THE APPLICATION OF NETWORK PLANNING USING CPM (CRITICAL PATH METHOD) FOR PRODUCTION OF POWER TRANSFORMER AT PT. UNINDO, JAKARTA, INDONESIA

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abstract

PT. UNINDO, a Joint Venture company between France and Indonesia is a transformer manufacturer company that one of its products is power transformer. PT. UNINDO strive to meet customer satisfaction in terms of optimization production planning and control. The idea is for the production activities that take place in the enterprise can be implemented properly so as to achieve the target, which includes the timeliness of production.

During this PT. UNINDO always do planning for transformer production time by using the time schedule. In this case there is no clear determination of the activity in the manufacture of transformers. This has led to production planning and control did not reach the target. Because there is no specification of time then there are often delays in production time. Therefore, standardization transformer production turnaround time is required, where the standard turnaround time of production processes associated with the transformer production accuracy.

Network Planning is a method to help control a project in the form of network diagram that contains information about the activities in it. CPM is a method of network planning, where once created and the time required, after that set a critical path that can affect the overall project activities. Before planning network implemented by the method of CPM (critical path method), the company does not know the activities that are sensitive to delay, so the company was not problematic to allow some activities delayed for some time, though these activities are in a critical path that can affect the overall project activities. Once implemented network planning with CPM (critical path method), company can observe what activities are in the critical path, so that companies can pay more attention to such activities and prevent delays to the overall project activities.

By using the time schedule of the company, obtained the total production time for 50 days. By using network planning with CPM method then can get the total production time for 44 days.

Keyword: CPM, Operation Management, Network Planning

1. Introduction

Circumstances of intense competition today must be properly addressed by the producers, both manufacturing and service industries producer. Growth and development of manufacturing industry is characterized by the rapid changes that accompanied the development of technology. Therefore, companies should have the power to deal with the situation that the company's survival can be maintained. One way is with a good

production management, so that with the smooth production can ensure its survival in the long run.

Sometimes companies have problems that are not directly related to the implementation of the project. Some companies have delayed the production process that would affect other activities outside the production process. If the production process are not well controlled and did not reach the target, that is not in accordance with the plan, they can lead to possible delays in the production of goods that affect other activities. In this case some companies do not have a standard time or precision in any production activity that is often a delay in any production process that resulted in delays in the overall production activity or project.

One way to do a good production control is the practice of network planning in the production process. In this case, PT. UNIDO has not been implemented by the method of network planning particularly CPM (critical path method). The company just set the production schedule and duration of the process in the time schedule estimates. Network planning is a planning network starting from the first assembly up to the most recent time that signifies the completion of the project. While the CPM (critical path method) is a method of network planning application that analyzes the critical path of a network planning. If any of these activities is in the critical path is delayed then automate the entire activities of the project will experience delays and will affect the work of others.In essence, network planning is a method performed in the project. The project is a series of activities that have the time of the earliest and most recent. But it is possible to use network planning in a manufacturing company, with a record of manufacturing companies are eligible to perform network planning. Manufacturing companies that can do network planning is a company that belongs to the engineering-manufacturing project. The main activities of this project is the development of products, assembly, manufacturing, and testing the resulting product. Examples of products produced from this project is an electric generator, factory machinery, vehicles, and the transformer.

The ability of firms can be seen from the capacity of its resources such as machinery, raw materials, human resources, and other production factors are expected to support the production process in order to operate effectively and efficiently. Therefore, the authors identified the problem as follows:

1. How to Time Schedule and project implementation by PT. UNINDO.
2. How the application of network planning method CPM (Critical Path Method) at Power Transformers production in PT. UNINDO.

2. Reviews

2.1 Definitions of Network Planning

To know the definition of network planning, the authors propose the opinion of some experts. William J. Stevenson (2005:737) describes as a network diagram of project activities That diagram shows sequential relationships by use of arrows and nodes. Iman Soeharto (1999:238) explains that: Networking is a method that is considered capable of presenting the basic techniques in determining the sequence of activities and elements of the project period, and in turn can then be used estimate the overall project completion time. Of opinion can be concluded that the network planning is a method to help control the form of project network diagram that contains information about the activities in it.

2.2 The Role of Network Planning

Operations using the network management planning in making decisions concerning the production process, capacity planning and monitoring, as well

as for various decisions that are continuous with respect to planning, scheduling and inventory.
If the network has made a proper planning, companies can be helped in terms of implementation and supervision of the production process. In addition, network planning can also help determine the production capacity and assist in achieving its targets. In this research, network planning methods used are CPM (critical path method), which created a network of production processes and their planningnya time required during the production process from the initial (raw material) to the end (finishing or finished goods). Before the method of CPM (critical path method) is being applied, the company is not aware of the activities that are sensitive to delay, so it's not a problem to allow some activities delayed for some time. But, these projects could be in a critical path that can affect the overall project activities.
Once applied the network planning with CPM (critical path method) to observe the activities of companies located anywhere in the critical path, companies can pay more attention to such activities and prevent delays and the overall project activities can take place properly.

2.3 CPM

In the CPM method known as the critical path, the path has a series of components to the total number of activities and shows the longest time period of the fastest project completion. Thus, the critical path consists of a series of critical events, starting from the first activity to the recent activities of the project.

The meaning of the critical path is crucial for implementing the project, because the track is situated activities when late will cause delays in the overall project.

3. Research Object and Method

3.1 Research Object

The object of the research is the production of transformer at PT. UNIDO. As the basis for making a network planning, manufacturing production data are then used, such as kind of linked activities, the period of execution of each activity, and the relationship between activities in the production of power transformers.

PT. Unelec Indonesia known as PT. UNIDO was established in 1969. This company is a joint venture (joint venture) with the status of Indonesia's oldest state-owned enterprises between the Government of Indonesia with a leading French company Alstom, which later changed to PT. AREVA Transmission in December 2004.

Products produced by PT. UNIDO, among others:

1. Distribution transformers.
2. Power transformer.
3. Electrical Panel.
4. Traction transformer

Machinery and equipment owned by PT. UNIDO, namely:

1. cutting machine
2. Press machine
3. Winding machine
4. Oven
5. filling machine
6. Crane
7. Folding machine
8. Welding machine
9. Conveyor

10. forklift

PT. UNINDO is located at Jl. PLN-governmental organizations Klender, East Jakarta, which lies adjacent to the PLN. PT area. UNIDO is 34 500 square meters with building area of 15 500 square meters and has an integrated mill in the area of the company. The breakdown is as follows:

1. The main office area of 3,000 square meters
2. Electricity production Panel 3900 square feet
3. Production of 6500 square meters of distribution transformers
4. Power transformer production 3240 square feet
5. traction transformer production 2240 square meters.

PT. UNINDO was led by Stephane Ageorges as president and oversees approximately 400 employees with the following details:

1. 24 people manager.
2. 73 people and professional engineers.
3. 47 person staff.
4. 256 workers.

3.2 Research Method

In this study, the method used is descriptive method of analysis, namely the search for the proper interpretation of the facts, in order to create a picture of a systematic, factual, and accurate based on the facts of the companies which are then processed using a particular theory has been accepted in the lecture and then concluded based on an alternative road solution.

3.2.1 Data Collection Technique

Data collection technique performed in this study are:

1. The field research (field research), through:
   a. Interviews conducted at the production company involved with the problem under study.
   b. Observation, namely the review and direct observation, especially on the production company.
2. Library Research.
   Namely the study of literature in the form of data collection, theory, literature, lecture notes, and so both derived from libraries and companies.

3.2.2 Problem-Solving Steps

The author's problem solving are conducted through the following stages:

1. Preparation

At this stage the necessary preparations for the study, both of which are directly related to research or other supporting things.

2. Formulating the problem

At this stage the authors formulate the problem under study, namely the application of network planning with CPM methods in the manufacture of transformers in the PT. UNIDO in order to know the time of production that can be used as the standard.

3. Data collection

Data collected in this study were divided into two, namely:

a) Primary data, ie data obtained directly from the company / sources, among others, consist of:
   - Data from the production process
   - Data time required for each production activity

b) Secondary data, ie data obtained indirectly from relevant sources such as through media such as books, literature and company documents relating to issues to be discussed include:
   - Management theory of production / operations
   - Theory of network planning

c) CPM theory
d) History of company
e) Data Analysis

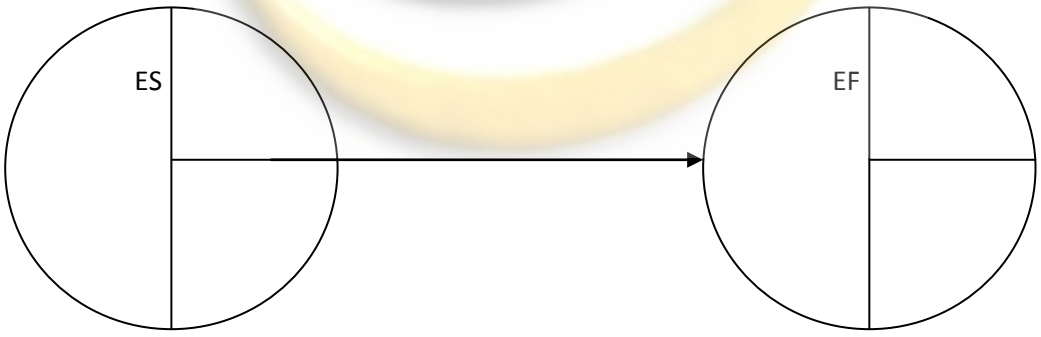
PT. UNIDO is a company whose main operations consist of a variety of linked activities. Authors analyze the problem-solving network planning is to describe the activities that are in the process of continuing operations by a rearrangement of these components in accordance with the sequence of activities and logic dependency, then draw a network diagram. After a network diagram consisting of structured activities, followed by complete data covering long activity. Analysis of the data used is by using the CPM method. CPM method using a point estimate. This is done when time can be known with accuracy. Here is a compilation of steps in a nutshell.

1. Defining the project and all existing activities or tasks.
2. Creating a symbol of each activity.
3. Creating links between activities. Decide which activities must precede and which must follow another.
4. Draw the network connecting all the activity.
5. Imposes a time estimate to each activity.
6. Calculate the longest time in the network; is called the critical path.
7. Use the network to assist with planning, scheduling, and project control.

The following is an analysis of existing data to find the critical path and float using CPM after a known network diagram.

A. Identification of the Critical Path

In identifying the critical path, used for setting the fastest time (TE) is calculated to determine the fastest time from carrying out an activity of the event by using the formula:



EF: As the fastest completion of the activity
ES: As the fastest start of the activity
t: Duration of activity

After a time the fastest known, then proceed with the counting time was acting at the latest. Search at the latest when it has the intention to know the time at the end of the operation can begin and end of each period of activity without delaying the overall project completion time by using the formula:

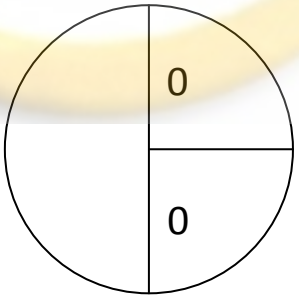
$$LS = TE - t$$

LS: When the slowest start of activity
TE: When an event's fastest
t: Duration of activity

Critical trajectory is the trajectory that consists of critical activities and critical events, and the dummy (if needed). The purpose is to know the critical path to quickly see activities and events at a high level of sensitivity to delay implementation. This track is the longest in the process of operation. Critical trajectories can be calculated in two ways are:

a) Trial and error (Trial and error)
   Trial and error which is a way to find the critical path by calculating the time available in a variety of process lines operating in a network diagram. In this way will be found a variety of channels, where the path has the longest time is the critical path.
b) Counting of the ES and LS in any event on the network diagram (TE = TL). Critical trajectory has the properties or the general conditions, namely:

1. In the first activities of ES = LS = 0 or TE = N = 0



2. In the last activity or terminal event EF = LF or TE = TL
3. Total Float = 0

B. Grace Period of Activity

Float is the length of time which is a measure of the tolerance of delay of the implementation of activity or production operations.

4. Implication/Result

4.1 Company Profile

PT. Unelec Indonesia, known as PT. UNINDO was established in 1969, is a joint venture company in Indonesia's oldest state-owned status between the Indonesian government with the French company Alstom, which later became AREVA.

At first PT. UNINDO manufactures Distribution Transformer. In 1983 PT. UNINDO expand its production network to produce power transformers in 1986 and manufactures electrical panels, medium voltage and Compact Substation GRC product launch in 1995. The results produced by PT. UNIDO licensed Alstom, one of the world's largest companies in the field of electrical equipment.

After passing several years, PT UNINDO which now has over 600 employees, has managed to meet the needs of foreign policy, national and international companies and become one company transformers and Medium Voltage Electrical Panel largest in ASEAN countries.

PLN, the State Electricity Company, shall meet the power needs to be increased by more than 10% each year in the last two decades. The need for electricity in Indonesia is the fastest growing in Asia and it is expected to be met. Estimated in the 90's needs to increase 17% annually and 12% at the beginning of the 21st century.

In 1969 the Indonesian government has felt the importance of electricity for economic development, industrial, and social. To overcome this, the government of Indonesia and Alstom set up a joint venture company located in East Jakarta, is engaged in distribution transformers. The company is growing rapidly, characterized by the expansion of business in 1983 (producing power transformers), and in 1986 (Medium Voltage Electrical Panel).

4.1.1 Power Transformer's Production

In the process of making these products there are some activities to process a variety of resources necessary to become a product that fits with what customers want. The activities are as follows

1. Preparation. Preparation consists of activities in the Area and Wood Area Carton. Area in Carton, carton material which has been obtained from the supplier and then cut to size. After that stuck with a long thin wood which is quite a lot as a base for the copper wire wrapped around the filling and oil media. In Wood Area, created various forms of wood that has been obtained from suppliers as a base for loops that have been completed. Its function is as an insulator, so that electric current in the transformer is not on the floor.

2. TOLERIE. In this stage there are three types of activities, namely Core Cutting Steel, Pre Stacking and Stacking Core. Core Steel Cutting is a cutting process of cutting the steel sheet with a thickness of 3 mm and a variety of different sizes as much as hundreds of pieces on the type of transformer to be made. Pre Stacking is when the steel sheet has been cut and separated by size. Core Stacking is the process of enforcement of the steel sheet that has been put together which will be ridden by bobin.

3. Bobinage. This process is called Winding process, where the copper wire that had been coated by an insulating material wrapped around the cardboard cylinder that has been formed by about 8 layers.

4. Montage. In this stage there are three processes, namely Coil Stabilization, Assembly Coils to Core, Upper Yoke and Leads and Conection.Coil Stabilization is the process by which a carton that has been wrapped around the wire at the top and bottom press that has the form of a balanced and proportionate. Coils to Core Assembly is the installation of cardboard that had been wrapped around the wire and in the press to have diberdirikan steel. Upper Yoke is the installation of steel sheet as a cover on top and steel wire assemblies. Leads and conection is the process of installation and connection of various components to be placed in the transformer.

5. Finition. In this stage there are five processes, namely Active part & Oil Filling, Final Erection, Internal Test, Leakage Test, Packing. Active Part & Oil Filling is the process of activation of components of the transformer, then put into an oven to remove water vapor. Once out of the oven made the process of tightening the bolts because once inserted into the oven that was installed bolts will expand and loose. After tightening the bolts oil filled transformers as an insulator and re-inserted into the oven for terkhir vacuum process to remove water vapor. Erection is the process of enforcement of the final end of the transformer is fitted with a complete component. Internal testing is the process of testing the performance of the transformer, if no problems then can proceed to the next process. Leakage Test of transformer is the process of testing whether or not a leak. Packing is the process of disposing of small components and then wrapped, put in a coffin, and the transformer and its components are ready for shipment.

4.1.2 Project's Time Schedule

Based on the results of research, planning made by PT. UNINDO to conduct the project is a Time Schedule in the form of Bar Chart.

Activity	Week									
	1	2	3	4	5	6	7	8	9	10
Carton Area										
Steel Cutting										
Pre Stacking										
Core Stacking										
Bobinage										
Wood Area										
Coil Stabilization										
Assembly Coils To Core										
Part Active										
Leads And Connection										
Active Part And Oil Filling										
Final Erection										
Internal Test										
Leakage Test										
Packing										

4.2 Result

Based on the description of the above results, it can be seen that the PT. UNIDO has not been done in the Network Planning project planning. It required a good management techniques for planning and controlling a project to run properly.

Authors apply the method of Network Planning with CPM (Critical Path Method) because this method can be used to conduct an analysis of the project completion time schedule, the probability of completion of the project, which activities are critical and do in the completion of the project, and how they affect the objectives of the project completion schedule if delay.

In a time schedule made by a company, not shown explicitly the interdependence between activities, while in network planning activities that have no clear dependence between the activities with each other woods. Seeing the condition of planning that made the company, the author tries to discuss the planning of a project schedule with network planning based on activity data and project time.

4.2.1 The Activities

Based on the time schedule that made PT. UNINDO, the authors conducted an analysis based on the steps to create the first network planning, which defines the project activities

NO	ACTIVITY
1	*PREPARATION* : *Carton Area*
2	*Wood Area*
3	*TOLERIE* : *Core Steel Cutting*
4	*Pre Stacking*
5	*Core Stacking*
6	*BOBINAGE* : *Winding*
7	*MONTAGE* : *Coil Stabilization and Stacking*
8	*Assembly Coils to Core*
9	*Upper Yoke*
10	*Leads and Connection*

11	*FINITION : Active Part and Oil Filling*
12	*Final Erection*
13	*Internal Test*
14	*Leakage Test*
15	*Packing*

NO	ACTIVITY	SYMBOL
1	*PREPARATION : Carton Area*	A1
2	*Wood Area*	A2
3	*TOLERIE : Core Steel Cutting*	B1
4	*Pre Stacking*	B2
5	*Core Stacking*	B3
6	*BOBINAGE : Winding*	C1
7	*MONTAGE : Coil Stabilization and Stacking*	D1
8	*Assembly Coils to Core*	D2
9	*Upper Yoke*	D3

10	*Leads and Connection*	D4
11	*FINITION : Active Part and Oil Filling*	E1
12	*Final Erection*	E2
13	*Internal Test*	E3
14	*Leakage Test*	E4
15	*Packing*	E5

4.2.2 The Connection between Activities

This stage is to determine the functional relationships between activities that logically requires connection. We will clarify in detail the dependency relationships between activities in the following table.

No	Activity Symbol	Previous Activity
1	A1	-
2	A2	A1
3	B1	-
4	B2	B1
5	B3	B2
6	C1	A1
7	D1	C1
8	D2	B3, CI, D1
9	D3	D2
10	D4	D3
11	E1	D4

12	E2	E1
13	E3	E2

4.2.3 Activity Time

Based on experience over the years, PT. UNINDO to determine the time at each activity in the manufacture of Power Transformer project as follows:

NO	Activity	Symbol	Time (Day)
1	*PREPARATION : Carton Area*	A1	4
2	*Wood Area*	A2	8
3	*TOLERIE : Core Steel Cutting*	B1	4
4	*Pre Stacking*	B2	1
5	*Core Stacking*	B3	3
6	*BOBINAGE : Winding*	C1	8
7	*MONTAGE : Coil Stabilization and Stacking*	D1	6
8	*Assembly Coils to Core*	D2	2
9	*Upper Yoke*	D3	3
10	*Leads and Connection*	D4	4
11	*FINITION : Active Part and Oil Filling*	E1	5

12	*Final Erection*	E2	3
13	*Internal Test*	E3	4
14	*Leakage Test*	E4	1
15	*Packing*	E5	4

4.2.4 Determination of Critical Path

Activity	Duration (day)	Fastest		Latest		Total Float	Free Float
		Start	Finish	Start	Finish		
		ES	EF	LS	LF		
A1	4	0	4	0	4	0	0 *
A2	8	4	18	4	18	6	6
B1	4	0	4	0	14	10	0
B2	1	4	5	14	15	10	0
B3	3	5	18	15	18	10	10
C1	8	4	12	4	12	0	0*
D1	6	12	18	12	18	0	0*
D2	2	18	20	18	20	0	0*
D3	3	20	23	20	23	0	0*
D4	4	23	27	23	27	0	0*
E1	5	27	32	27	32	0	0*
E2	3	32	35	32	35	0	0*
E3	4	35	39	35	39	0	0*

E4	1	39	40	39	40	0	0*
E5	4	40	44	40	44	0	0*

Critical path that does not have the time to be allowed to experience delays in the so-called float. From the table above, can be seen in activities that have a float is:

1. activity A2
2. activity B1
3. activity B2
4. activity B3

This stage can also show the critical path, where each activity indicates the completion time of the float value equal to zero.

4.2.5 Production Time Analysis

PT. UNINDO is not using the CPM method, so the company does not have a great time on each activity. Given the changing times, then any production activity can be delayed. Based on the results of research conducted by the author using the CPM, the project completion time obtained for 44 days, from the beginning where the project may take 50 days, can be seen from the time schedule for 10 weeks of work time a week for 5 days.

5. Conclusion and Suggestion

5.1 Conclusion

The conclusions can be drawn from the results of the discussion are as follows:

A. PT. UNINDO has not been implemented in the network planning of production activities. PT. UNIDO estimates that only with the production completion time schedule with the timing of production of a transformer unit for 50 days, with the details of working time for 10 weeks where there is a 5 day working week. Time can be changed at any time in the absence of a clear breakdown of each activity. Production operations transformer consists of a wide range of activities, namely Preparation consisting of the manufacture of parts and wood board. TOLERIE steel core which consists of cutting, stacking and pre-core stacking. Bobinage only consists of the winding. Montage consisting of coil stabilization and stacking, assembly coils to the core, upper yoke and the leads and connections. Finition last is composed of the active part and oil filling, final erection, internal test, leakage test, and packing.

B. The results of the analysis of network planning with CPM methods result in the acquisition of the production of transformers for 44 days, where the critical path is A1, C1, D1, D2, D3, D4, E1, E2, E3, E4 and E5. So it can see the difference between before and after the applied network planning. Before being applied to network planning transformer production time for 50 days. Once applied to network planning, there is a difference of 6 days is 44 days.

5.2 Suggestion

Based on the results of research and data analysis has been done, the author tries to give advice that:

A. PT. UNINDO is better to use planning based on network planning with CPM method because it can demonstrate timeliness in the production process that can be used as a standard transformer production time.

B. PT. UNIDO should pay attention to the critical activities in the production of transformers, since these activities do not have the tolerance to be late, so that in case

of delay in completion of these activities will slow down the production of transformers as a whole.

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