Analysis of time acceleration using Critical Path Method (CPM) to increase motorcycle maintenance in authorized service station

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Abstract. Numerous studies have shown that maintenance requires proper scheduling by using preventive and corrective maintenance scheduling to maintain the state of the machine. The fact is the number of Honda motorcycle products has increased. This has resulted in a long motorcycle queue. Motorcycle queues cannot be prevented only by scheduling preventive and corrective maintenance, so scheduling of maintenance activities is necessity to speed up motorcycle maintenance time. This study uses the Critical Path Method (CPM) activity scheduling method with the help of the POM-QM program to increase the acceleration of maintenance time. Scheduling is made by calculating the logic of dependency and time of each maintenance activity. Activity scheduling is carried out on 7 types of maintenance, namely carburetor light service, carburetor and CVT light service, injection light service, injection and CVT light service, oil change, spare part replacement, oil and spare part replacement and final inspection of each type of maintenance. After that, the analysis of the scheduling results is done by comparing the results before and after the proposed improvement. Based on the results of research conducted it can be seen that the maintenance time at the authorized service station can be accelerated by using the CPM scheduling method. The efficiency of acceleration of maintenance time is 16.666\% to 57.889\%. The preparation of maintenance activities and processing of heavy service data is required if there is heavy service maintenance in the authorized service station.

1. Introduction

Maintenance activities are undertaken to maintain the condition of the equipment and its components to be ready for operation [1]. Millions of motorbike populations need routine maintenance to function properly, this results in queues at workshops, eventually requiring maintenance scheduling to speed up maintenance time. Some research on scheduling planning using several methods, namely bar chart method, network method (CPM, PERT, PDM), LOB and Time Chainage Diagram. Where Bar Charts are easy to make and understand, but cannot recognize the critical path, determine the interrelationships between these activities and are not effective on large projects [2]. The network method such CPM, PDM, and PERT, it has the reliability to show specifically the logic of dependency relationships between activities and determine the critical trajectory of project activities so that the priority activities in the event of delays can be identified, but cannot directly detect activities that experience disturbances in
scheduling projects [3][4]. LOB is simple and easy to understand because as a line that shows the productivity of a job. However, LOB cannot show specifically the relationship between the logic of dependency and activities. LOB has the advantage of being able to directly detect activities that experience disturbances in project scheduling by looking at the presence of intersecting bar charts [5]. Another name for Time Chainage Diagram is Space-Time Diagram. Time Chainage Diagrams are another variation of the LOB. This method is also known as Time Distance Chart which is a simple extension of the Bar Chart method which is widely known by users of the planning system [6]. The scheduling needs to determine the relationship of each activity, identify relationships that should take precedence over other activities, help the use of labor and other resources in an optimal way on a project. In the CPM diagram, it can be showing specifically for dependency logic relationship used on all work items is Finish to Start (FS). Likewise, the maintenance completion time can be estimate by mathematics calculation. Also, the CPM method can also be seen a critical trajectory in a project schedule so that if there is a delay in project work, the priority of the work to be evaluated becomes easier to do. Work items traversed by the critical track monitored, the other hand overall maintenance delays cause of experience delays as well [7].

Long queues at official service stations can be described as a good level of customer loyalty [8]. However, this can also be a serious problem because they can lose up to 10 customers a week. Therefore, the Critical Path Method (CPM) is a suitable method to solve critical trajectory of maintenance activities in the authorized service station. This study uses CPM method to propose priority work on maintenance activities and increasing time acceleration for motorcycle maintenance.

2. Method
The scheduling method used in this study is CPM using a POM computer program. Sample taken is the type of motorcycle maintenance such as carburetor-type light service, carburetor and CVT light service, injection-light service, injection-light service and CVT, oil change, replacement of spare parts, oil and spare parts replacement and inspection of each type of maintenance. Sample total is taken based on the type of maintenance served during the duration of data collection. The research design stage showed in Figure 1

![Figure 1. Research design stage](image-url)
CPM has six basic steps [9], namely:
1. Identify the project and prepare a fractional work structure.
2. Building relationships between activities, deciding which activities should go first and which one follows.
3. Describe the network that connects the whole activity.
4. Establish an estimated time for each activity.
5. Calculate the longest time path through a network called the critical path.
6. Using networks to help with project planning, scheduling, and control.

Data processing using the POM program can be formulated into 4 steps, namely [10]:
1. In the Project management module select a single time estimate with network immediate predecessor.
2. Enter the number of numbers based on the number of work activities.
3. Input by existing data, ranging from tasks (activities) to activities that precede (Predecessor).
4. Then solve.

### 3. The results

Reliable logic of each activity item that is protected for scheduling maintenance activities, one of the results of scheduling using the CPM method can be seen in Table 1. Early Start is the earliest start time of an activity while Early Finish is the earliest time to finish the activity. Late Start shows the slowest start time of the activity can be started without delaying maintenance time. Late Finish shows the end time of the activity can be ended at the latest without an extended period of maintenance. The Slack is the difference in time, if slack is zero then the activity is called critical activity.

**Table 1. The logic of carburetor type motorcycle light service maintenance dependency**

| Activity Code | Activity                  | Activity Time (Second) | Predecessor | Early Start | Early Finish | Late Start | Late Finish | Slack  |
|---------------|---------------------------|------------------------|-------------|-------------|--------------|------------|-------------|--------|
| 1             | Light Check               | 30                     | 0           | 30          | 1650         | 1680       | 1650        |
| 2             | Horn Check                | 30                     | 0           | 30          | 1650         | 1680       | 1650        |
| 3             | Cover Body Removal        | 420                    | 0           | 420         | 0            | 420        | 0           |
| 4             | Engine Oil Inspection     | 60                     | 0           | 60          | 1620         | 1680       | 1620        |
| 5             | Oil Filter Check          | 60 3 420 480 960 1020  | 540         |             |              |            |             |
| 6             | Inspection and Adjustment | 60 3 420 480 960 1020  | 540         |             |              |            |             |
| 7             | Carburetor Cleaning and   | 600 3 420 1020 420    | 0           |              |              |            |             |
|               | Adjustment                |                        |             |             |              |            |             |
| 8             | Cleaning and Replacement  | 60 3 420 480 960 1020  | 540         |             |              |            |             |
|               | of Fuel Filters           |                        |             |             |              |            |             |
| 9             | Cleaning and Replacement  | 60 3 420 480 960 1020  | 540         |             |              |            |             |
|               | of Air Filters            |                        |             |             |              |            |             |
| 10            | Valve Check and Adjustment| 300 3 420 720 720 1020 | 300         |             |              |            |             |
| 11            | Clutch Check and Adjustment| 120 3 420 540 900 1020 | 480         |             |              |            |             |
| 12            | Chain Adjustment          | 120                    |             | 120         | 1560         | 1680       | 1560        |
| 13            | Brake Check and Adjustment| 60                     |             | 60          | 1620         | 1680       | 1620        |
| 14            | Brake Light Switch        | 60                     |             | 60          | 1620         | 1680       | 1620        |
| 15            | Battery Checkup Examination| 120 3 420 540 1560 1680 | 1140        |             |              |            |             |
| 16            | Addition of Tire Wind     | 120                    |             | 120         | 1560         | 1680       | 1560        |
| 17            | Pressure                  |                        |             |             |              |            |             |
| 18            | Steering Handlebar Checks| 60 3 420 480 1620 1680 | 1200        |             |              |            |             |
|               | and Adjustments           |                        |             |             |              |            |             |
| 19            | Wheel Bearing Inspection  | 60                     |             | 60          | 1620         | 1680       | 1620        |
| 20            | Mounting Cover            | 600 4,5,6,7,8,9,10,11  | 1620 1620 1620 |              |              |            |             |
| 21            | Nuts and Bolts Inspection | 60 20 1620 1680 1620   | 0           |              |              |            |             |

**Total Before Proposed Improvement = 3120**  
**Total After Proposed Improvements (CPM) = 1680**
Based on the results of scheduling the overall type of maintenance using the CPM method, it is known that the speed of time before and after the proposed improvement can be seen in Table 2.

Table 2. Comparison results of scheduling activities before and after proposed improvements

| No | Type of Maintenance          | Before Proposed Improvement | After Proposed CPM Repair | Time Saving | Equivalent Efficiency |
|----|------------------------------|------------------------------|---------------------------|-------------|-----------------------|
|    |                             | Time                        | Time                      |             |                       |
|    |                             | 3120 second (52 minute)     | 1680 second (28 minute)   | 1440 second (24 minute) | 46,153 %             |
| 1  | Carburetor                  | 3120 second (52 minute)     | 1680 second (28 minute)   | 1440 second (24 minute) | 46,153 %             |
| 2  | Carburetor and CVT          | 3900 second (65 minute)     | 1680 second (28 minute)   | 2220 second (37 minute) | 43,076 %             |
| 3  | Injection                   | 3120 second (52 minute)     | 1680 second (28 minute)   | 1440 second (24 minute) | 46,153 %             |
| 4  | Injection and CVT           | 3900 second (65 minute)     | 1680 second (28 minute)   | 2220 second (37 minute) | 57,894 %             |
| 5  | Oil                         | 720 second (12 minute)      | 600 second (28 minute)    | 120 second (2 minute)   | 16,666 %             |
| 6  | Spare part                  | 2760 second (46 minute)     | 2700 second (45 minute)   | 60 second (1 minute)    | 2,173 %              |
| 7  | Oil and Spare part          | 660 second (11 minute)      | 510 second (8.5 minute)   | 150 second (2.5 minute) | 22,727 %             |
| 8  | Final Inspection            | 270 second (4.5 minute)     | 120 second (2 minute)     | 150 second (2.5 minute) | 55,555 %             |

The graph of the comparison of the scheduling of activities before and after the proposed improvement can be seen in Figure 2. The graph of the results of the comparison of the scheduling of the activities before and after the proposed improvement shows that there is an acceleration of maintenance time after the proposed improvement of the activity schedule using the critical path method.

Figure 2. Comparison results of scheduling activities before and after proposed improvements
4. Conclusion

Maintenance of a light carburetor motorcycle service accelerates for 1440 seconds, with an efficiency of 46.153%. Maintenance of the carburetor and CVT lightweight service motorcycle accelerates for 2220 seconds, with an efficiency of 43.076%. Maintenance of light injection service motorbikes accelerates for 1440 seconds, with an efficiency of 46.153%. Maintenance of light injection and CVT service motorbikes accelerates for 2220 seconds, with an efficiency of 57.894%. Motorcycle oil changes obtain acceleration for 120 seconds with an efficiency of 16.666%. Motorcycle spare parts replacement gained acceleration for 60 seconds with an efficiency of 2.173%. Oil and motorcycle spare parts changes have accelerated for 150 seconds, with an efficiency of 16.666%.

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References

[1]  Kandemir C, Celik M, Akyuz E and Aydin O 2019 Application of human reliability analysis to repair & maintenance operations on-board ships: the case of HFO purifier overhauling Appl. Ocean Res. 88 317–25
[2]  Rolsen C N and Merschbrock C 2016 Acceptance of construction scheduling visualizations: bar-charts, flowline-charts, or perhaps BIM? Procedia Eng. 164 558–66
[3]  Hajdu M and Isaac S 2016 Sixty years of project planning: history and future Organ. Technol. Manag. Constr. an Int. J. 8 1499–510
[4]  Nursanti E, Avief R M, Sibut S and Kertaningtyas M 2018 Peningkatan Efisiensi Waktu dan Biaya Pemeliharaan Overhaul Pesawat Tempur J. Teknol. dan Manaj. Ind. 4 7–15
[5]  Badukale P A and Sabihuddin S 2014 Line of balance Int J Mod Eng Res 4 45–7
[6]  Olivieri H, Seppänen O and Denis Granja A 2018 Improving workflow and resource usage in construction schedules through location-based management system (LBMS) Constr. Manag. Econ. 36 109–24
[7]  Hegazy T and Menesi W 2010 Critical path segments scheduling technique J. Constr. Eng. Manag. 136 1078–85
[8]  Khadka, Kabu and Maharjan S 2017 Customer satisfaction and customer loyalty (Centria University of Applied Science)
[9]  Barry R, Hezser J and Chu M 2014 Operations Management (Pearson)
[10]  Weiss H J 2004 POM/QM for Windows (Prentice Hall)