CPM And PERT Technique Efficiency Model For Child Veil Production

Farid Hirji Badruzzaman, M Yusuf Fajar, Onoy Rohaeni, Gani Gunawan, Erwin Harahap

Abstract—The production process is a major problem in implementing the production of raw materials into finished materials. Inaccuracy and delay in completion time will result in additional time and costs. In order to anticipate such situation, one method is by using network analysis. Network analysis is described as a network that must be run which limited by time. The purpose of this study is to determine the work-network in a logical work sequence, when the child veil production process in PD ABC Bandung business units. Planning is prepared using the Critical Path Method (CPM) and Program Evaluation and Review Techniques (PERT). The critical path method (CPM) can be interpreted as a path that has the longest total activity period during which the project must be completed in a short time between the starting point and end point on the project network. PERT can be interpreted as an analytical method designed to assist in scheduling activities that must be carried out in a particular order. Further analysis of the average completion time at this time, the average for every 15 dozen was 4.28 hours. Through the proper scheduling of activities, using PERT / CPM techniques, the activities of child veil production processes for every 15 dozen products, it takes 3,822 hours. This means there is a time difference of 0.456 hours. With this time difference will help the level of production speed and reduce production costs.

Index Terms—model, demand, product, veil, cpm, pert, network-analysis.

1 INTRODUCTION

Demand for child veil in the PD ABC Bandung child’s veil business unit are generally processed in the form of orders. The production process to fulfill orders is striving to be completed on time. If the production process is completed more than the scheduled time, it will cause additional costs outside the planned budget. The production process can be interpreted as an activity to add value to an item by utilizing the resources of raw materials, human resources and production equipment in order to gain profits. In order to get accurate results as a basis for calculation before carrying out the production process, planning is needed, such as: proper and logical scheduling so that errors are not expected, the production process is stopped due to the absence of raw materials, traffic jams between work units, and late delivery of goods. Likewise, if there are inaccuracies in planning to determine the amount of production, the company will experience a shortage of production or an excess of production. Careful time planning is very important for the success of production activities. Production activities that are completed beyond the targeted time cause an increase in costs exceeding the budgeted costs. This program is carried out by companies, to encourage management to use certain techniques that can help in preparing plans, scheduling activities, evaluating, controlling activity costs. In practice, planning in a company's production activities can be deviated from what was planned before, this occurs because of the lack of coordination and supervision of the company during the production process itself so that there are inefficiencies in the use of time, costs and existing resources. So that the production process can be completed on time, the company needs to arrange a production process schedule.

One of the tools of supervision and control over the course of the production process that is widely used is the network method or network control method. Operational management that can help in making plans for the completion of production activities better and more efficiently can use the CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) techniques. This technique can divide larger activities into smaller activities and organize them in a network, so that the duration and cost of working on the program can be reduced. PERT and CPM can explain the flow of the production process, so that it can be determined the critical path of the production process to complete the work in an efficient time. Thus deviations and errors that arise as well as activities that are not in accordance with the plan can be seen as early as possible, so as to reduce risks that can harm the company. PD ABC, is a company engaged in the production of veil child. The models currently produced (2019) range from 25-30 models, with the size of a baby veil, kindergarten veil and elementary school veil. For each month, the company gets an average order of 3400 dozen for all models or an average of 425 dozen per cycle. In facing of Ramadhan, orders can increase to 100%. At this time, the PD ABC production process uses an estimated time based on previous experience. This experience is used as a basis for determining how long it will take to complete it. In many activities, PD ABC has not implemented a standard scheduling system in the production process, so there are often problems of inefficient use of time in the production process. In addition to the inefficient use of time, it is also influenced by the limited workforce in production. In this study, PD ABC applies network analysis to the production process, so that there is no work pending in completion. One of the efforts to anticipate late completion of activities is to use network analysis using the CPM / PERT method. Associated with the veil production process carried out several stages of work including: design planning, preparation of raw materials, measurements, pattern making, cutting materials, sewing, grinding, neci, accessories preparation, installation of accessories, color and size separation, grouping, calculation of the number of orders, and packing.

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2 THEORETICAL FRAMEWORK
2.1 Management
Management is a process concerned with the achievement of goals or objectives [1]. Management can be defined as the pursuit of organizational goals efficiently and effectively [12]. There are several activities that managers do to coordinate workers effectively and efficiently which includes Planning, Organizing, Leading, and Controlling [2], [12]. Project management as the process of managing, allocating, and timing resources to achieve a given objective expeditiously. The phases of project management are: planning, organizing, scheduling, and controlling [3]. Therefore, conceptually management means an activity carried out by two or more people using management principles, by empowering resources in order to achieve certain goals effectively and efficiently.

2.2 Project Planning
Networks are graphical representations of activities and events that are logically and sequentially connected to a project. Planning can be defined as a process of thought to make things done in future [40]. A project is a temporary endeavor undertaken to create a unique product, service, or result [16]. Project planning is an iterative process: it proceeds in steps from a first rough outline to a final [4]. Project planning approach methods are CPM (Critical Path Methods) and PERT (Program Evaluation and Review Technique methods). [16], [18], [20], [21], [27], [38], [42]. From some of the above meanings, Project planning is a process that is arranged in steps from the starting point to the final. Two alternative types of project networks are available, one type is the activity-on-arc (AOA) network, where each activity is represented by an arc. The second type is the activity-on-node (AON) network, where each activity is represented by a node [5], [12], [15], [21], [28], [34], [37]. An AOA diagram can be used to generate much information about the timing of individual activities in the project.

![Fig 1 Network Diagram Activity](image)

2.3 PERT/CPM Technique
A path of a network is one of the routes following the arcs from the start node to the finish node [5]. In estimating and analyzing time, one or several paths will be obtained from activities on the network that can determine the duration of completion of the entire project. To determine the estimated completion time, the term critical path is known as a path that has a series of activities with the longest total amount of time and the fastest project completion time. PERT model was invented by Booz Allen Hamilton, Inc. under contract to the United States Department of Defense’s US Navy Special Projects Office in 1958 as part of the Polaris mobile submarine-launched ballistic missile project to analyze and represent the tasks involved in completing a given project, especially the time needed to complete each task, and identifying the minimum time needed to complete the total project. PERT was developed primarily to simplify the planning and scheduling of large and complex projects. The research team led by Morgan R Walker and James E Kelly at E.I. Du Pont Inc. developing CPM networks to improve planning, scheduling and reporting [6]. PERT/CPM technique is based on a network diagram and network planning can help manager monitor and control projects [9]. The main difference between PERT and the CPM network is that CPM is event based and then activity based. Furthermore for this in the CPM network there is no leeway for uncertainty in the duration of time involved and in the time of the CPM associated with direct costs [29].

2.4 Critical Path Methods (CPM)
Critical path method (CPM) is a major tool for planning and scheduling production [13]. Critical Path Method or Critical Path Analysis is a project management tool that is used in project planning process [32]. One form of algorithm for the planning process is the Critical Path Method (CPM) [15]. The critical path is the path that has the longest total period of activity that supplies the project to be completed in a short time between the starting point and end point on a project network [24]. The critical path is a sequence of individual activities of a project that must be finished on schedule so that the whole project is completed on time [39]. Critical Path is Total activities on this path is greater than any other path through the network (delay in any task on the critical path leads to delay in the project) [44]. Critical path method (CPM) is a powerful technique of economically scheduling construction, engineering, and other activities [17]. Critical path is obtained from the longest path from a process model [15]. The Critical Path method is a heuristic one based on the graphs theory, containing some process of adjustment and estimation of activities length, as well as on the knowledge of advanced techniques that it can analyze in terms of the development phase in time [22]. With CPM, a single estimate for activity time was used that did not allow for variation; activity times were treated as if they were known with certainty [21]. The critical path method (CPM) is a step-by-step project management technique for process planning that defines critical and non-critical tasks with the goal of preventing time-frame problems and process bottlenecks [25]. The CPM is an elementary technique developed for project management assumption under unlimited resource convenience [26]. Therefore, critical path method is the longest path in a network to predict total time. The estimated project duration is equals the length of the longest path through the project network. This longest path is called the critical path. It is assumed that the duration of each activity is known with certainty. The minimum time in which the project can be completed, which activities may be executed at the same time, which activities are critical, meaning that a delay in any one of them is bound to cause a delay to the entire project, and which activities are not critical, meaning that some time-slack is available for their completion. The data obtained is processed using the network analysis method and the CPM. To construct the critical path define the following notations:

\[ t_i = \text{Time duration of activity emanating from node}\ i\ \text{and ending at node}\ j\ \text{or estimate of the mean duration time for activity}. \]

In determining the critical path analysis, there are two methods used in the method of Forward Pass (Forward Pass) and Access to Back (Backward Pass) [40]. Forward Pass Rules-
Computation of Early Start and Finish Times [1], [30], [33], [34], [40]:

RULE 1. The initial project event is assumed to occur at time is zero.

RULE 2. All activities are assumed to start as soon as possible, that is, as soon as all of their predecessor activities are completed. \( ES_j = \text{Maximum of EF's of activities immediately preceding activity (i - j)} \)

RULE 3. The earliest start time of an activity is merely the sum of its early start time and the estimated activity duration. \( EF_j = ES_j + t_j \)

\( ES_j = \text{earliest start time for activity (i - j)} \)

\( EF_j = \text{earliest finish time for activity (i - j)} \)

Backward Pass Rules: Computation of Latest available Start and Finish Times

RULE 1. The latest allowable finish time for the project terminal event (t) is set equal to either an arbitrary scheduled completion time for the project, or else equal to its earliest occurrence time computed in the forward pass computations. \( L_f = E_f \)

RULE 2. The latest allowable finish time for an arbitrary activity (i - j) is equal to the smallest, or earliest, of the latest allowable start times of its successor activities. \( LF_j = \text{Minimum of LS's of activities directly following activity (i - j)} \)

RULE 3. The latest allowable finish time for an arbitrary activity (i - j) is merely its latest allowable finish time minus the estimated activity duration time. \( LS_j = LF_j - t_j \)

\( LS_j = \text{latest allowable start time for activity (i - j)} \)

\( LF_j = \text{latest allowable finish time for activity (i - j)} \)

\( S_j = \text{slack time for activity (i - j)} \)

\( S_j = LS_j - ES_j \)

\( S_j = LF_j - EF_j \)

Slack can be interpreted as a delay / delay of an activity in the project. Positive slack (+) would indicate ahead of schedule; negative slack would indicate behind schedule; and zero slack would indicate on schedule.

Applications of Critical Path Method (CPM) [28]

1. All types of construction and maintenance work.
2. Retooling programs for high volume production.
3. Budget planning.
4. Mobilization, strategic and tactical planning.
5. Low volume production scheduling.
6. Installation, programming and debugging of computer systems.
7. Assembly and testing of electronics system.

Another application, Critical path method provides a graphical representation of the project and predicts its completion time [30].

Important characteristics of Critical Path Method (CPM) are listed below [28]:

1. It is deterministic model of project management.
2. It can be used only for repeated activities.
3. It requires accurate time calculation for an activity.
4. It cannot be used for a project that does not have any precedence.

2.5 Program Evaluation and Review Technique Methods (PERT)

PERT was designed for projects in which durations are unclear such as research and development projects [24]. PERT is a technique of project management which is used to plan, schedule, organize and coordinate all the activities in a proper manner within a project [41]. Program (Project) Evaluation and Review Technique (PERT) is a project management tool used to schedule, organize, and coordinate tasks within a project. It is basically a method to analyze the tasks involved in completing a given project, especially the time needed to complete each task, and to identify the minimum time needed to complete the total project [43]. The PERT method calculates uncertainty by using three types of estimated time for an activity to get information about its probability distribution. In PERT calculations, it is almost universal practice to use a very simple, but good, approximation for the mean, \( T_a = (a + 4m + b)/6 \), where \( a \) : estimate of the most optimistic duration, \( m \) : estimate of the duration under the most favorable conditions, and \( b \) : estimate of the duration under the most unfavourable conditions [7-11], [13], [19], [21], [22], [24], [31], [35], [36], [38], [43].

2.6 Gantt Chart

Gantt chart is a traditional management technique for scheduling and planning small projects that have relatively few activities and precedence relationships. This scheduling technique (also called a bar chart) was developed by Henry Gantt, a pioneer in the field of industrial engineering at the artillery ammunition shops of the Frankford Arsenal in 1914. [21]. The Gantt chart is a graph with a bar representing time for each activity in the project being analysed [21]. Gantt chart is a graphical tool used to show expected start and end times for project activities and to track actual progress against these time targets. A Gantt chart therefore provides both a planning function and a control function [27]. Therefore, A Gantt Chart is a graph that shows the time for each activity in the project being analyzed.

3. Materials And Method

3.1 Production

Part of the production process and production results are shown in the figure 1.

Fig. 1. Production process for Child Veil Production PD ABC

3.2 Method

The method used in this research is qualitative and quantitative method. The data obtained in the form of primary and secondary data. To obtain primary data carried out in the form of several activities, so that in the analysis carried out can obtain appropriate results based on what is in the company, while the activities are: Interview, namely through question and
answer directly with the leadership related to the problem under study. Interviews were also conducted with production managers, procurement managers, and several labors. Observation, namely through observation and recording of things obtained during the study for 3 month. Secondary, data is done by library research, by studying the theories that exist in the literature relating to the problem to be examined. At present, PD ABC has 50 sewing machines and 5 overlock machines and neci machines. Based on observations, the skills of tailors are very varied where some are already proficient and some are still beginners. Such condition affects the production results. Delivery of raw materials and transportation of finished materials is done to 4 place, so it requires correct scheduling. Before compiling a network, the composition of work and the average time of activity unit should be held. In table 1 below, we present the average time needed for each activity, from making a model, providing raw materials etc to finished materials.

**Table 1**

**Realistic Time of Production Activities (15 Dozen) for 1 Type of Child Veil Model**

<table>
<thead>
<tr>
<th>No</th>
<th>Activity Description</th>
<th>Average Real Time of Activity (hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design planning</td>
<td>0.13</td>
</tr>
<tr>
<td>2</td>
<td>Preparation of raw materials</td>
<td>0.19</td>
</tr>
<tr>
<td>3</td>
<td>Measurements</td>
<td>0.09</td>
</tr>
<tr>
<td>4</td>
<td>Pattern making</td>
<td>0.09</td>
</tr>
<tr>
<td>5</td>
<td>Cutting materials</td>
<td>0.16</td>
</tr>
<tr>
<td>6</td>
<td>Sewing</td>
<td>1.64</td>
</tr>
<tr>
<td>7</td>
<td>Grinding</td>
<td>0.33</td>
</tr>
<tr>
<td>8</td>
<td>Neci</td>
<td>0.24</td>
</tr>
<tr>
<td>9</td>
<td>Accessories preparation</td>
<td>0.15</td>
</tr>
<tr>
<td>10</td>
<td>Installation of accessories</td>
<td>0.60</td>
</tr>
<tr>
<td>11</td>
<td>Color and size separation</td>
<td>0.172</td>
</tr>
<tr>
<td>12</td>
<td>Grouping</td>
<td>0.168</td>
</tr>
<tr>
<td>13</td>
<td>Calculation of the number of orders, and packing</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>Sum</td>
<td>4.28</td>
</tr>
</tbody>
</table>

From table 1 above, it can be seen that to complete 15 dozen, 1 types of veil child model takes 4.28 hours. Next will be determined the relationship between several activities. Based on his experience, the manager of production has compiled the step for each production unit, as in the table 2 below.

**Table 2**

**Activity and Precedence Relationships**

<table>
<thead>
<tr>
<th>Description</th>
<th>Code</th>
<th>Activity</th>
<th>Must be Preceded by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design planning</td>
<td>1-2</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Preparation of raw materials</td>
<td>2-3</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>Measurements</td>
<td>1-3</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Pattern making</td>
<td>3-4</td>
<td>D</td>
<td>B and C</td>
</tr>
<tr>
<td>Cutting materials</td>
<td>4-5</td>
<td>E</td>
<td>D</td>
</tr>
<tr>
<td>Sewing</td>
<td>5-6</td>
<td>F</td>
<td>E</td>
</tr>
<tr>
<td>Grinding</td>
<td>6-7</td>
<td>G</td>
<td>F</td>
</tr>
<tr>
<td>Neci</td>
<td>7-8</td>
<td>H</td>
<td>G</td>
</tr>
<tr>
<td>Accessories preparation</td>
<td>6-8</td>
<td>I</td>
<td>F</td>
</tr>
<tr>
<td>Installation of accessories</td>
<td>8-9</td>
<td>J</td>
<td>H and I</td>
</tr>
<tr>
<td>Color and size separation</td>
<td>9-10</td>
<td>K</td>
<td>J</td>
</tr>
<tr>
<td>Grouping</td>
<td>10-11</td>
<td>L</td>
<td>K</td>
</tr>
<tr>
<td>Calculation of the number of orders, and packing</td>
<td>11-12</td>
<td>M</td>
<td>L</td>
</tr>
</tbody>
</table>
From the discussion above, the critical path is A - B - D - E - F - G - H - J - K - L - M or 1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 - 11 - 12 with a total time of 3.822 hours, there is a time difference between what is currently used by using the CPM and PERT methods, which is 4.28 - 3.822 = 0.458 hours or 27.48 minutes for each producing 15 dozen. In 1 month, there is a reduction in time for (3400 : 15) × 0.458 = 103.813 hours of work or 12.977 hour per cycle.

5 RESULT AND DISCUSSION

The theory of PERT/CPM techniques supports the application of production process activities. From the discussion above, it can be seen that there is time effectiveness using CPM and PERT, which is 103.813 hours in 1 month or 12.977 hours per cycle. By using PERT/CPM technique, the activities of the chill production process, the measurement activity can be carried out simultaneously with the material preparation activity. Likewise, the accessories preparation activity can be done together with the neci activity.

In figure 3, 4, and 5 below we present scheduling the result of data processing using software.
6 Conclusion
This paper discussed the problem of the application of scheduling production. Critical path methods is a model of project activities that are described the form of a network. It used if the completion time of each activity is known with certainty. PERT is a technique can divide a main activity into smaller individual activity and arrange it into a logical network. It has a major contribution the optimization of time in the production process and can be applied in other industrial project in the calculation of reducing time and cost Using CPM and PERT veil production will take 3.822 hour for 15 dozen and if compared to the current one, there is a time difference of 0.458 hour.

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