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36,000 HOURS OF MAINTENANCE PLANNING ON WARTSILA MACHINES W18V50DF USING THE CRITICAL PATH METHOD AND EVALUATION REVIEW TECHNIQUE PROGRAM AT PT ANTAM PLTD

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ABSTRACT
Antam Diesel Power Plant is one main power plant that supply electricity for processing nickel ore. Antam Diesel Power Plant is consisting of 8 engines Wartsila W18V50DF. The reliability of Antam Diesel Power Plant is quietly well maintenance for avoid disturbance in processing nickel ore dan avoid material loss. Obviously, that power plant needs frequently maintained, one of maintenance is 36000 hours maintenance. This job is conducted by manufacturer PT Wartsila Indonesia. As contractor Wartsila given a mandatory for shorter the duration of maintenance 36000 hours but still maintain engines performance also avoid loss from both parties. Maintenance Planning 36000 hours using Critical Path Method and Program Evaluation and Review Technique. With using CPM dan PERT the maintainance can be shortened from 36 days to 32 days with increase of margin from 16,75% to 20,91% and probabily of success 77,94%. Using additional crash duration method is not suitable for this project because the cost is increase directly proportional with failure rate and for avoid labor from being tired.

Keywords: Antam Diesel Power Plant, W18V50DF, Critical Path Method, Program Evaluation and Review Technique, Crash Duration, Margin

INTRODUCTION

PT ANTAM is a member of MIND ID (Indonesian Mining Industry), the Mining Industry SOE Holding is a vertically integrated, export-oriented, and diversified mining and metals company (Tardok, 2018). With operations spread across Indonesia's mineral-rich archipelago, ANTAM conducts all activities from exploration, mining, processing to marketing nickel, ferronickel, gold, silver, bauxite, and coal ores (Alfalah, 2023; Asmawati & Muhammad, 2024; Bakri, 2017; Fadli et al., 2019; Siahaan, 2018).

One of PT Antam's operating units is UBPN Kolaka which is in Pomalaa district, Kolaka Regency, Southeast Sulawesi, where this business unit is engaged in mining and processing ore/raw soil into nickel or ferronickel ore in the processing process (MARSUDI & Herlina, 2023; Md et al., n.d.; Ponidi, 2018; Yasa et al., 2021). The ore processing process uses a cooking system by sticking electrodes into the ground. Of course, with electrode stapling, this requires electrical energy with large power and is also reliable to handle these loads (Asmawati & Muhammad, 2024).

The details of the power requirements are as follows:

1. FeNi 2 (30 MWatt)
2. FeNi 3 (42 MWatt)
3. FeNi 4 (38 MWatt)
4. Auxiliary FeNi (16 MWatt)
5. Housing (1.8 MWatt)

There are two power plants that distribute power for operations at UBPN Kolaka, namely PLTD and PLTU. Diesel Power Plants or PLTDs have the advantage in terms of their flexibility, capacity, and ability to operate independently in a variety of geographical and weather conditions.

PLTD Antam uses 8 engines from Wartsila with W18V50DF type with a power of 16.63 MWatt per machine, a total power of 136 MW. Meanwhile, PLTU is a manufacturing from Sumitomo of 2 turbines with a maximum power of 30 MWatt per engine.

FeNi 2, FeNi 3 and FeNi 4 have fluctuating characteristics so that they use supply from PLTD and 1 engine from PLTU while for Auxiliary and housing which tend to be stable using 1 PLTU machine.

The current condition is that if the full load of all FeNi and coal-fired power plants is not an obstacle, then the engine is running 5 engines and the coal-fired power plant is 1 engine (Nurcahyo, 2024).

The employment contract between PT Antam and PT Wartsila is maintenance with additional advisory services. In addition to advisory for maintenance activities at the plant, PT Wartsila is obliged to carry out major overhaul in accordance with the contract.

As a contractor, PT Wartsila was given demands from the customer, namely PT Antam to be able to complete 36000 hours of maintenance as quickly as possible but still maintain the quality of work and no rework. Of course, PT Wartsila also wants the same thing to optimize margins. 36000 hours of maintenance work is carried out for 36 working days for each machine in accordance with the applicable contract (Samlawi, 2015; Saputra, 2022; Setiawannie, 2022; Setywan, 2021; Sodikin, 2024).

This maintenance, of course, has costs incurred to the customer. These costs are divided into two, namely offshore or spare parts costs and onshore costs or work services. Onshore costs amounted to Rp. 2,965,676,823 and offshore costs amounted to Rp. 21,878,406,092.

36000 Hours Maintenance Management

In 36000 hours of Maintenance work, there are several challenges or aspects that need to be considered to get an efficient job

Some of the factors are:

1. Maintenance Scheduling

In this study, it will be focused on planning maintenance scheduling. Maintenance of 36000 hours itself is planned for 36 days of contract. This scheduling is very important because it will correlate with manpower, spare parts delivery and operational maintenance.

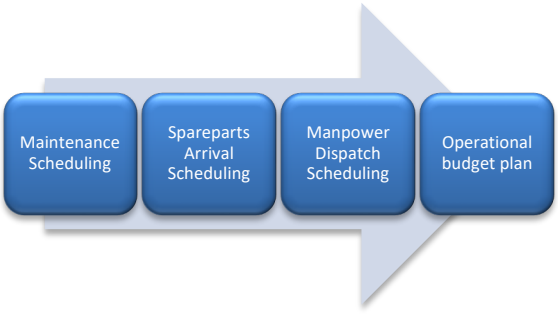


Figure 1 Maintenace Ruler Flow Diagram

Source: by Researcher

2. Manpower Cost

Manpower costs concern the cost of salaries, overtime costs and mobilization. The calculation of overtime costs uses basic employee where the calculation is: basic/173 x the number of overtime hours. For mobilization costs, the price of a round-trip plane from Jakarta to Pomalaa is calculated (Hari Ganesh et al., 2021; Li et al., 2022).

3. Operating Costs

Operational costs concern the costs incurred for daily activities. The following are the cost components that affect project scheduling in addition to manpower and overtime costs in the table below:

Table 1 Operating costs

Yes	Items	Cost
1	Snack	13,000,000/month
2	Hotel	Max 750,000/person/night
3	Main meal	60,000/person/day

Source: by Researcher

Critical Path Method

In scheduling a project, it is known as the Critical Path Method (CPM). The terms contained in this method are (Setiawan, Ferry; Sofyan, Edi; Scott, S. (2021).

1. E (earliest event occurence time): the fastest time an event occurs.
2. L (latest event occurence time): the longest time that an event is still allowed to occur.
3. ES (earliest activity start time): the earliest start time of an activity.
4. EF (earliest activity finish time): the earliest completion time of an activity. The EF of a previous activity is the same as the ES of the next activity.
5. LS (latest activity start time): the slowest time an activity can start without slowing down the project.
6. LF (latest activity finish time): the slowest time an activity is completed without slowing down the overall completion of the project.
7. D (activity duration time): the period required for an activity (day, week, month, hour).
8. TF (slack or float): the amount of time an activity is allowed to be postponed, without affecting the overall project completion schedule, the way to find the total slack is TF = LF-EF = LS-ES.

In this CPM, there is also a fictitious activity called dummy. For an overview of this activity, you can see the following figure 1.

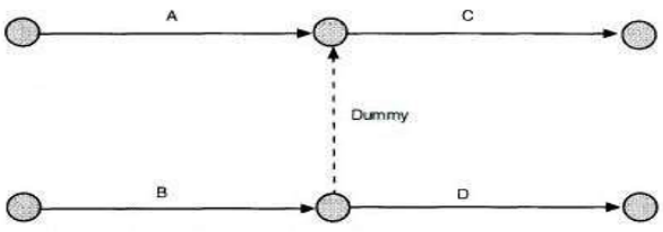


Figure 2. Dummy Activities

Source: by Researcher

Program Evaluation and Review Technique

PERT is a time-network-based project scheduling method that requires three-time predictions for each event: optimistic, most likely and pessimistic. Using these three approximate times, the chances of completing the project on a set date can be calculated, along with the standard start and end times for each activity or event". The purpose of the three allegations is:

1. Optimistic Time (to)
   That is the estimated time of the best activity that can be expected if everything goes well,.
2. Most Likely Time (tm)
   That is the time of the activity that will occur if an activity is carried out under normal conditions, with certain delays that can be accepted.
3. Pessimistic Time(tp)
   That is the worst time, if there are many obstacles or delays.

The beta distribution function is used as the basis for determining the duration (te), standard deviation (se), and variant (ve) of PERT as follows:

$te = (to + 4m + tp)/6$

$se = (tp - to)/6$

$ve = \{(tp - to)/6\}2$

Where te is the Expected time; tp is pessimistic time; to is optimistic time; se is the standard deviation; m is most likely; ve is Variance.

METHOD

This research is included in the type of descriptive approach. This study aims to describe in detail the planning process and maintenance implementation, including mentioning a little about the condition of the workforce in planning (Sugiyono, 2013).

RESULTS AND DISCUSSION

1. CPM method analysis results

In analyzing CPM, a relationship between jobs is needed to determine the relationship between previous activities and the next activity. An activity is likely to have many predecessor activities and many activities that follow (Successor). The results of the CPM method calculation are shown in table 1.1

Table 1. CPM method calculation results

Code	Activity Details	Preceeding	Duration (days)	IS	EF	LS	LF	Float
A	Heatrate test before	-	1	0	1	0	1	0
B	Machine Disassembly	A	1	1	2	1	2	0
C	Piston Lift	B	2	2	4	13	15	11
D	Overhaul Cylinder Head	B	8	2	10	13	21	11

And	Overhaul Injection Pump	B	8	2	10	11	19	9
F	Overhaul exhaust bellows	B	3	2	5	13	16	11
G	Overhaul Damper Side	B	7	2	9	2	9	0
H	Overhaul Charge Air Cooler	B	3	2	5	16	19	14
I	Remove Piston	C	1	4	5	15	16	11
J	Overhaul Injection Valve	And	2	10	12	19	21	9
K	Overhaul Water Pump	G	2	9	11	9	11	0
L	Overhaul Cylinder Liner	F,I	4	5	9	16	20	11
M	Overhaul Intermediate Gear	K	8	11	19	11	19	0
N	Inspect All Bearing	M	1	19	20	19	20	0
Or	Install Charge Air Cooler to Engine	H	1	5	6	19	20	14
P	Overhaul turbocharger	Or	7	6	13	20	27	14
Q	Install piston to Engine	L,N	1	20	21	20	21	0
R	Install Cylinder Head to Engine	Q,J,D	1	21	22	21	22	0
S	I/O Test Electrical and Replace module	R	2	22	24	22	24	0
T	Cleaning Cover, pipes, and other parts	R	2	22	24	22	24	0
In the	Install injection pump and fuel pipes	R	2	22	24	22	24	0
V	Install cover, pipes and other parts	S,T,U	2	24	26	24	26	0
In	Flow water check	V	1	26	27	26	27	0
X	Flow oil check and final check	W,P	1	27	28	27	28	0
And	Safety Device Test	X	1	28	29	28	29	0
With	Running in program	And	1	29	30	29	30	0
AA	Heatrate test after and troubleshooting	With	1	30	31	30	31	0

Source: by Researcher

Based on Table 1, the critical path is the path that has a float value = 0 . The critical path is obtained in the table below. Listed in table 2

Table 2. Activities with floats = 0

Code	Activity Details	Float
A	Heatrate test before	0
B	Machine Disassembly	0
G	Overhaul Damper Side	0
K	Overhaul Water Pump	0
M	Overhaul Intermediate Gear	0
N	Inspect All Bearing	0

Q	Install piston to Engine	0
R	Install Cylinder Head to Engine	0
S	I/O Test Electrical and Replace module	0
T	Cleaning Cover, pipes, and other parts	0
In the	Install injection pump and fuel pipes	0
V	Install cover, pipes and other parts	0
In	Flow water check	0
X	Flow oil check and prelube engine	0
And	Safety Device Test	0
With	Running in program	0
AA	Heatrate test after and troubleshooting	0

Source: by Researcher

It was found that the critical path in this activity was A-B-G-K-M-N-Q-R-S-T-U-V-W-X-Y-Z-AA. By using the CPM method, the job can be completed in 31 days from the previous 36 days

2. Results of PERT Method Analysis

The method is used to calculate the likelihood that a project can be completed. The PERT method uses 3 estimated times, namely, optimistic time (a), most likely time (a) and pessimistic time (b). The results of the PERT method are shown in table 1.3.

Table 3. PERT Method Results

Code	Duration			In	S = (b-a)/6	$V(te) = S^2$
	a	m	b			
A	1	1	2	1,17	0,17	0,03
B	1	1	2	1,17	0,17	0,03
G	6	7	10	7,33	0,67	0,44
K	1	2	3	2,00	0,33	0,11
M	7	8	10	8,17	0,50	0,25
N	1	1	2	1,17	0,17	0,03
Q	1	1	2	1,17	0,17	0,03
R	1	1	2	1,17	0,17	0,03
S	1	2	4	2,17	0,50	0,25
T	1	2	3	2,00	0,33	0,11
In the	1	2	3	2,00	0,33	0,11
V	1	2	3	2,00	0,33	0,11
In	1	1	2	1,17	0,17	0,03
X	1	1	2	1,17	0,17	0,03
And	1	1	2	1,17	0,17	0,03
With	1	1	2	1,17	0,17	0,03
AA	1	1	2	1,17	0,17	0,03

Σv(te)	1,667
Standard Deviasi	1,291

Source: by Researcher

After calculating the standard values of deviations and variances, we can calculate the probability of this project being completed on time by determining the value of Z and looking at the normal distribution value from the Z table.

Table 4. Project completion probability

No	With	Target Time	Normal Distribution Table	Probabilities (%)
1	3,10	35	0,999	99,90%
2	2,32	34	0,9898	98,98%
3	1,55	33	0,9394	93,94%
4	0,77	32	0,7794	77,94%
5	0,00	31	0,5	50,00%
6	-0,77	30	0,2206	22,06%
7	-1,55	29	0,0606	6,06%
8	-2,32	28	0,0102	1,02%
9	-3,10	27	0,001	0,1%

Source: by Researcher

It is found in the table that the best possibility is that the project can be completed in 35 days with a probability of 99.99%, while for the results of the optimization method the project will be completed in 31 days with a probability of 50%.

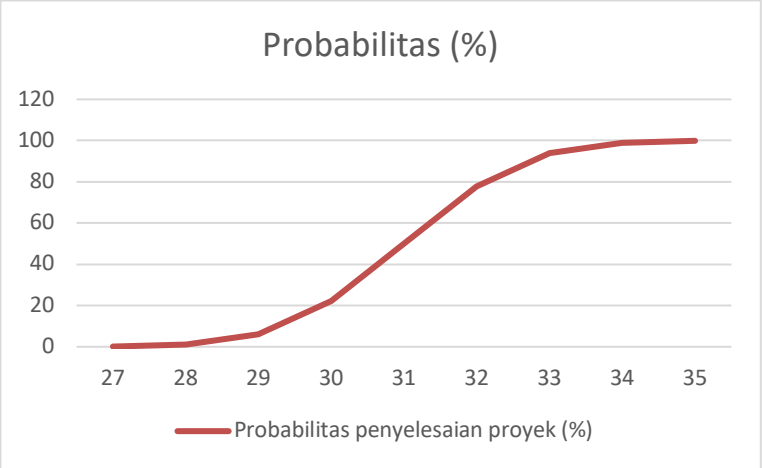


Figure 3. Project completion probability graph
Source: by Researcher

Based on this data, it is obtained that work faster than 31 days has a very small probability of completing the project and is almost not recommended at all. This data will

be combined with the results of the CPM method to determine the best project duration (Sartika, 2018).

3. Determining the best duration

The probability of project completion and profit margin need to be correlated to see which duration is best.

Table 5. Comparison between margin and probability

No	Target Time	Probabilities (%)	Profit Margin
1	27	0,10%	26,10%
2	28	1,02%	25,06%
3	29	6,06%	24,02%
4	30	22,06%	22,99%
5	31	50,00%	21,95%
6	32	77,94%	20,91%
7	33	93,94%	19,87%
8	34	98,98%	18,83%
9	35	99,90%	17,79%

Source: by Researcher

To see the comparison clearly, the comparison graph is:

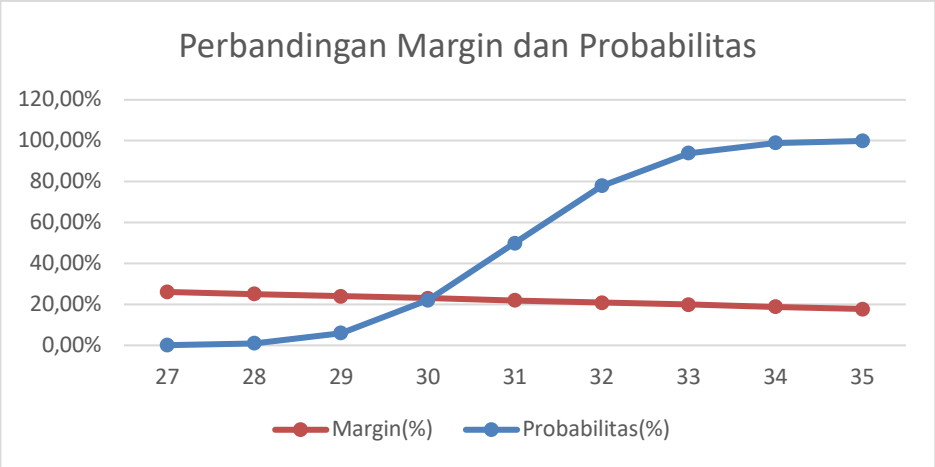


Figure 4. Margin and probability comparison chart
Source: by Researcher

Based on the graph, the comparison between the probability and the margin is reversed. The larger the margin, the lower the probability of project completion. Therefore, the probability below 50% can be ignored to be used because it is too risky if you decide below 50% or under 31 days. The most optimal number of days is at 32 days with a margin of 20.91% and a probability of 77.94%.

The optimal planning is with the number of days in 32 days with a probability of project completion at 77.94% and a margin of 20.91% or an increase of 4.16% equivalent to a saving of Rp120,749,030. The results of this planning are shown in table 1.5

Table 6. Final results of cost changes

Duration	Inclusion	Production	Advantage	Margin
36	IDR 2,906,355,787	IDR 2,419,440,408	IDR 486,915,379	16,75%
32	IDR 2,906,355,787	IDR 2,298,691,378	IDR 607,664,409	20,91%

Source: by Researcher

CONCLUSION

The results of the analysis of the maintenance planning of 36000 hours of Wartsila machines W18V50DF using the CPM and PERT methods at PLTD Antam were obtained The conclusion is as follows: The Maintenance Planning of 36000 hours of Wartsila machines W18V50DF at PLTD Antam has a critical path in the activity code A-B-G-K-M-N-Q-R-S-T-U-V-W-X-Y-Z-AA. The combination of the PERT and CPM methods obtained the most optimal results from 36 days to 32 days so that the margin increased from 16.75% to 20.91% with the probability of project completion at 77.94%. Based on the results of the probability of project completion for work under 32 days gets a probability of 50%, this indicates the vulnerability of the project will be at risk of failure and this is also a reference for optimal conditions for the workforce to be at 32 days. Using the crash cost method with an additional overtime of 1 hour and 2 hours with a reduction in working days to 30 and 27 days. However, there are additional costs of IDR 21,437,354 and IDR 18,929,743 respectively so that they are not used for planning because they increase the budget even though the number of working days is limited.

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