The recommendation of line-balancing improvement on MCM product line 1 using genetics algorithm and moodie young at XYZ Company, Co.

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Abstract. Kencana Gemilang, Co. is one electronics industry engaging in the manufacture sector. This company manufactures and assembles household electronic products, such as rice cooker, fan, iron, blender, etc. The company deals with an issue of underachievement of an established production target on MCM products line 1. This study aimed to calculate line efficiencies, delay times, and initial line smoothness indexes. The research was carried out by means of depicting a precedence diagram and gathering time data of each work element followed by examination and calculation of standard time as well as line balancing using methods of Moodie Young and Generics Algorithm. Based on results of calculation, better line balancing than the existing initial conditions, i.e. improvement in the line efficiency by 18.39%, deterioration in balanced delay by 28.39%, and deterioration of a smoothness index by 23.85% was obtained.
Keywords: Line Balancing, Moodie Young, Genetics Algorithm, Balanced Delay

1. Introduction

XYZ, Co. is one of electronics industries engaging in the manufacture sector. This company produces and assembles household electronic products such as, rice cooker, fan, iron, blender, etc. Line 1 is an initial line production at XYZ, Co., however production target on this line is less efficient which leads to underachievement of a production target established by the company. In order to overcome the problem, an analysis on line balancing to improve the efficiency is required, because according to [2], line balancing can solve combinatorial optimization problems and [6], Line balancing can be used to minimize the number of workstations, balancing the workload between work-stations. [4]said, that line balancing is a balancing assignment of task elements from an assembly line to work stations. The goal is to minimize the number of work stations and idle time on all work stations

MCM product line 1 has 34 work stations equipped with 35 operators. It is known that there is not optimum achievement of the established production target on this line. The target achieved by a production section is only approximately 275 units per hour as compared with 300 units per hour or 85% of its maximum number. Accordingly, this study was conducted aiming at identifying causes of the unachieved production target, line efficiencies, balanced delays, and smoothness indexes of initial line conditions followed by an analysis of line balancing to be able to improve efficiency and output of the line. Regarding employment of methods in the line balancing, According to [1], Moodie Young is considered appropriate for a precedence diagram starting from one or a couple of separated operations yet being united in one operational element and ending with one operational element. Thus the study was conducted using methods of Young and Genetics algorithm. The reason used GA because, according to [5], Genetic algorithms are optimal for complex problem solving. The most appropriate result of the analysis was taken as a recommendation of the line improvement.

2. Methods
Research methodology employed in the present study is as follows :

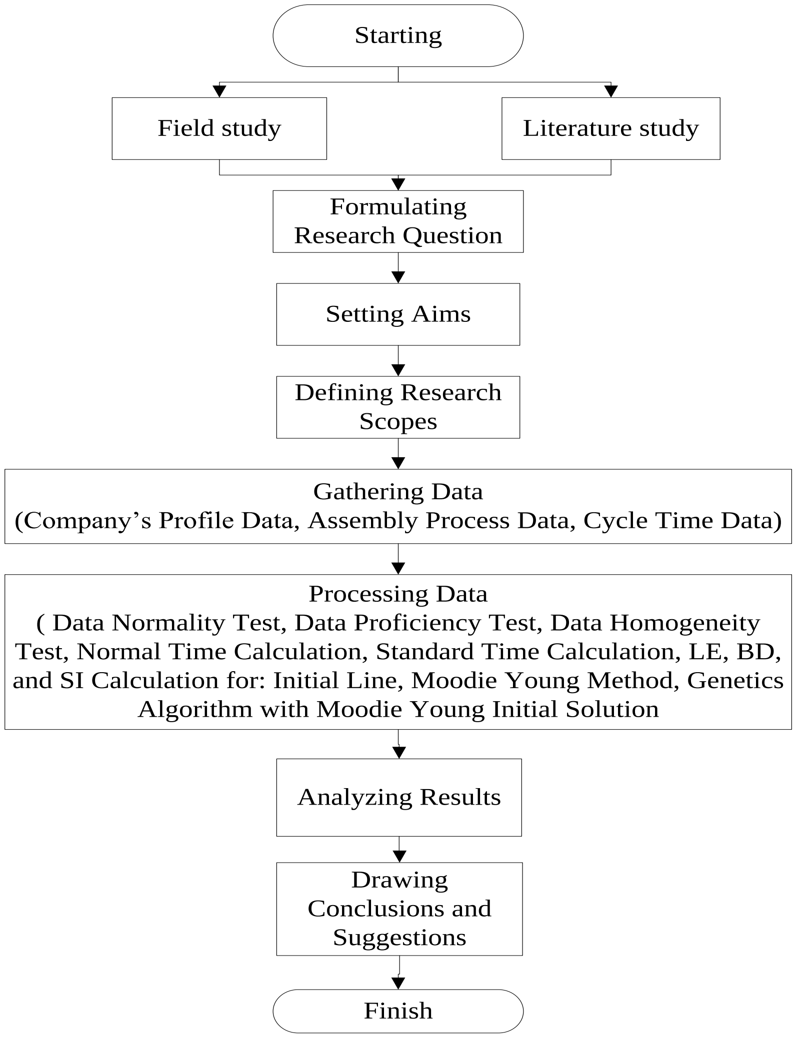

Figure 1. Research Flowchart

3. Results and discussion

3.1. Standard Time Calculation
Data gained was subject to a couple of tests before being used, i.e. normality, homogeneity, and proficiency tests. In this research, a confidence level of 95% and significance level of 5% were used. According to results of data tests, the gathered data was valid and able to be incorporated in the study.

In order to obtain a standard time, a normal time was calculated formerly. The normal time was gained from an average cycle time multiplied by an adjustment factor. An adjustment factor included was derived from the Westinghouse method. Standard time was obtained by multiplying the normal time by a leeway percentage then adding by the normal time itself. The leeway factor was given for three things, i.e. private needs, fatigue elimination, and inevitable obstacles.

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3.2. Initial Line Conditions

In the initial line conditions, there were 34 work stations of which arrangement is showed in Table 1.

Table 1. Initial Line Conditions

Stat	Work Elements	Standard Time (sec)	Number of Workers (people)	Work station (sec)
1	1	7.80	1	9.83
	10	2.03		
2	2	9.48	1	12.56
	8	3.08		
3	3	9.96	1	9.96
4	4	6.54	1	11.01
	5	3.30		
	6	1.17		
5	11	2.30	1	9.05
	12	4.36		
	13	2.39		
6	52	3.92	1	10.26
	53	4.01		
	54	2.33		
7	51	3.30	1	3.30
8	55	3.64	1	7.44
	56	3.80		
9	59	2.13	1	12.04
	60	9.91		
10	50	7.67	1	7.67
11	48	3.70	1	6.47
	49	2.77		
12	15	9.85	1	11.68
13	19	1.75	1	6.27
	21	4.52		
14	20	3.23	1	10.73
	23	7.509		
15	18	2.15	1	8.34
	24	6.19		
16	22	11.81	1	11.81
17	14	2.04	1	8.27
	25	4.57		
18	63	1.66	2	9.16
	26	11.11		
19	31	6.13	1	6.13
20	32	2.19	1	4.90
	33	2.72		
21	37	7.29	1	7.29
22	42	5.86	1	12.93
	43	7.08		
23	17	5.28	1	5.28
24	7	5.01	1	8.30
	9	3.29		
25	47	14.38	1	14.38
26	57	6.55	1	10.52
27	61	9.41	1	9.41
28	62	9.65	1	9.65
29	28	2.13	1	6.88
	29	2.81		
	30	1.95		
30	34	1.99	1	7.35
	35	5.36		
31	38	7.81	1	10.52
	39	2.71		
32	40	2.36	1	9.77
	41	7.41		
33	44	4.65		10.85
	45	6.20		
34	46	5.91	1	5.91

A precedence diagram of line production at XYZ, Co. is presented in Figure 2.

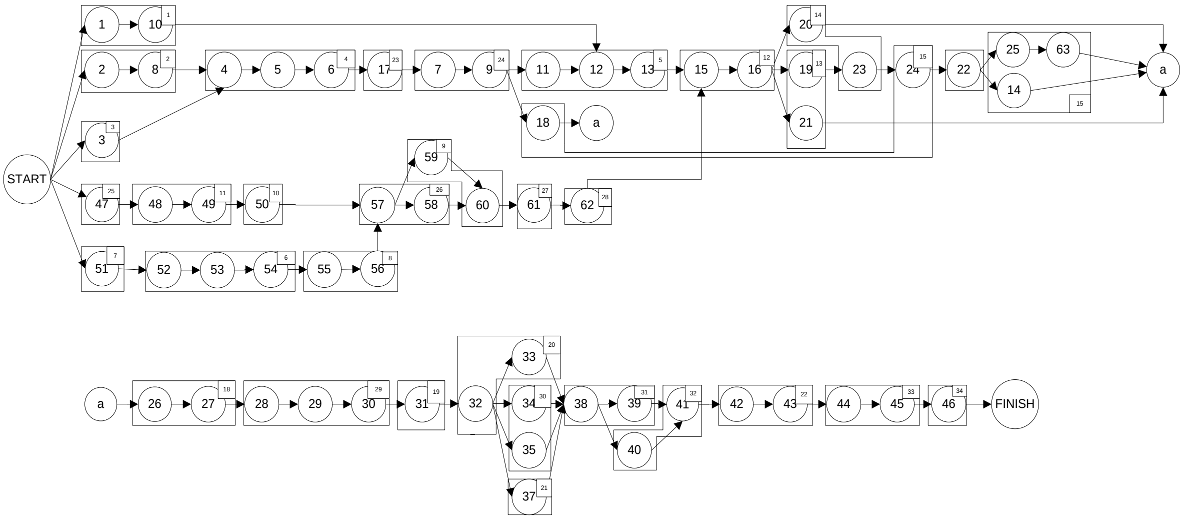

Figure 2. Precedence Diagram of XYZ, Co.'s Line 1

Based on the above initial line conditions, a line efficiency of 62.57, a balanced delay of 37.43%, and a smoothness index of 40.12% were obtained as shown in the following calculation.

3.3. Moodie Young Method-Based Improvement in Line Design

According to a Moodie Young method-based line design, 63 work elements were divided into 31 work stations (WS) as we can see in Table 2.

Table 2. Moodie Young method-based line design

WS	Work Elements	Standard Time (sec)	Number of Workers (people)	Time in WS (sec)	WS	Work Elements	Standard Time (sec)	Number of Workers (people)	Time in WS (sec)
1	3	9.96	1	9.96		21	4.52		
2	2	9.48	1	9.48	16	20	3.24	1	9.50
3	1	7.80	1	11.10	17	19	1..4	1	7.50
	51	3.30				23	7.50		
4	47	14.38	2	11.70	18	24	6.19	1	6.19
	52	3.92			19	22	11.81	1	11.81
	8	3.08			20	25	457	1	8.27
5	4	6.54	1	10.55		14	2.04		
	53	4.01				63	1.66		
	48	3.70			21	26	11.11	1	11.11
6	5	3.30	1	10.94	22	27	7.21	1	9.34
	49	2.77				28	2.13		
7	6	1.17	2	11.47	23	29	2.81	1	10.88
	50	15.33				30	1.95		
	17	5.28				31	6.13		
	54	2.33			24	32	2.19	1	9.48
						37	7.29		

Table 2. Moodie Young method-based line design (continued)

Stat	Work Elements	Standard Time (sec)	Number of Workers (people)	Time in WS (sec)	Stat	Work Elements	Standard Time (sec)	Number of Workers (people)	Time in WS (sec)
8	7	5.01	1	11.94	15	15	9.85	1	11.68
	55	3.64				16	1.84		
	9	3.29			25	33	2.72	1	10.07
9	56	3.80	1	10.35		34	1.99		
	57	6.55				35	5.36		
10	58	3.97	1	10.64	26	38	7.81	1	10.52
	11	2.30				39	2.71		
	12	4.36			27	40	2.36	1	9.77
11	13	2.39	1	6.67		41	7.41		
	18	2.15			28	42	5.85	1	5.85
	59	2.13			29	43	7.08	1	11.72
12	60	9.91	1	9.91		44	4.65		
13	61	9.41	1	9.41	30	45	6.20	1	6.20
14	62	9.65	1	9.65	31	46	5.91	1	5.91

An initial line efficiency of 80.96% with a balanced delay of 19.04% and a smoothness index of 16.27% were obtained from the calculation

3.4. Genetics Algorithm Calculation

Genetics Algorithm recognizes terms of gen, chromosome, and population. In this case, gen constituted the existing work elements. There are several ways to identify the arrangement of chromosomes, one of which is by using a random generator on Microsoft Excel software. Combination of each chromosome makes up a population. After the population was identified, fitness of each chromosome was calculated. The fitness value comprised a line efficiency of each chromosome.

Once the fitness of each chromosome was obtained, two best chromosomes from each population were selected as a pair of parents for crossover. The crossover was performed uniformly, in which every point can be an intersection. Random numbers between 0 and 1 were drawn in every chromosome, of which ≤ 0.5 was rounded down to 0 and > 0.5 was round up to 1. Random numbers were able to be drawn on Microsoft Excel. Numbers of 0 and 1 functioned to determine the selected chromosomes. If the number was 0, chromosome 1 was selected while if the number was 1, chromosome 2 was selected.

Mutated chromosomes obtained were followed by gain of a fitness value of 79.55%. The subsequent step was elitism in which a chromosome with the best fitness would be selected to be passed down to the next generation. The selected chromosome was chromosome 1 in population 1.

3.5. Genetics Algorithm-Based Moodie Young and Line Design Improvement

According to [3], When there are numerous alterations to calculate, Evolver 5.5 software can be employed to facilitate the calculation. There are up to 1000 iteration performed on the Evolver. The calculation was continuously carried out until reaching defined limits. It was found from the software calculation of an initial solution using the young moodie method that the line efficiency was 80.96, the balanced delay was 19.04%, and the smoothness index was 16.27%, while from the calculation of an initial line solution showed the line efficiency of 79.44%, the balanced delay of 20.56%, and the smoothness index of 17.37%.

3.6. Calculation results

Calculation results of comparison of the initial line between Young and Genetics Algorithm methods are presented in Table 3

Table 3. Comparison of the initial line between Young and Genetics Algorithm methods

	The first	Moodie Young	Genetic Algorith with Moodie Young
Line eficiency (%)	62.57	80.96	80.96
Balance Delay (%)	37.43	19.04	19.04
Smoothing Index	40.12	16.27	16.27
Amount of workstations	34	31	31
Output/Hour (Unit)	251	300	300

Table 3 shows that lines recommended with Moodie Young and Genetics Algorithm with Moodie Young initial solutions demonstrate the best results. These same results were due to limited movement of work elements based on a precedence diagram. Grouping of workstations based on the Moodie Young method and Genetic Algorithm with Moodie Young initial can be seen in Table 4.

Table 4. Proposed grouping of workstations

Stat	Work Elements	Standard Time (sec)	Number of Workers (people)	Time in WS (sec)	Stat	Work Elements	Standard Time (sec)	Number of Workers (people)	Time in WS (sec)
1	3	9.96	1	9.96	9	56	3.80	1	10.35
2	2	9.48	1	9.48		57	6.55		
3	1	7.80	1	11.10	10	58	3.97	1	10.64
	51	3.30				11	2.30		
4	47	14.38	2	11.70		12	4.36		
	52	3.92			11	13	2.39	1	6.67
	8	3.08				18	2.15		
	10	2.03				59	2.13		
5	4	6.54	1	10.55	12	60	9.91	1	9.91
	53	4.01			13	61	9.41	1	9.41
6	48	3.70	1	10.94	14	62	9.65	1	9.65
	5	3.30			15	15	9.85	1	11.68
	49	2.77				16	1.84		
7	6	1.17	2	11.47	16	21	4.52	1	9.50
	50	15.33				20	3.24		
	17	5.28				19	1.74		
	54	2.33			17	23	7.50	1	7.50
8	7	5.01	1	11.94	18	24	6.19	1	6.19
	55	3.64			19	22	11.81	1	11.81
	9	3.29							

Table 4. Proposed grouping of workstations (continued)

Stat	Work Elements	Standard Time (sec)	Number of Workers (people)	Time in WS (sec)	Stat	Work Elements	Standard Time (sec)	Number of Workers (people)	Time in WS (sec)
	25	4.57			25	33	2.72		
20	14	2.04	1	8.27		34	1.99	1	10.07
	63	1.66				35	5.36		
21	26	11.11	1	11.11	26	38	7.81	1	10.52
22	27	7.21	1	9.34		39	2.71		
	28	2.13			27	40	2.36	1	9.77
	29	2.81				41	7.41		
23	30	1.95	1	10.88	28	42	5.85	1	5.85
	31	6.13			29	43	7.08	1	11.72
24	32	2.19	1	9.48		44	4.65		
	37	7.29			30	45	6.20	1	6.20
					31	46	5.91	1	5.91

According to analysis from Table 4, it is shown that Moodie Young and Genetics Algorithm methods equipped with Moodie Young initial solutions are better than the existing initial lines therefore recommendation of Moodie Young and Genetics Algorithm with Moodie Young initial solutions can be implemented in order to improve the line productivity.

Grouping of work elements in the precedence diagram based on Moodie Young and Genetics Algorithm methods are shown in Figure 3.

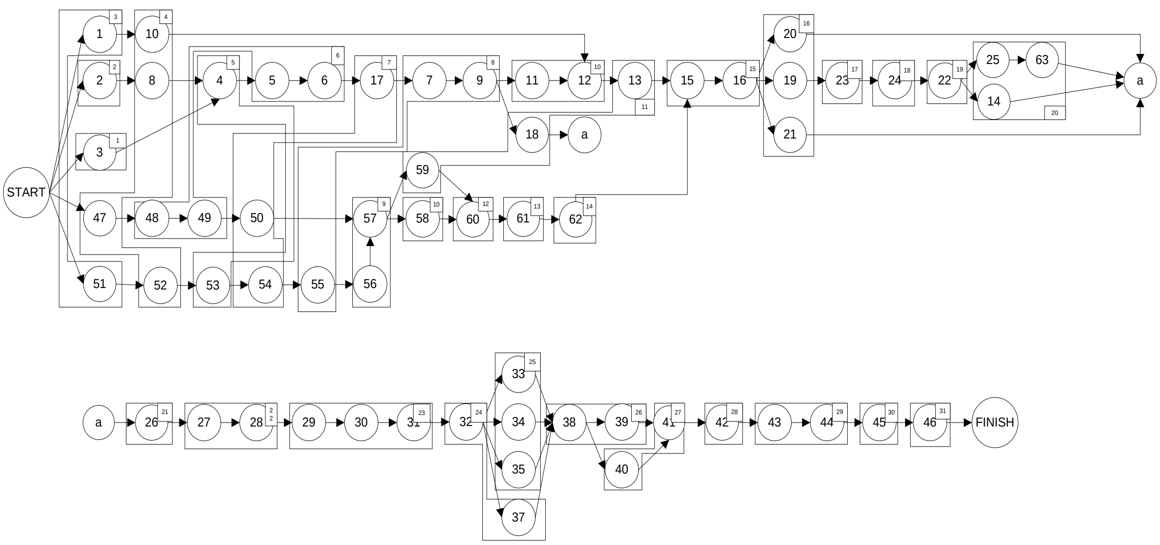

Figure 3. Grouping of Proposed Work Elements

Analysis from Figure 3 indicates that Moodie Young and Genetics Algorithm methods with Moodie Young initial solutions show same values of efficiency, balanced delay, and smoothness index. This was due to limited movement of work elements following the precedence diagram. This grouping of work elements was able to occur as every activity in each work element does not require high skills enabling the work element to be aggregated one another.

4. Conclusions

Based on the conducted present study, following conclusions are drawn.

a. Results of calculation show that initial line of the company indicated a line efficiency of 62.57%, balanced delay of 37.43%, and smoothness index of 40.12% with an output of 251 units per hour.
b. Results of calculation using Moodie Young and Genetics Algorithm with Moodie Young initial solutions show a line efficiency of 80.96%, balanced delay of 19.04%, and smoothness index of 16.27% with an output of 300 units per hour.
c. Results of calculation using Genetics Algorithm with initial line solutions show a line efficiency of 79.44%, balanced delay of 20.56%, and smoothness index of 17.37 with an output of 300 units per hour.
d. The best method recommends an implementation of line balancing based on Moodie Young and Genetics Algorithm methods with Moodie Young initial solutions to the company.

5. References

[1] Baroto T 2006 Simulasi perbandingan Algoritma Regionapproach, Positional Weight, Dan Modie-Young dalam efisiensi dan keseimbangan lini produksi, *Gamma*, **vol. II**, no. I, 49–54.
[2] Battaïa A D O 2013 A taxonomy of line balancing problems and their solution approaches, *Int. J. Prod. Econ.*, **142**, 259–277.
[3] Bernhard M 2011 Analisa Keseimbangan Lini Pada Departemen Chassis PT Toyota Manufacturing Indonesia Dengan Algoritma Ant Colony, Rank Positional Weight dan Algoritma Genetika. *Thesis*. Universitas Tarumanagara.
[4] Gaspersz V 2000 *Manajemen Produktivitas Total*. Jakarta: Gramedia.
[5] Sihombing R S 2014 Pemanfaatan algoritma genetik pada aplikasi penempatan buku untuk perpustakaan sekolah, *Pelita Informatika Budi Darma,* **vol. 6**, no. 2, 113–118.
[6] Shahabudeen P and Sivasankaran P 2014 Literature review of assembly line balancing problems, *Int J Adv Manuf Technol* **73**, 1665–1694.