Strategy of Rescheduling Project of Elevation and Roof Replacement of Granular-I NPK Plant by CPM Method (Critical Path Method) at PT. Pupuk Kujang Cikampek

by Cindy Cahyaning

Strategy of Rescheduling Project of Elevation and Roof Replacement of Granular-I NPK Plant by CPM Method (Critical Path Method) at PT. Pupuk Kujang Cikampek

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Abstract— Project elevation and replacement of NPK Granular-I roof plant is a management effort of PT. Kujang fertilizer to cope with roof leaks which resulted in frequent factory shutdown. It is expected that there will be acceleration of project implementation duration, so that the productivity of the factory will be maintained. This project scheduling uses CPM (Critical Path Method) and Crashing Project method. With the process of adding labor, the efficiency of implementation time for 8 days or as much as 23.08%, from the original 72 days to 64 days and no additional cost. As after the acceleration of the project duration, the productivity of the factory increased and potentially produce as much as 2,400 tons of granular NPK fertilizer or potentially revenue Rp. 12.96 Billion.

Index Terms— CPM, project scheduling, crashing project, project management

1 Introduction

Pupuk Kujang company is currently experiencing a decline in the achievement of NPK Granular fertilizer production. This can be seen from the data of NPK Granular production achievement in the last 5 (five) years. Granular NPK production data can be seen on graph (figure 1). In the graph, it can be seen that the achievement of production in 2011 amounted to 38,785 tons, in 2012 amounted to 40,592 tons, in 2013 amounted 37,281 tons, in 2014 amounted to 14,437 tons and in 2015 amounted to 80,414 tons. Granular NPK production is below the annual target of 90,000 tons / year, while Factory capacity is 100,000 tons / year, or 300 tons / day.

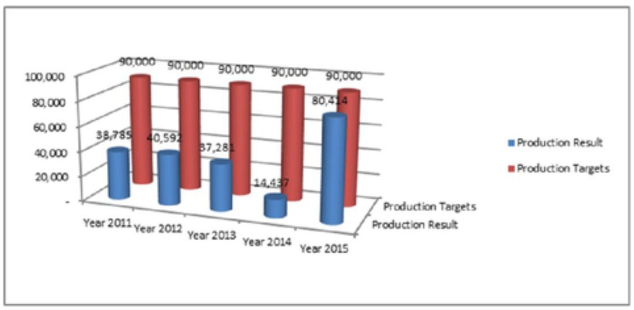

Fig. 1. Granular NPK Production Results

Once evaluated it can be seen that the cause of Granular NPK production target is not achieved due to the frequent shutdown of the machine. With the occurrence of machine shutdown, then the potential revenue of production becomes lost. A day of machine shutdown means a loss of production potential of 300 tons of Granular NPK fertilizer, or loss of potential revenue of 300,000 kg x Rp. 5,400, - = Rp. 1.620.000.000, - / day. The most dominant cause of engine shutdown is a roof leak that concerns the conveyor engine resulting in slip conveyor and raw materials being processed into damp (wet) so that the machine can not continue the production process. To handle the roof leak, the management plans the project of raising and replacing the roof with better materials.

Based on Time Schedule, the project elevation and replacement of the Granular NPK roof will take 11 (eleven) weeks or 72 (seventy two) days. The stages of the project include: 1) engineering, 2) preparation, 3) project office and safety, 4) fabrication, 5) sandblasting, 6) painting, 7) Unloading, 8) erection, and 9) weaning and ordering. The duration of the work item 7, 8 and 9 is scheduled to be executed at 5 (five) weeks' shutdown time, which means production is stalled. The management of Kujang Fertilizer company expects the shutdown duration of the machine is not too long, then the work items 7, 8 and 9 are expected to be completed within 3 (three) weeks so the factory can immediately reproduce.

To maintain the productivity of the NPK plant, the project raising and replacing the roof of the Granular-I NPK plant is expected to be completed by accelerating the project implementation time. Heizer and Render states that CPM is a project management technique to help managers schedule, monitor and control large and complex projects [1]. Crashing Project is the process of shortening project time duration in the cheapest way.

Based on the above background, it can be formulated the problem in this research is how the strategy of rescheduling project elevation and replacement of roof of Granular-I NPK Plant with CPM method (Critical Path Method) in PT. Pupuk Kujang Cikampek.

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2 RESEARCH METHOD

Data analysis techniques in this study using the CPM (Critical Path Method). Soeharto in Dannyanti states that the systematic process of preparing networks with CPM methods are [2]:

a. Review and identify the scope of the project, describe it, break it down into activities or activity groups that are components of the project.
b. Rearrange the components in item 1, into a chain with the corresponding sequence of dependency logic.
c. Provides an approximate period of time for each activity resulting from the decomposition of the project scope.
d. Identify critical paths and float on the network.

Once a critical path is known, the next step is to accelerate the project. The steps are:

a. Determine the acceleration time and calculate the additional cost for the acceleration of each activity.
b. Accelerate project completion time by prioritizing critical activities that have the lowest cost slope. If acceleration efforts are made on activities not on the critical path, then the overall completion time will not be reduced.
c. Reorganize the network.
d. Repeat the second step and stop doing the acceleration effort if there is a critical trajectory increase. If there is more than one critical path, the acceleration effort is performed simultaneously on all activities on the critical path. Try not to add or move critical path if held acceleration duration in one of activity.
e. The acceleration attempt is stopped when the activities on the critical path are completely saturated (no longer possible to be suppressed).

Calculate the overall cost due to acceleration to know the total cost of the project issued.

3 RESULT

Networking

Before the network is created (Network Planning), must first know the time required and the normal cost of each activity as in Table 1.

TABLE 1. CONSTRUCTION PROJECT ACTIVITIES
ELEVATION AND ROOF REPLACEMENT OF GRANULAR-I NPK PLANT
WITH NORMAL TIME AND COST

No.	Type of activity	Time that Needed (Day)	Normal Cost (Rp)
A	Engineering	13	23.000.000
B	Preparation	7	2.500.000
C	Project Office, safety etc.	7	41.500.000
D	Fabrication	26	2.168.924.200
E	Sandblasting	20	84.250.000
F	Painting	7	151.639.550
G	Dismantling	13	52.062.400
H	Erection	20	1.351.625.000
I	Weaning and ordering	13	4.500.000
		Amount	**3.880.001.150**

Then we can describe the critical path network with normal time, as shown in Figure 4.5. The critical path is marked with a red arrow.

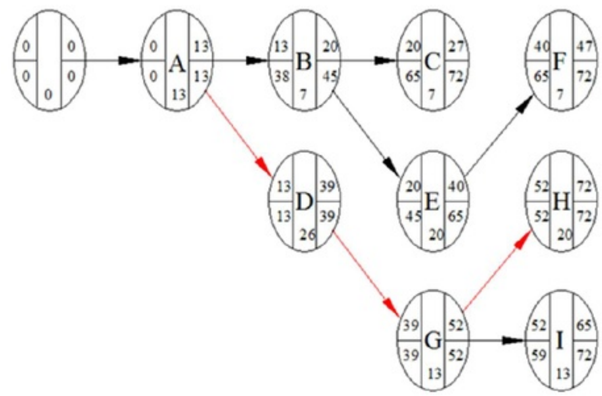

Figure 2 Critical Path Network Normal Time

Based on Figure 2 can be known the critical path is the ADGH line which is the path with the longest time for 72 days.

The next step is to calculate the duration of the project based on the time of accelerated (crash time) and the cost of accelerated (crash cost). One method of speeding up the project duration is by overtime. Here's how to calculate daily employee overtime wages based on ministerial decree 102 year 2004.

ACCELERATION OF PROJECT DURATION WITH ADDITION OF HOURS

Sampled analysis on fibrealum roof work:

Volume = 2.376 m^2
Normal duration = 13 days
The labor capacity per 1 m^2 is:
Worker = 0,2052 Oh @ Rp. 135.600,00
Builder = 0,1035 Oh @ Rp. 169.500,00
Foreman = 0,0205 Oh @ Rp. 226.000,00

Calculation of normal labor wage:

Number of labor = $\frac{labor\ coefficient\ x\ volume}{normal\ duration}$

1. Number of workers = $\frac{0{,}2052\ x\ 2.376}{13} = 37{,}50\ persons$
   So the worker's wage = 37,50 × Rp. 135.600,00 = Rp. 5.085.000,00
2. Number of builders = $\frac{0{,}1035\ x\ 2.376}{13}$ = 18,92 persons
   So wage builders = 18,92 × Rp. 169.500,00 = Rp. 3.206.940,00
3. Number of Foreman = $\frac{0{,}0205\ x\ 2.376}{13} = 3{,}75\ persons$
   So the Foreman wage = 3,75 × Rp. 226.000,00 = Rp. 847.500,00
   So the normal labor wage for 13 days is:
   (Rp 5.085.000,00 + Rp 3.206.940,00 + Rp. 847.500,00) x 13 = Rp. 118.812.720,00

Normal labor wage is rounded = Rp. 118.800.000,00

Normal duration (hours) = 13 × 9 = 117 hours

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Productivity normal clock $= \frac{2.376}{117} = 20{,}31\ m2\ per\ hour$

Maximum crashing $= \frac{2.376}{((20{,}31x9)+(1x0{,}8x20{,}31)+(1x0{,}7x20{,}31))} =$ $10{,}26\ days \sim 10\ days$

Then maximum crashing = 13 days - 10 days = 3 days

Acceleration duration = 13 days - 3 days = 10 days

Acceleration duration (hour) = 10 × 9 = 90 hours

Productivity accelerated clock = $\frac{2.376}{90}$ = 26.40 m2 /hour

Overtime maximum per day = $\frac{26{,}40-20{,}31}{20{,}31}\ x\ 9\ hours\ x\ 90\% =$ $2{,}43\ hours\ per\ day \sim 2\ hours\ per\ day$

Rate of overtime per hour:

1. Normal workers wage = Rp. 135.600,00 per day
   Wages of workers per month = 25 days x Rp. 135.600,00 = Rp. 3.390.000,00 per month
   Workers overtime wages per hour = $\frac{1}{173}$ x wages per month
   Workers overtime wages per hour = $\frac{1}{173}$ x Rp. 3.390.000,00 = Rp.19.595,00 per hour
2. Normal builder wage = Rp. 169.500,00 per day
   Wages of builder per month = 25 days x Rp. 169.500,00 = Rp. 4.237.500,00 per month
   Builder overtime wages per hour = $\frac{1}{173}$ x wages per month
   Builder overtime wages per hour = $\frac{1}{173}$ x Rp.4.237.500,00 = Rp.24.494,00 per hour
3. Normal foreman wage = Rp. 226.000,00 per day
   Wages of foreman per month = 25 days x Rp. 226.000,00 = Rp.5.650.000,00 per month
   Foreman overtime wages per hour = $\frac{1}{173}$ x wages per month
   Foreman overtime wages per hour = $\frac{1}{173}$ x Rp.5.650.000,00 = Rp.32.659,00 per hour

Calculation of additional hours worked (overtime):

Number of workers = 37.50 Persons, so wages workers = {(1x Rp.135.600) + (1x1,5x Rp.19.595) + (1x2x19.595)} x 37,5 = Rp.7.656.843,00

Number of builder = 18.92 Persons, so wages builder = {(1x Rp.169.500) + (1x1,5x Rp.24.494) + (1x2x24.494)} x 18,92 = Rp. 4,828,932.00

Number of Foreman = 3.75 Persons, so wages foreman = {(1x Rp.226.000) + (1x1,5x Rp.32.659) + (1x2x Rp.32.659)} x 3,7 = Rp.1.259.134,00

So the labor overtime wages for 10 days is: (Rp.7.656.843,00 + Rp.4.828.932,00 + Rp.1.259.134,00) x 10 = Rp. 137.449.090,00

Efficiency of project time = $\frac{13-10}{13}$ = 23.08%

Additional project cost = $\frac{Rp.\ 137.449.090 - Rp.\ 118.800.000}{Rp.\ 118.800.000}$ = 15.70%

The addition of working hours (overtime) as in the analysis of the above fibrealum roof tide work, applied to the work items of unloading and erection, then the results will be obtained:

1. **Dismantling work**
   Normal duration = 13 days
   Normal labor wage = Rp. 52.062.400,00
   With a time efficiency of 23.08%, it will get the efficiency of time = $\frac{23{,}08}{100}$ x 13 = 3 days
   Accelerated duration = 13 - 3 = 10 days
   With an additional project cost of = 15.70%, then:
   Normal labor wage dismantling work x 15.70% =
   Rp. 52.062.400,00 x 15.70% = Rp. 8,173,796.00
   So the cost of dismantling work with the addition of overtime hours are:
   Rp. 52.062.400,00 + Rp. 8,173,796.00 = Rp. 60.236.196,00
   Slope Costs due to acceleration = $\frac{accelerated\ cost - normal\ cost}{normal\ time - accelerated\ time}$
   $= \frac{Rp.\ 60.236.196 - Rp.\ 52.062.400}{13-10}$ = Rp. 2.724.598,00
2. **Erection Work**
   Normal duration = 20 days
   Normal labor wage = Rp. 191.850.000,00
   With a time efficiency of 23.08%, it will get the efficiency of time = $\frac{23{,}08}{100}$ x 20 = 4.60 days.
   Rounded to 5 days.
   Accelerated duration = 20 - 5 = 15 days
   With an additional project cost of = 15.70%, then:
   Normal labor wage erection x 15.70% =
   Rp. 191.850.000,00 x 15,70% = Rp. 30.120.450,00
   So the cost of erection work with the addition of overtime hours are: Rp. 191.850.000,00 + Rp. 30.120.450 = Rp. 221.970.450,00
   Slope Costs due to acceleration = $\frac{accelerated\ cost - normalcost}{normal\ time - accelerated\ time}$
   $= \frac{(Rp.221.970.450 - Rp.191.850.000)}{(20-15)}$ = Rp. 6.024.090,00

So the cost of erection work with the addition of overtime hours are:

Material cost + Wages = Rp. 1.159.775.000,00 + Rp. 221.970.450,00 = Rp. 1.381.745.450,00

The next step calculates the acceleration cost per unit time (slope).

TABLE 2. ACCELERATED COST PER UNIT TIME (SLOPE)

No.	Normal Cost (Rp)	Accelerated Cost (Rp)	Normal Time (day)	Accelerated Time (day)	Slope (Rp)	Critical Path
A	23.000.000	23.000.000	13	13	0	Yes
B	2.500.000	2.500.000	7	7	0	No
C	41.500.000	41.500.000	7	7	0	No
D	2.168.924.20	2.168.924.20	26	26	0	Yes
E	84.250.000	84.250.000	20	20	0	No
F	151.639.550	151.639.550	7	7	0	No
G	52.062.400	66.335.828	13	10	2.724.59	Yes
H	1.351.625.00	1.405.258.78	20	15	6.024.09	Yes
I	4.500.000	4.500.000	13	13	0	No
	3.880.001.15	**3.918.295.39**				

From Table 2 it is known that on the activity of G and H happened acceleration time. On activity G from the normal time of 13 days, become crash time 10 days with the cost crash (slope) equal to Rp. 2,724,598.00. At activity H from normal time 20

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days, become crash time 15 days with cost crash (slope) equal to Rp. 6.024.090,00. Changes in project completion time can be seen in Figure 4.6.

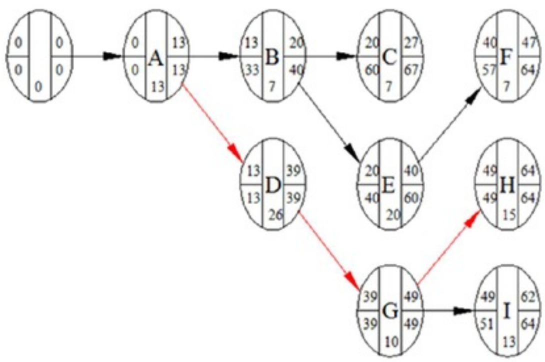

Figure 3 Network Time Accelerated Critical Path (Crashing)

From Figure 3 the project completion time for 64 days with cost Rp. 3.880.001.150,00 + (13-10) x Rp. 2.724.598,00 + (20-15) x Rp. 6.024.090,00 = Rp. 3.918.295.396,00 ~ **Rp. 3.918.295.000,00**

After done Crashing Project by manual, got optimal time of project implementation for 64 days with optimal cost equal to **Rp. 3.918.295.000,00**

THE ACCELERATION OF PROJECT DURATIONS WITH THE ADDITION OF THE WORK

Sampled analysis on fibrealum roof work:

Volume = 2.376 m²

Normal duration = 13 days

The labor capacity per 1 m² is

Worker = 0.2052 Oh @ Rp. 135.600.00

Builder = 0.1035 Oh @ Rp. 169.500,00

Foreman = 0,0205 Oh @ Rp. 226.000,00

Calculation of the number of labor:

Number of labor = $\frac{labor\ coefficient\ x\ volume}{normal\ duration}$

1. Number of workers = $\frac{0,2052\ x\ 2.376}{13}$ = 37,50 $Persons$

   So the worker's wage = 37,50 × Rp. 135.600,00 = Rp. 5.085.000,00
2. Number of builders = $\frac{0,1035\ x\ 2.376}{13}$ = 18,92 $Persons$

   So the builders wage = 18.92 × Rp. 169.500,00 = Rp. 3.206.940,00
3. Number of Foreman = $\frac{0,0205\ x\ 2.376}{13}$ = 3,75 Persons

   So the Foreman wage = 3.75 × Rp. 226.000,00 = Rp. 847.500,00

So the normal labor wage for 13 days is:

(Rp 5.085.000,00 + Rp 3,206,940,00 + Rp. 847,500,00) x 13 = Rp. 118.812.720,00

Normal labor wage is rounded = Rp. 118.800.000,00

This work will be accelerated with a duration of 3 days acceleration, as for the calculation is:

Volume = 2.376 m²

Crashing = 3 days

Accelerated duration = 13 - 3 = 10 days

Calculation of the number of labor:

Number of labor = $\frac{labor\ coefficien\ x\ volume}{accelerated\ duration}$

1. Number of workers = $\frac{0,2052\ x\ 2.376}{10}$ = 48,76 $Persons$

   So wages workers = 48.76 × Rp. 135.600,00 = Rp. 6.611.856,00
2. Number of builders = $\frac{0,1035\ x\ 2.376}{10}$ = 24,59 $Persons$

   So wages builders = 24.59 × Rp. 169.500,00 = Rp. 4.168.005,00
3. Number of Foreman = $\frac{0,0205\ x\ 2.376}{10}$ = 4,87 $Persons$

   So wages Foreman = 4.87 × Rp. 226.000,00 = Rp. 1.100.620,00

So the wage of labor accelerated for 10 days is:

(Rp 6.611.856,00 + Rp 4.168.005,00 + Rp 1.100.620,00) x 10 = Rp. 118.804.810,00

Normal wage of labor is rounded = Rp. 118.800.000,00

Efficiency of project time = $\frac{13-10}{13}$ 23,08 %

Efficiency of project cost = $\frac{Rp.\ 118.800.000-118.800.000}{118.800.000}$ = 0 %

The addition of labor as in the analysis of the above fibrealum roof tide works, applied to the work items of dismantling and erection, it will get the results:

1. Dismantling work

Normal duration = 13 days

Normal labor wage = Rp. 52.062.400,00

With a time efficiency equal to 23.08%, it will get the efficiency of time = $\frac{23,08}{100} x$ 13 = 3 $days$

Accelerated duration = 13 - 3 = 10 days

Cost efficiency = $\frac{Rp.\ 52.062.400-Rp.\ 52.062.400}{Rp.52.062.400}$ = 0 %

Slope Costs due to acceleration = $\frac{accelerated\ cost-normal\ cost}{normal\ time-accelerated\ time}$

= $\frac{Rp.\ 52.062.400-Rp.\ 52.062.400}{13-10} = Rp.0$

So the cost of dismantling work with the addition of manpower is fixed (no additional cost) = Rp. 52.062.400,00. While the time efficiency equal to 23.08%

2. Erection work

Normal duration = 20 days

Normal labor wage = Rp. 191.850.000,00

With a time efficiency equal to 23.08%, it will get the efficiency of time = $\frac{23,08}{100} x$ 20 = 4,60 $days$ ~ 5 $days$

Accelerated duration = 20 - 5 = 15 days

Cost efficiency = $\frac{Rp.\ 191.850.000-Rp.\ 191.850.000}{Rp.\ 191.850.000}$ = 0 %

Slope Costs due to acceleration = $\frac{accelerated\ cost-normal\ cost}{normal\ time-accelerated\ time}$

= $\frac{Rp.\ 191.850.000-Rp.\ 191.850.000}{20-15} = Rp.0$

So the cost of erection work with the addition of manpower is fixed (no additional cost) = Rp. 191.850.000,00. While the time efficiency equal to 23.08%

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4 Discussion

After analyzing the data, we can see the results of rescheduling of the project elevation and replacement of the roof of Granular-I NPK Plant by CPM (Critical Path Method) method at Kujang Pertilizer Cikampek. Figure 4.4 shows that the optimum time duration of the project elevation and replacing the roof of the granular NPK plant with normal time and cost is 72 days. In Figure 4.5 it is known that ADGH is the critical path with the longest time is 72 days.

Then in figure 4.6 known there is acceleration of project duration. Activity G (dismantling) from the original duration 13 days to 10 days. Activity H (erection) from the original duration 20 days to 15 days. Acceleration is done by adding hours of work (overtime) to activities G and H. As for activity A (engineering) and D (fabrication) is not done acceleration because both of these activities can be done when the factory operates normally. While the activities of G and H is done at the factory shutdown, so the acceleration needs to be done so that the factory immediately operate again and produce the product. After the acceleration (crashing project), there is a change in the optimal duration of the project from the original 72 days to 64 days. Thus, the optimal time of the project with crashing time and crash cost using the method of adding working hours (overtime) is for 64 days, or obtained the efficiency of time is 23.08%.

The results of the above analysis, then compared with the analysis using WinQSB software. The result shows the same number, the optimal time of project with normal time and cost is for 72 days with total cost Rp. 3.880.001.150,00. While the optimal time of the project with crashing time and crash cost using the method of additional working hours (overtime) is for 64 days with a total cost is Rp. 3.918.295.000,00. Means there is an additional project cost equal to Rp. 38.294.000,00.

Then the project acceleration is analyzed using the method of addition of labor, with the same acceleration duration as the method of adding work hours (overtime). The results show that the project cost is no increase and the time efficiency equal to 23.08%.

5 Conclusion

Obtained the efficiency of project execution time for 8 (eight) days, from the original duration for 72 (seventy two) days to 64 (sixty four) days, or 23.08%. With a time efficiency of 8 (eight) days, the productivity of the granular NPK plant can be maintained. The plant has a production potential equal to 2,400 tons or potential revenue equal to Rp. 12.96 Billion.

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