26	32,21	35,26	33,68	35,26	33,68	510,40
3	Maintenance Cost	CM	-	0,38	0,25	0,31	0,25	0,38	0,25	0,31	0,25	0,38	0,25	0,31	0,25	0,38	0,25	0,31	0,25	0,31	4,52
4	Repair Cost	CF	-	0,06	0,18	0,18	0,18	0,12	0,12	0,18	0,18	0,18	0,12	0,12	0,18	0,18	0,18	0,18	0,12	0,12	2,34
5	Disposal Cost	CD	-	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	3,91
6	Total Cost		6,51	32,91	35,96	34,44	35,94	32,97	35,89	34,44	35,96	33,04	35,90	34,38	35,96	33,04	35,96	34,38	35,96	34,38	527,68
7	Sells		-	64,04	70,11	66,97	70,07	64,03	70,11	66,97	70,11	64,04	70,11	66,97	70,11	64,04	70,11	66,97	70,11	66,97	1.014,79
8	Cash Flow		-6,51	31,13	34,15	32,53	34,13	31,06	34,22	32,53	34,15	31,01	34,21	32,59	34,15	31,01	34,15	32,59	34,15	32,59	487,12
9	Interest Rate	10%	-6,51	28,30	28,23	24,44	23,31	19,29	19,31	16,69	15,93	13,15	13,19	11,42	10,88	8,98	8,99	7,80			243,42

From table 16, the total cost of unit 1 IDF equipment simulation for 15 years is Rp. 527.68 billion, assuming the selling price of electricity is 1,352 Rp / kWh, the electricity sales for 15 years is 1,014.79 billion. Assuming the bank interest rate in 2017 is 10%, the NPV value = 243.42 will be obtained then IRR = 4.85 and B / C = 75.82.

Table 17. LCCA for IDF unit 2 (in billion)

No.	Discription	ID	Year -															Total		
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14		15	
1	Investation Cost	CI	6,51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,51
2	Operation Cost	CO	-	38,53	31,98	35,26	33,68	35,37	32,06	35,26	33,68	35,37	32,11	35,26	33,68	35,37	32,11	35,26	35,26	514,99
3	Maintenance Cost	CM	-	-	0,38	0,25	0,31	0,25	0,38	0,25	0,31	0,25	0,38	0,25	0,31	0,25	0,38	0,25	0,38	4,21
4	Repair Cost	CF	-	0,14	0,14	0,21	0,14	0,28	0,14	0,21	0,14	0,21	0,22	0,21	0,14	0,21	0,14	0,28	0,28	2,82
5	Disposal Cost	CD	-	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	3,91
6	Total Cost		6,51	38,93	32,76	35,98	34,40	36,16	32,84	35,98	34,40	36,09	32,96	35,98	34,40	36,09	32,89	36,06	36,06	532,42
7	Sells		-	76,60	63,58	70,11	66,97	70,31	63,74	70,11	66,97	70,32	63,83	70,11	66,97	70,32	63,83	70,11	70,11	1.023,91
8	Cash Flow		- 6,51	37,67	30,82	34,13	32,57	34,16	30,90	34,13	32,57	34,23	30,87	34,13	32,57	34,23	30,95	34,06	34,06	491,49
9	Interest Rate	10%	- 6,51	34,25	25,47	25,64	22,25	21,21	17,44	17,51	15,20	14,52	11,90	11,96	10,38	9,92	8,15	8,15	8,15	247,44

From table 17, a simulation of the total cost of the unit 2 IDF equipment for 15 years is Rp. 532.42 billion, assuming the selling price of electricity is 1,352 Rp / kWh, the electricity sales for 15 years is 1,023.91 billion. Assuming the bank interest rate in 2017 is 10%, the NPV = 247.44 will be obtained, then IRR = 5.64 and B / C = 76.49

Table 18. LCCA for IDF unit 3 (in billion)

No.	Discription	ID	Year -															Total			
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14		15		
1	Investation Cost	CI	6,51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6,51
2	Operation Cost	CO	-	38,53	31,97	35,16	33,68	35,37	32,10	35,26	33,68	35,37	32,11	35,26	33,68	35,37	32,11	35,26	35,26	514,91	
3	Maintenance Cost	CM	-	-	0,38	0,25	0,31	0,25	0,38	0,25	0,31	0,25	0,38	0,25	0,31	0,25	0,38	0,25	0,38	4,21	
4	Repair Cost	CF	-	0,15	0,23	0,23	0,15	0,30	0,30	0,15	0,23	0,30	0,23	0,15	0,23	0,23	0,15	0,15	0,15	3,16	
5	Disposal Cost	CD	-	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	0,26	3,91	
6	Total Cost		6,51	38,93	32,83	35,90	34,41	36,17	33,04	35,92	34,49	36,18	32,97	35,92	34,49	36,11	32,89	35,92	35,92	532,70	
7	Sells		-	76,60	63,56	69,90	66,97	70,32	63,83	70,11	66,97	70,32	63,83	70,11	66,97	70,32	63,83	70,11	70,11	1.023,77	
8	Cash Flow		- 6,51	37,66	30,72	34,01	32,56	34,14	30,79	34,19	32,48	34,14	30,86	34,19	32,48	34,21	30,94	34,19	34,19	491,07	
9	Interest Rate	10%	- 6,51	34,24	25,39	25,55	22,24	21,20	17,38	17,54	15,15	14,48	11,90	11,98	10,35	9,91	8,15	8,18	8,18	247,14	

From table 18, a simulation of the total cost of the unit 1 IDF equipment for 15 years is Rp. 532.70 billion, assuming the selling price of electricity is 1,352 Rp / kWh, the electricity sales for 15 years is 1,023.77 billion. Assuming the bank interest rate in 2017 is 10%, the NPV value = 247.14, then IRR = 5.64 and B / C = 76.43.

From the LCC analysis results of the IDF equipment's in unit 1, unit 2 and unit 3 then recapitulated in table 19.

Table 19. Recapitulation of IDF equipment LCC analysis (in billions)

No.	Unit	NPV	IRR	B/C	LCC
1	Unit 1	243,42	4,855	75,82	527,68
2	Unit 2	247,44	5,639	76,49	532,42
3	Unit 3	247,14	5,635	76,43	532,70

CONCLUSIONS

From the qualitative data analysis with Life Cycle Cost calculation for 15 years the lowest total cost is IDF unit 1 of 527.68 billion then IDF unit 2 of 532.42 billion and IDF unit 3 of 532.7 billion. From the above calculation with the same periodic maintenance cycle (SI-ME-SI-SE) for each unit, the total cost of maintaining an IDF equipment's for each unit for 15 years is different. The lowest total maintenance costs are on IDF unit 1. For the optimal maintenance cost, we recommended to simulate the equipment failure using data IDF unit 1 to prepare the predictive and preventive maintenance for each IDF unit then we can immediately anticipate the equipment failure with spare part preparation and quick equipment repair.

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