

Improving Assembly Line Balancing Using Moodie Young Methods on Dump Truck Production

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Abstract Dump truck is a transportation equipment to facilitate the process of loading and unloading. The company has 7 work stations different cycles time. The difference in cycle time at each work station causes a bottleneck on the line balancing production. The bottleneck occurring in the line balancing production causes a delay in the completion of the product. Delays in delivery of goods certainly gives a bad impact to the company. Therefore, companies need to balance the line balancing production to reduce bottlenecks that cause delayed product completion time. Bottleneck minimization will increase the efficiency of the assembly line balancing. Line balancing aims to obtain a smooth flow of production that resulting maximum line balancing efficiency. One method of line balancing is by using Moodie Young method. The result of the calculation with Moodie Young method obtains an increase of line efficiency by 75% from the actual method. This method is also reduce balance delay from 53.86% to 19.18% the decline in smoothness index to be 597,57. It can be concluded that the Moodie Young Method is better than the actual method.

1. Introduction

Production activities in a manufacturing industry are closely related to the balance of assembly line balancing. Assembly line balancing is one of the criteria to determine the effectiveness of the industry which a number of assembly work elements are grouped into several work stations. Each work station is expected have the same cycle time though with different capacities so that no idle time and bottlenecks occurs. This research is conducted on industries that produce dump trucks, namely transportation equipment used for material transfer. This industry has seven (7) work stations with different capacity each time period. The differences of capacities cause various problems in line balancing.

The problems can be seen with the bottleneck activity. The bottleneck causes a longer cycle time. The bottleneck occurring in line balancing causes a delay in the completion of the product. Delays in delivery of goods certainly gives a bad impact to the company. The problem shows of unfilled line balancing and low efficient line balancing. Therefore, it must be handled quickly and one way to handle the line balancing problem is to do the assembly line balancing. Line balancing is a method to balance the assignment of some work elements from an assembly line balancing to the work station to minimize the number of workstations and minimize total of idle time on the whole work station on a certain level of output [1] Therefore it is necessary to do the line balancing to this company which aims to reduce the bottleneck to increase line efficiency and reduce balance delay.



Line Balancing is leveling the workload across all processes in a cell or value stream to remove bottlenecks and excessive capacity. The main objective of line balancing is to distribute the task evenly over the work station so that idle time to man or machine can be minimized [2] and to minimize total of *idle time* on the whole work station on a certain level of output [3] In general, the main purpose of line balancing is how to minimize the number of work stations and to improve the production rate. In addition, line balancing also used to obtain the minimization of cycle time; the maximization of workload smoothness; and the maximization of work relatedness [4] There are some indicators used to determine the quality of line balancing, line efficiency, smoothing index and time of line balancing [5,6,7] In this research used line efficiency, balance delay and smoothing index to measure and increase the efficiency of line balancing.

The method used in this research is Moodie Young method. This method is one of the heuristic methods. [8] Heuristic methods have become the most popular techniques for solving the problem. But we should underline that many studies on assembly line including the exact solution method and heuristics have been reported in many research. [9,10] Moodie Young method also has been widely used in a variety of manufacturing industries including in the t-shirt industry consisting of 15 work elements [11] heuristic approaches have also been done on CNC machines [12] However, no research has been done to reduce balance delay and increase line efficiency in industries that produce transportation equipment such as dump trucks. The aim of this study was to create assembly lines which have the highest line efficiency and to reveal the applicability of Moodie Young methods for dump truck industry

2. Methods

Assembly line balancing methods are separated into three groups according to the solution approach: single model, multi-model and mixed-model assembly lines [13,14]. Assembly line balancing method based solution approaches are threefold: heuristic methods, analytical methods and simulation techniques [15] There are several methods of line balancing in heuristics models that are often used, such as Moodie-Young Method, Killbridge and Wester Heuristic, Hoffmans or Precedence Matrix, Immediate First Fit and Method Fit Methods Post Weighted Method (RPW)

This research uses Moodie Young method to overcome the line balancing problem. Moodie Young method consists of two phases [16], namely the first phase is to make the grouping of work stations which the work elements are placed on the work station with rules in the form of two work elements that can be selected then the bigger time working elements are placed first. In this phase, a precedence diagram based on the work elements matrix earlier and work elements follows.

Then do the second phase (trade and transfer) is to distribute idle time evenly for each station. This activity to identify the largest and smallest time, determining the goal, identifying the smaller work elements time than the goal at the station with the highest time, moving the work elements with the condition not to violate the precedence diagram rules, and evaluation until no work elements are moved. Then do the calculation of :

- Balance delay is the ratio between idle time in the assembly line balancing with the time available. The smaller balance delay means the less idle time (idle) an assembly line balancing.
- Line efficiency is the ratio of work stations time to the cycle time multiplied by the number of stations and
- Smoothness index is an index that becomes the relative refining index of an *assembly line balance*. The minimum value of the smoothness index is 0 which indicates a perfect balance. The smaller of smoothness index means the model is closer to the perfect balance [17,18].

3. Results and discussion

3.1. Line balancing with the actual method

In the production process dump truck, there are conditions which work elements affect the other work elements described in the form of precedence diagram. Precedence diagram of making dump truck can be seen on Figure 1.

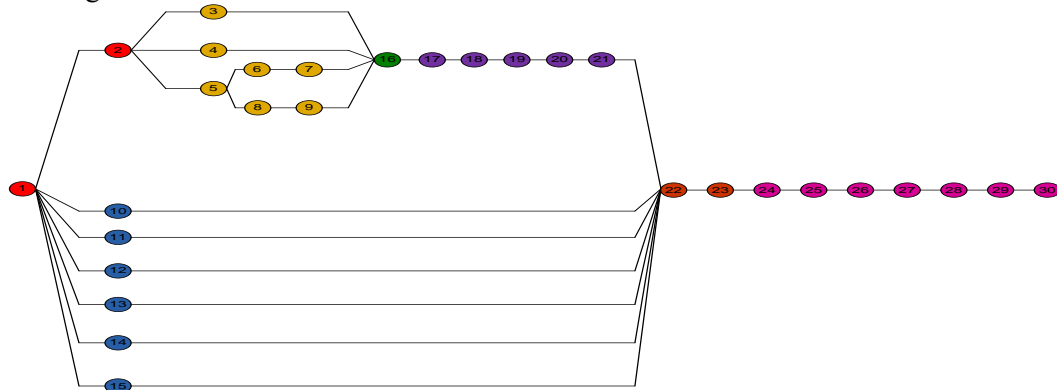


Figure 1. Actual Precedence Diagram

From figure 1 shows that there are 30 work elements and 7 work stations (metal cutting, forming, installed assy, welding body, painting, installed hydraulic and finishing) that can be viewed based on the color difference. Furthermore, the calculation of actual line balancing with 30 work elements allocated in 7 work stations with total time 4054 minutes. Allocation of work elements can be seen in the following table:

Table 1. Allocation of Actual Work Elements

Work Stations	Work Elements	Total Time (min)
I	1,2	35
II	3,4,5,6,7,8,9	336
III	10,11,12,13,14,15	458
IV	16	1254
V	17,18,19,20,21	1109
VI	22,23	594
VII	24,25,26,27,28,29,30	268
Total		4054

Based on the above table shows that there are seven (7) work stations with 30 work elements and total time of 4054 minutes. The above table is based on precedence diagrams such as figure 1. Then calculated as follows:

a. The Calculation of *Balance Delay*

The calculation of *balance delay* in a line is:

$$D = \frac{7 \times 1254 - 4054}{7 \times 1254} \times 100\%$$

$$= 53,82 \%$$

b. *Line Efficiency*

The calculation of *line efficiency* is:

$$E = \frac{4054}{7 \times 1254} \times 100\%$$

$$= 46,18\%$$

c. *Smoothness Index*

The calculation of *smoothness index* is:

$$SI = \sqrt{(1254 - 35)^2 + \dots + (1254 - 268)^2}$$

$$= \sqrt{3418926} = 1849,03$$

3.2. Line balancing with the moodie young method

Moodie Young method has two phases. The first phase using the method *Moodie young* to conduct the formation of new work station. The formation of workstations done by grouping elements work based on rank positional weight. From the grouping were obtained the formation of workstations as on a table 2.

Table 2. Work Stations Forming Using *Moodie Young* Method First Phase

Work Stations	Work Elements	Total Time (min)
I	1,15,13,10,14,11,12,2,5,4,3,8,6,7,9	825
II	16	1254
III	17,18,19,20,21,22	1162
IV	23,24,25,26,27,28,29,30	813
Total		4054

From the table above there is the reduction of workstations into 4 work station. After that continued in the second phase which consisted of several stages .The first stage in the second phase is identifying of the largest and smallest work station time. Next goal is determined by the goal formula = (largest time-smallest time)/2. After the goal value is obtained, transfer to the minimum work station for the work elements value is below the goal value which does not violate the precedence diagram. Based on this, it is found that the working element 22 which takes 50 minutes is transferred to the IV work station, so that the work station formed can be seen in Table 3.

Table 3. Work Stations Forming using *Moodie Young* Method Second Phase

Work Stations	Work Elements	Total Time (min)
I	1,15,13,10,14,11,12,2,5,4,3,8,6,7,9	825
II	16	1254
III	17,18,19,20,21	1112
IV	22,23,24,25,26,27,28,29,30	863
Total		4054

Line balancing results using *Moodie Young* obtained 4 (four) work stations. Because no more elements work greater than the goal so iteration stopped. . Then will be calculation balance delay, line efficiency and smoothing index from the table above. Based on the above table, the calculation is:

a. The calculation of *Balance Delay*

The calculation of balance delay of a line is:

$$D = \frac{4 \times 1254 - 4054}{4 \times 1254} \times 100\%$$

$$= 19,18 \%$$

b. *Line Efficiency*

The calculation of *line efficiency* is:

$$E = \frac{4054}{4 \times 1254} \times 100\%$$

$$= 80,82\%$$

c. *Smoothness Index*

The calculation of *smoothness index* is:

$$SI = \sqrt{(1254 - 825)^2 + \dots + (1254 - 863)^2}$$

$$= \sqrt{357086} = 597,57$$

The next step is to make precedence diagram to dump truck production based on line balancing with the Moodie young as on a table 3. The final precedence diagram to the dump truck production is presented in figure 2.

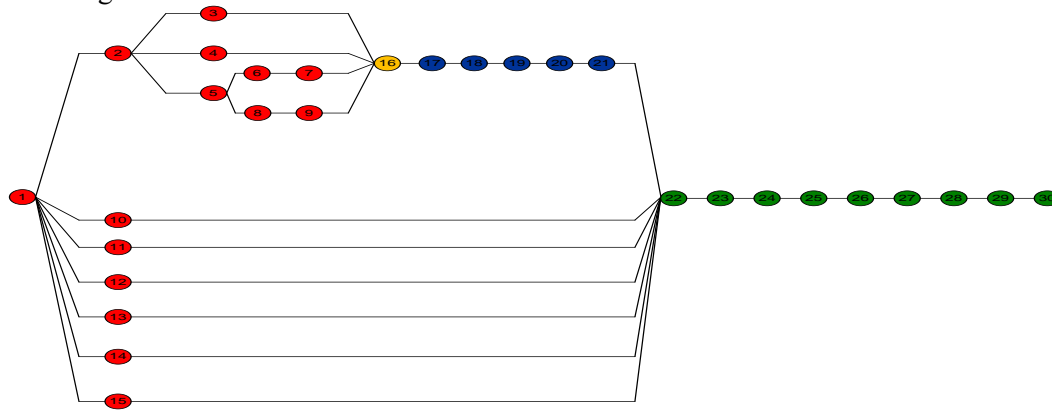


Figure 2. *Precedence Diagram* Using Moodie Young Method

From the above it is seen any different precedence diagram the actual condition with the moodie young. Then performed a comparison between line balancing actual and line balancing using the Moodie Young method. A comparison of the line balancing condition criteria actual and Moodie Young method can be seen in the Table below:

Table 4. Comparison of the Line Balancing Condition Criteria Actual and Moodie Young

Comparison Parameters	Condition	
	Actual	Moodie Young
Number of Work Stations (Unit)	7	4
<i>Balance Delay (%)</i>	53,82	19,18
<i>Smoothness Index</i>	1849,03	597,57
<i>Line Efficiency (%)</i>	46,18	80,82

Based on the table above, it can be seen that the recommendation by using Moodie Young method gives a better value by having a line balancing efficiency value of 80.82% from the previous condition. This means the decrease in the bottleneck between workstations. The reduction of the station shows that the line with 4 work stations is more efficient and the delay time becomes smaller. Reducing of balance delay indicates that the reduced idle time caused by bad allocation between workstations. The reduction of smoothness index also shows that the quality of line balancing is getting better. Previous studies conducted in t-shirt production also have shown that by using the method Moodie young also improve line efficiency [9]

4. Conclusion

By using the method Moodie Young proves to solve the problems in line balancing could be happened. Moodie Young method reduces the work stations to 4 (four) work stations. Moodie Young method improved line efficiency to be 80,82 %, the decline in smoothness index to be 597,57 and the decrease in the balance delay to be 19,18%. Third above criteria showed that with the application of Moodie Young method could improve the line efficiency of dump trucks industry.

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