Production Track Balance Analysis Using The Moodie Young Method

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Abstract

The purpose of this study was to find out the efficiency level of the production line by using the Moodie Young method. Where the method was used to determine the balance level of the production line consisted of 3 parts, namely: Line Efficiency, Balance Delay, and Smooth Index.The results showed that in the actual production line arrangement, there were 5 workstations with 7 work elements with Line Efficiency results of 40.29 %, Balance Delay of 59.70%, and Smoothness Index of 9578.22. While the composition of the new production line as a result of research using the Moodie Young method, there were 3 workstations with 7 work elements with Line Efficiency of 67.15%, Balance Delay of 32.84%, and Smoothness Index of 4449.71.

Keywords: Line Balancing, Moodie Young, Line Efficiency, Balance Delay, Smooth Index

INTRODUCTION

The development of the business world makes industry players have to come up with innovative ideas to produce maximum products both in terms of quality and quantity. Every industry should strive to maintain and maintain stability. Often there is an imbalance problem in the production process which results in a long time to complete a job.

Production line balance is closely related to mass production. A number of production jobs are grouped into several work centers. The time allowed to complete the elements of the work is determined by the speed of the production line. All work stations have the same cycle time as much as possible. If a work station has a time below the ideal cycle time, then the station will have idle time.

The problem that is solved in the production line balance minimizes idle time on the line, because the output produced is determined by the longest operation so other operations have to wait. Therefore, inefficiencies exist in the utilization of equipment and operators where output is reduced and production capacity is wasted.

The imbalance in the trajectory in production activities can be seen from the unemployment of several work stations, while other work stations continue to work fully. This is due to the time required by the work station to complete a job more than the predetermined trajectory speed. The speed is determined from the level of capacity, demand, and the longest operating time.

The existing process on the production floor is considered to be still not optimal due to an imbalance in the production process which results in the length of time to complete a job. As in work element 3, it is the longest and largest production process so that there is a buildup of raw materials and the next work element experiences idle time.

RESEARCH METHODS

The type of research used is a case study. Case studies are methods that are applied to understand the problem more deeply by reviewing the field in an integrative and comprehensive manner. The data used in this study are primary data and secondary data. The data processing method on the balance of this production line uses the Moodie Young method. The Moodie Young method is one of the production line balancing methods that is able to solve problems on track balance and the results obtained are close to efficient. The steps for data processing are as follows:

1. Data adequacy test
2. Data uniformity test
3. Calculating normal time
4. Calculating standard time
5. Calculation of line efficiency, balance delay, smooth index on the actual track and the moodie young path
   a. Line efficiency
   b. Balance Delay
   c. Smooth Index

RESULTS AND DISCUSSION

Data Adequacy Test

Calculation of the data adequacy test is useful to determine whether the data obtained is sufficient or not. The data is said to be sufficient if N' < N, meaning that there is no need for additional data. The data is said to be insufficient if N' > N, meaning that there is a need for additional data. For example, the calculation of the data adequacy test for the first work element, namely the weighing of raw materials.

Table 1. Recapitulation of Data Sufficiency Test for Each Work Element

Work Element	N'	N	Desc
1	0,0009	7	Enough
2	0	7	Enough
3	0,0361	7	Enough
4	2,92	7	Enough
5	0	7	Enough
6	0,11	7	Enough
7	0,08	7	Enough

In Table 1. it can be seen that all the data taken have a value of N' which is smaller than the value of N (N' < N). So that all the data is sufficient.

Data Uniformity Test

This test is useful to see whether the time measurement data collected is uniform or not. The data uniformity test was carried out using the upper control limit and lower control limit. For example, the calculation of the first work element data uniformity test, namely the weighing of raw materials.

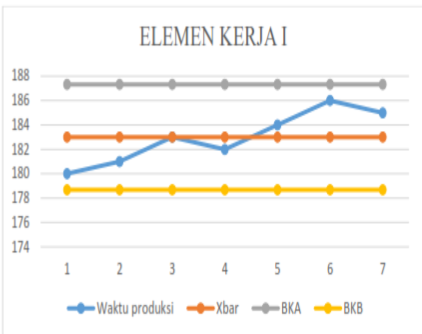

Figure 1. Work Element Control Map 1

Based on the graph above, it can be concluded that the measurement data on work element one is uniform. The recapitulation for the data uniformity test on all work elements can be seen in table 2.

Table 2. Recapitulation of Data Uniformity Test for Each Work Element

Work Element	X	σ	UCL	LCL	Desc
1	183,00	2,16	187,32	178,68	Uniform
2	900,00	0,00	900,00	900,00	Uniform
3	3623,57	18,64	3660,86	3586,28	Uniform
4	328,57	15,20	358,97	298,18	Uniform
5	1200,00	0,00	1200,00	1200,00	Uniform
6	915,71	8,56	932,83	898,60	Uniform
7	1215,43	9,61	1234,64	1196,22	Uniform

Calculating Normal Time

Normal time is the time required by workers to complete a job under normal conditions. To calculate the normal time, it is necessary to know the rating factor of each work station. In this study, the rating factor for each work station is 1 because it is assumed that the observed workers are workers who are experienced enough when working to carry it out without excessive efforts, master the established work methods and show sincerity in carrying out their work.

Table 3. Normal Time Recapitulation

Work St	Work Element	Normal Time
1	1	183,00
2	2	900,00
	3	3623,57
3	4	328,57
4	5	1200,00
	6	915,71
5	7	1215,43

Calculating Standard Time

Standard time is the time it takes a worker to complete a job. To calculate the standard time, it is necessary to know the allowance for each work station. There are several factors that determine the allowance, namely the energy expended, work attitude, work movements, eye fatigue, ambient temperature conditions, and personal circumstances.

Table 4. Recapitulation of Normal Time and Standard Time

Work St	Allowance	Work Element	Normal Time	Standard Time
1	9%	1	183,00	210,09
2	7%	2	900,00	967,74
3	34%	3	3623,57	5490,25
	34%	4	328,57	497,83
4	17%	5	1200,00	1445,78

International Journal Of Health, Engineering And Technology (IJHET) E-ISSN 2829 - 8683
Volume 1, Number 2, July 2022, *Page. 71 - 76*
Email : editorijhess@gmail.com

5	13%	6	915,71	1052,54
	13%	7	1215,43	1397,04

Calculation of Line Efficiency, Balance Delay, and Smoothness Index on the Actual Track

On the actual track, there are 5 work stations with a total of 7 work elements. The actual trajectory with standard time for each work element can be seen as follows:

Table 5. Actual Work Trajectory Standard Time

Work St	Work Element	Standard Time	Time St	Idle Time	% Idle
1	1	210,09	210,09		
2	2	967,74	967,74		
3	3	5490,25	5.988,08		
	4	497,83			
4	5	1445,78	1445,78	4.542,30	75%
5	6	1052,54	2449,58	3538,5	59%
	7	1397,04			

In Table 5. the standard time for each work element is known. This standard time will be used in the next calculation process. After knowing the standard time, and determining the cycle time of the work station, then calculate the Line Efficiency, Balance Delay, and Smoothness Index on the actual track.

Line Efficiency

Line efficiency is the ratio between the time used and the time available. The higher the value of the efficiency of the path, the better the path.

Balance Delay

Balance delay is a measure of path inefficiency resulting from actual idle time caused by imperfect allocation between work stations. A good production line has a balance delay value close to zero.

Smoothness Index

Smoothness index is an index that has a relative smoothness of balancing a certain production line. A good production trajectory has a smoothness index value that is close to zero.

For the results of the calculation of the balance on the actual trajectory, the results obtained for Line Efficiency of 40.29%. Balance Delay is 59.70%, and Smoothness Index is 9,578.22

Calculation of Line Efficiency, Balance Delay, and Smoothness Index Using the Moodie Young Method

In the first phase, grouping of work stations is made by making a precedence diagram to form a matrix P (predecessor) and matrix F (follower). Precedence diagram is a diagram that describes the sequence of work operations as well as linkages to other work operations with the aim of facilitating the control and planning of related activities in it.

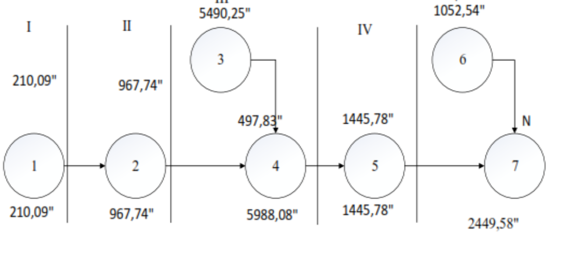

Figure 2. Precedence Diagram

The next step is to create a matrix P and matrix F. As an example, the P matrix shows the relationship of the predecessor work elements and the F matrix shows the relationship of the following work elements.

Table 6. Matrix P

Work element	Predesescor	
1	0	
2	0	
3	2	1
4	3	
5	4	
6	5	
7	6	

Table 7. Matrix F

Work element	Followers
1	3
2	3
3	4
4	5
5	6
6	7
7	-

The results of grouping work elements based on what is known so far, such as P and F matrices, and cycle time (5490, 25sec). We can arrange work elements according to the conditions, namely that the time of each work station must not exceed the cycle time, and the transfer of work elements must not violate the precedence diagram or the P and F matrices.

Table 8. Establishment of Work Stations (First Phase)

Work St	Work Element	Standard Time	Time at St	Idle Time	% Idle
1	1	210,09	1177,83	-	-
	2	967,74			
2	3	5490,25	5490,25	-	-
	4	497,83			
3	5	1445,78	4393,19	1097,06	25%
	6	1052,54			
	7	1397,04			

In the first phase, a new production path is obtained that changes from the actual production path. Where on the actual track there are 5 work stations with 7 work elements, on the new track the results of the first phase of Moodie Young turn into only 3 work stations with 7 work elements. The following is an overview of the precedence diagram for the new trajectory of the results of the first phase using the Moodie Young method.

International Journal Of Health, Engineering And Technology (IJHET) *E-ISSN 2829 - 8683*
Volume 1, Number 2, July 2022, *Page. 71 - 76*
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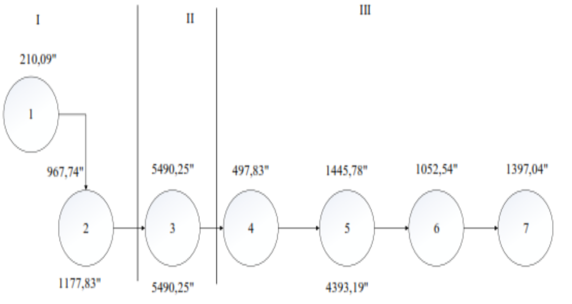

Figure 3. New Production Path Precedence Diagram

Then in the second phase, which is the result of improvements in the first phase. In this second phase there are several steps, namely as follows:

1. Identify the largest work station time and the smallest work station time. The order of the largest to the smallest work station is work station 2 (5490.25 seconds), work station 3 (4393.19 seconds), work station 1 (1177.83 seconds), Determine GOAL. GOAL is the difference between the maximum work station time minus the minimum work station divided by two.
2. Identify a work element contained in the work station with the maximum time, which has a smaller time than the GOAL, whose work element when moved to the minimum work station does not violate the precedence diagram. Work elements at station 1 can be moved because there are work elements that have a time below the GOAL. Likewise with stations 2 & 3 which have several work elements that have a time below the goal but cannot be moved due to violating the precedence diagram. Because in the second phase there is no change from the first phase because all work elements cannot be moved because they violate the conditions, then this is the result of the new production path obtained:

Table 9. Production Path Results of the Moodie Young Method

Work St	Work Element	Standard Time	Time at St	Idle Time	% Idle
1	1	210,09	1177,83	-	-
	2	967,74			
2	3	5490,25	5490,25	-	-
	4	497,83			
3	5	1445,78	4393,19	1097,06	25%
	6	1052,54			
	7	1397,04			

In table 9 can be seen that in this new line all work stations now have a time closer to the cycle time so that the idle time is less than the actual production line. Then calculate the Line Efficiency, Balance Delay, and Smoothness Index and then compare them with the results obtained from the actual production line.

Line Efficiency

Line efficiency is the ratio between the time used and the time available. The higher the value of the efficiency of the path, the better the path.

Balance delay

Balance delay is a measure of path inefficiency resulting from actual idle time caused by imperfect allocation between work stations. A good production line has a balance delay value close to zero.

Smoothness Index

Smoothness index is an index that has a relative smoothness of balancing a certain production line. A good production trajectory has a smoothness index value that is close to zero.

For the results of the balance calculation on the new trajectory of the Moodie Young method, the results for the Line Efficiency are 67.15%, the Balance Delay is 32.84%, and the Smoothness Index is 4.449.71.

Table 10. Differences in Line Efficiency, Balance Delay, and Smooth Index on the Actual and Moodie Young Paths

	Actual Path	Moodie Young
Line Efficiency	40,29%	67,15%
Balance Delay	59,70%	32,84%
Smooth Index	9.578,22	4.449,71

On the actual track there is a line efficiency of 40.29%, a balance delay of 59.70% and a smooth index of 9.578.22. Meanwhile, the moodie young line efficiency method is 67.15%, balance delay is 32.84%, and the smooth index is 4,449.71. This proves that the production trajectory using the Moodie Young method is proven to have a better level of trajectory balance compared to the actual trajectory.

CONCLUSION

Based on the results of the research obtained, the conclusion in this study is that the level of line efficiency on the actual path is currently considered not optimal. There are 5 work stations with 7 work elements with Line Efficiency results of 40.29%, Balance Delay of 59.70%, and Smoothness Index of 9578.22 and the line efficiency level on the Moodie Young method path, there are 3 work stations with 7 work elements with the results of Line Efficiency of 67.15%, Balance Delay of 32.84%, and Smoothness Index of 4449.71.

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