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ANALYSIS OF NEW PRODUCTION LINE PROJECT IMPROVEMENT THROUGH CRITICAL PATH METHOD (CPM), DESIGN STRUCTURE MATRIX (DSM) AND PROGRAM EVALUATION AND REVIEW (PERT)

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Abstract *Implementing manufacturing projects involves many parties, using various resources and efforts, and facing difficult or even uncontrolled problems. Those indicate a need for planning tools or methods that can help manage resources effectively, which can help anticipate problems that will arise as soon as possible. There are projects in companies involved in the automotive parts manufacturing industry that perform poorly due to project implementation. Those are due to iterations and restructuring that took place and poor project implementation scheduling. The purpose of this research is to analyze and identify a series of activities and process time to build a new production line using Critical Path Method (CPM), Design Structure Matrix (DSM), and Evaluation and Review Technique (PERT) Program to be able to implement management targets. This study shows an increase in the construction of new production lines with the previous duration, four tears, 13 critical paths from 18 activities. At the same time, after the repair, a total time 185 days is total tears 0, 9 critical lines from 18 activities with a success rate of 90.1%. With this study's results, it recommends that companies with new production line construction projects consider using PERT-CPM techniques in project scheduling.*

Keywords : Project Management, WBS, CPM, DSM, PERT

A. Background

According to the global automotive production and sales region, the Asian region has the highest production and sales volumes because vehicles' characteristics and mobility in the European areas have stricter fuel efficiency regulations. In an increasingly competitive global economy, the industry's sustainability, both manufacturing and services, is highly dependent on how the sector can serve the needs of customers quickly and produce quality products and services.

Every industry is challenging to improve its performance to respond quickly and produce quality products and services. For the project to run on time and avoid excessive capacity production, new development projects expect to be completed immediately by speeding up project implementation time. Project performance measurement is based on the value of achieving contract success and company objectives in the form of a plan that defines all the efforts produced, assigns responsibilities, primarily identifies organizational elements, forms schedules, and estimates for performing work.

There are projects in companies involved in the automotive parts manufacturing industry that perform poorly due to project implementation, iterations and restructuring, and poor project implementation scheduling. Fair scheduling is needed to construct new production line projects to achieve project continuity on time and efficiently. The purpose of this research is to analyze and identify the network of activities and process time to build a new production line using the analysis of the Critical Strip Method (CPM), Design Structure Matrix (DSM), and Program Evaluation and Study Techniques (PERT) to implement management targets.

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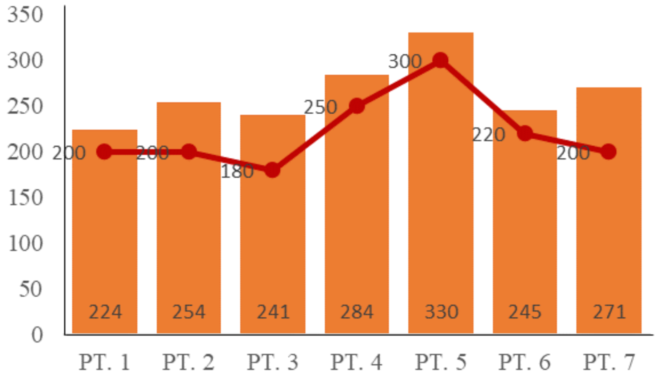

Figure Timeliness new development project production line
Source. automotive industry 2019

B. Literature Study

Project is a combination of interrelated activities that must be carried out in a specific sequence before the entire task can be complete. (Hamdy, 2003). A project can be defined as a temporary activity that lasts for a limited period, with the allocation of specific resources, and are intends to produce a product or result whose quality criteria were defined. (Suharto, 1999). Project management aims to coordinate people, materials, estimates, and schedules to meet / complete projects on time at agreed costs. Project management has five essential functions: planning, organizing, staffing, directing, and controlling. (Dimyati & Nurjaman, 2014). Project scheduling or project planning is the process of identifying all the activities needed to complete a project. Project scheduling is the process performed to determine the sequence of activities that have been planned, set a realistic timeline for each activity, and decide the start and finish of each activity. Therefore, project planning is a condition for project scheduling to determine the sequence of activities until identified. Good planning tracks changes and schedule adjustments in the most efficient way. (Garold D. Obelrender, 2000). WBS is a list that goes up and down, and hierarchically describes the components that must be construct and its works (Elsye, Latief, & Sagita, 2018). The structure at WBS defines tasks that can be completed separately from other tasks, facilitating resource allocation, assignment of responsibilities, measurement, and project control.

Network Planning Methods. This method is a management technique that can use to assist in project planning and control. There are two methods commonly used in this method, namely Critical Strip Method (CPM) and Program Evaluation Study and Technique (PERT) (Arianie & Puspitasari, 2017). The Critical Strip Method (CPM), a method used to plan and monitor projects, is the most widely used system, among other systems that use network formation. With CPM, the amount required to complete various project stages considered to know with definite results. (Levin & Kickpatric, 1972).

ES = Max (EF all direct predecessors) or the time to start the earliest activity
EF = ES + activity time. Or the earliest completion time of the activity
LF = mean (LS of all activities that take place following it) or the final settlement time.
LS = LF – activity time. Alternatively, the time to start the last activity.
S = Activity retreat time = LF – EF or LS – ES

PERT addresses the problem of time variability in activities while scheduling projects. PERT does not use a single value but uses the division of opportunities based on 3 (three) time estimates for each activity performed (Fedderick & Gerald, 2001)

1. Optimistic time [a]. Optimistic time is the time required by activity if everything goes according to plan or what is commonly call the minimum time of the activity, where everything will go smoothly.
2. Realization time (most likely time) [m]. is the most realistic estimate of the time required to complete an activity because, in some similar activities, the time needed to complete a job is almost the same or the same.
3. Pessimistic time [b] is the time required by an activity assuming the worst or unexpected situation and requires maximum time to do the job.

$$Expected\ time(Te) = \frac{a + 4m + b}{6}$$

Te is Expected Time
a is an optimistic time
m is most likely time
b is pessimist time

Or from the above formula can be indicated by the variance formula

$$V = \left(\frac{b-a}{6}\right)^2$$

V is a variant activity
S is deviation standard activity
b is pessimist time
a is optimist time

The value of z can obtain by using the following formula:

$$z = \frac{T(d) - Te}{\sqrt{6}}$$

z is the number of chances of reaching the target T(d) is the target time
Te is a critical activity time
V is various

Design Structure Matrix (DSM), also known as Dependency Structure Matrix, analyzes model systems in various application areas. (Danilovic & Browning, 2007).

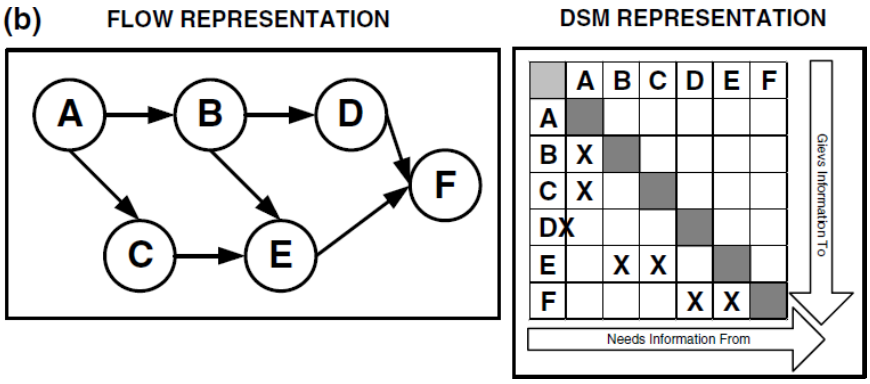

Figure Information Flow Representation in Graph and DSM Matrix
Source. (Danilovic & Sandkull, 2005).

C. Research Method

In applied research, a problem known by the researcher seeks a solution or, in other words, uses research to answer specific questions. The emphasis in applied research is on solving practical problems. It focuses specifically on how general theories can put into practice. This study uses data on companies engaged in the automotive industry, including general information on the company, company product information, company business process information, production process information, company working hours, organizational structure, interviews, observations, and primary documents. Secondary. As for the data used in this study, the first is secondary data in the form of new production line construction data in several companies engaged in the automotive manufacturing industry, data on each process's duration, and predecessor duration data. The methods used range from problem finding, determining research objectives, collecting, and processing data. The steps taken for data processing are:

a. Organize activities and project activity duration
b. Arrange project activities and pour them into WBS (Work Breakdown Structure).
c. Calculate the critical/slack path using the CPM method
d. Make repairs using the DSM method
e. Recalculate the critical path of improvement using CPM and calculate probability using PERT

D. Discussion

Scheduling of resources (resources) in the Critical Path Method (BPS) by looking at the project's critical pathways. Activities that are on the critical path are activities that affect the overall duration of the project.

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Table Activities and Predecessor construction of new production lines
Source

ACTIVITY	CODE	PREDECESSOR	DURATION
Detail Background Activity	A	-	4
Preparation machine spec	B	A	5
Manufacturing machine	C	B,D	95
Budget preparation	D	A,B	5
Layout preparation	E	B	4
upper and lower piping installation	F	D,E,I	12
Ducting Installation	G	I	19
Handling machine inline	H	L	2
positioning, leveling, and install the machine	I	E, H	3
install the main panel and upper cable	J	D,E,I	14
Machine trial	K	F,G,I,J	21
Machine delivery	L	C	10
kanban and production system installation	M	I	4
Quality check dimension	N	K	21
Operator training	O	P,M,N	3
Safety check machine	P	K	10
final acceptance and approval	Q	O	1
Mass production	R	Q	1

The table shows that the activity that has slack is activity across the road A-B-C-D-G-H-I-K-L-N-O-Q-R, a network of activities with the longest time has a relaxation time of 0 (zero) as shown in Figure 4.9 below.

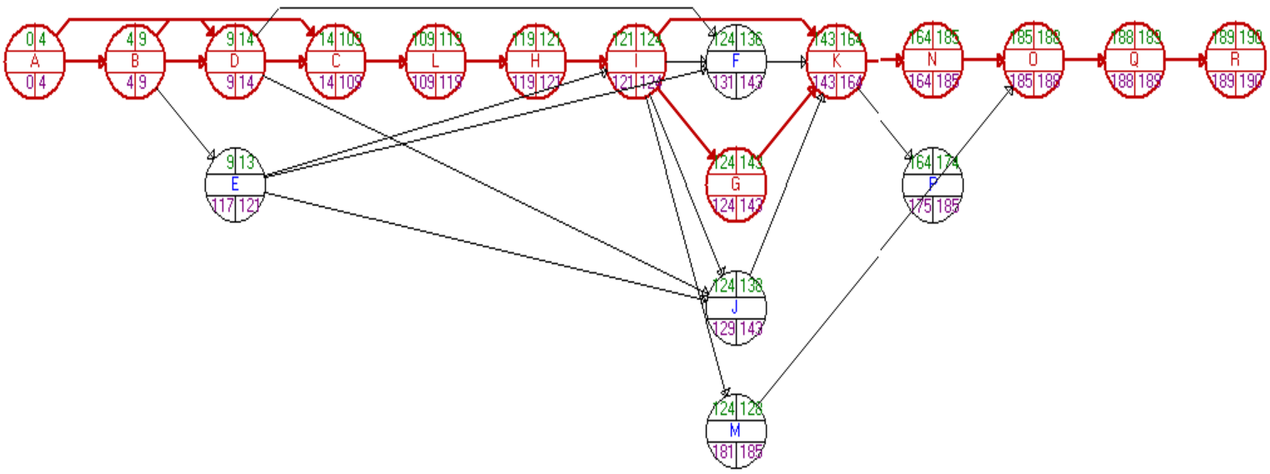

Image Critical path before improvement
Source. processed

Five parameters are considered for each activity, including the earliest start and end time (most initial start, earliest finish), start and end time (last start, last finish), and buffer time (slack/float).

Table slack before improvement
Source. Processed

ACTIVITY	KODE	DURATION	ES	EF	LS	LF	Slack	Critical Path
Detail Background Activity	A	4	0	4	0	4	0	Yes
Preparation machine spec	B	5	4	9	4	9	0	Yes
Manufacturing machine	C	95	14	109	14	109	0	Yes
Budget preparation	D	5	9	14	9	14	0	Yes
Layout preparation	E	4	9	13	117	121	108	No
upper and lower piping installation	F	12	124	136	131	143	7	No
Ducting Installation	G	19	124	143	124	143	0	Yes
Handling machine inline	H	2	119	121	119	121	0	Yes
positioning, leveling and install machine	I	3	121	124	121	124	0	Yes
install panel and upper cablle	J	14	124	138	129	143	5	No
Machine trial	K	21	143	164	143	164	0	Yes
Machine delivery	L	10	109	119	109	119	0	Yes
kanban and production system installation	M	4	124	128	181	185	57	No
Quality check dimension	N	21	164	185	164	185	0	Yes
Operator training	O	3	185	188	185	188	0	Yes
Safety check machine	P	10	164	174	175	185	11	No
final acceptance and approval	Q	1	188	189	188	189	0	Yes
Mass production	R	1	189	190	189	190	0	Yes

Using the Matrix Structure Design (DSM) method, activities involving rework or iteration can be scenarios. Each scenario has a difference in what activities are reworking and which activities are not. This scenario can be done by creating a suitable DSM matrix for each scenario and carrying out activities that not repeat. Partitioning is a way of grouping and closing the sequence of doing paired activities in a project in a matrix. Through the results of the division, the paired activities can see clearly. Pictures and pictures show the initial DSM matrix and the results of the DSM matrix after separation.

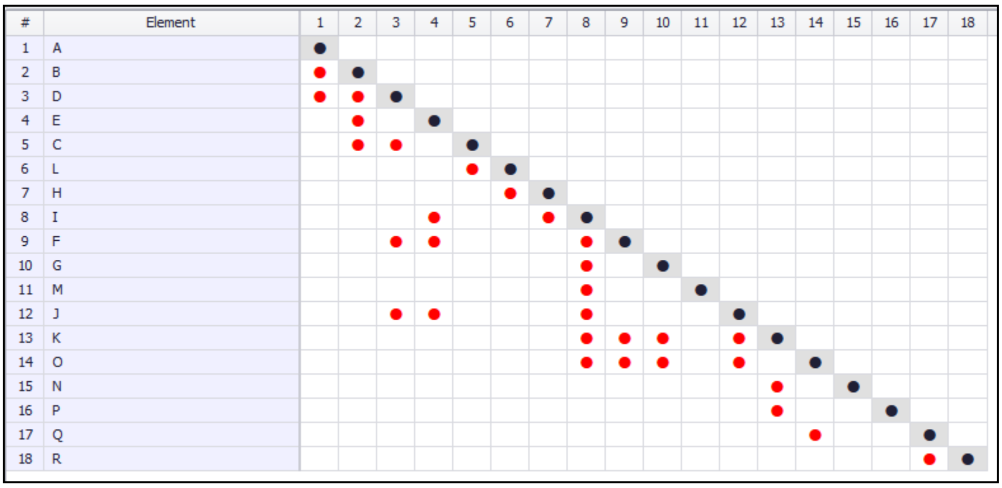

Image. Partittioning using DSM
Source. Processed

The second improvement is to parallel the potential of the dependent activity. In the new production line construction project, dependent activity is present inactivity G, ducting installation work. Installation of ducting (activity G) independent of activity E and activity D. After setting up the work network and determining the

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duration of work, the next step is to determine the critical path that can be done by determining ES, LS, EF, and LF. At ES values starting from the beginning to the end of the activity.

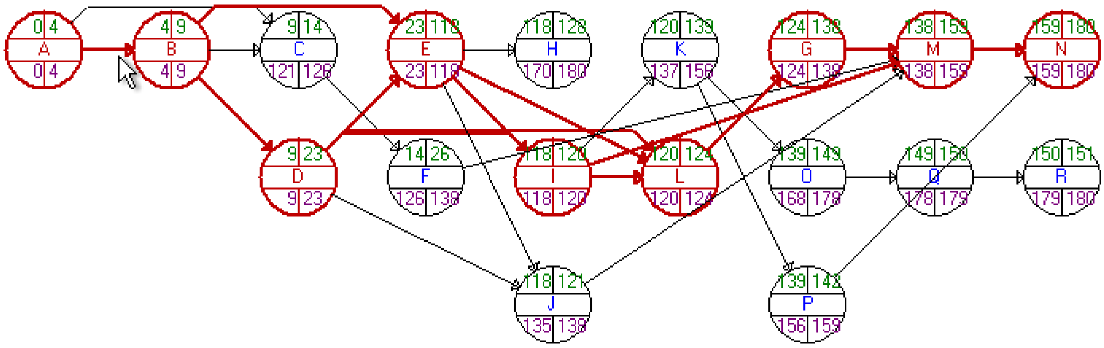

Image. Critical Path after improvement
Source. Processed

Five parameters are considered for each activity, including the earliest start and end time (earliest start, earliest finish), start and end time (last start, last finish), and buffer time (slack/float).

Table. Slack after improvement
Source. Processed

ACTIVITY	CODE	DURATION	ES	EF	LS	LF	Slack	Critical Path
Detail Background Activity	A	4	0	4	0	4	0	Yes
Preparation machine spec	B	5	4	9	4	9	0	Yes
Budget preparation	D	5	9	23	9	23	0	Yes
Layout preparation	E	14	23	118	23	118	0	Yes
Manufacturing machine	C	95	9	14	121	126	112	No
Machine delivery	L	12	120	124	120	124	0	Yes
Handling machine inline	H	14	10	118	170	180	52	No
positioning, leveling, and install the machine	I	10	118	120	118	120	0	Yes
upper and lower piping installation	F	2	14	26	126	138	112	No
Ducting Installation	G	3	124	138	124	138	0	Yes
kanban and production system installation	M	19	138	159	138	159	0	Yes
install the main panel and upper cable	J	4	118	121	135	138	17	No
Machine trial	K	21	120	139	137	156	17	No
Operator training	O	21	139	149	168	178	29	No
Quality check dimension	N	10	159	180	159	180	0	Yes
Safety check machine	P	3	139	142	156	159	17	No
final acceptance and approval	Q	1	149	150	178	179	29	No
Mass production	R	1	150	151	179	180	29	No

The PERT method uses the concept of probability with 3 (three) alternatives in the period used for an activity or activities. Data on development projects similar to the plan to build a new production line 2020 is taking where each activity is a measure for each stage of its activity. In this case, the data presented in the form of 4 (four) similar project data for constructing a new line collect from the Department of Production Engineering.

Table. PERT Calculation
Source

ACTIVITY	CODE	Expected Time (Te)	Variance
Detail Background Activity	A	6.33	1.00
Preparation machine spec	B	6.83	0.25
Budget preparation	D	6.83	0.25
Layout preparation	E	3.50	0.25
Manufacturing machine	C	97.50	6.25
Machine delivery	L	9.50	0.25
Handling machine inline	H	13.17	0.69
positioning, leveling, and install the machine	I	10.50	0.69
upper and lower piping installation	F	4.50	0.69
Ducting Installation	G	19.17	0.69
kanban and production system installation	M	4.50	0.25
install the main panel and upper cable	J	6.50	0.25
Machine trial	K	24.00	1.00
Operator training	O	24.00	1.00
Quality check dimension	N	10.00	0.44
Safety check machine	P	3.17	0.25
final acceptance and approval	Q	1.17	0.03
Mass production	R	1.00	0.00
amount		251.17	14.25
Critical path amount		185.33	11.39

Referring to the determination of the critical path on CBS, the picture above the critical path is A-B-E-C-H-F-J-K-O of 9 critical paths with a completion time at Te value of 250.17 days, which is the sum of all critical paths in table 4.12 above. Besides, time on the critical path is the total processing time reduced by time for non-critical activity up to 250.17 days reduced by 64.83 days; the result is 185.33 days. This calculation covers the whole process in a critical way.

$$z = \frac{T(d) - Te}{\sqrt{V}} = \frac{190 - 185.33}{3.37} = 1.384$$

From the above calculation, the value of z is 1,384 rounded to 1.38 with the value of z, then when viewed from the table, the standard distribution curve shows the figure of 0.9099 and rounded to 0.91. This value means a 91% chance to construct a new production line to be completed according to the 190-day target schedule.

E. Conclusion and Suggestions

Conclusion

Based on data analysis that has been discussed previously, can draw conclusions in This research is as follows:

1. To improve the production line construction project schedule at PT. Denso Indonesia using the Critical Path Method, obtained 09 critical paths from 18 paths with a duration of 185 days. The improvement is better than the previous activity where the results obtained in 2019 were 13 critical paths in 18 pathways
2. The probability of improving the project schedule for the construction of a new production line at PT. Denso Indonesia using the Program Evaluation Review Technique (PERT) method, is 90.1%.

Advice

1. For further research, it is necessary to analyze the project costs incurred in the normal route to the resulting quality in detail
2. Further research needs to analyze the effect of accelerated project duration and cost of acceleration on the resulting quality in detail
3. For further research, other methods can be used to determine the amount of time/day, costs, and resources in carrying out the project so that it can be used as a comparison to produce optimal results.

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