LINE ASSEMBLY ANALYSIS FOR R-223 PRODUCT BY KILBRIDGE-WESTER HEURISTIC METHOD, HELGESON-BIRNIE METHOD AND MOODIE YOUNG METHOD AT PT. MULIA KNITTING FACTORY

by Lina Gozali

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Day/Date	Time	Room No	Paper ID
Wednesday 2 October 2013	13.00-15.00	1	AE-01, AE-06, UE-04, CE-06, CE-19
	13.00-15.00	2	IE-02, IE-04, IE-05, IE-06, IE-07
	13.00-15.00	3	IE-19, IE-21, IE-22, IE-23, ME-07
	13.00-15.00	4	ME-10, ME-11, ME-18, ME-20, ME-27, ME-34
	15.00-15.30		*Coffee Break*
	15.30-17.30	1	CE-07, CE-09, CE-11, CE-14, CE-18, CE-21
	15.30-17.30	2	EE-01, EE-02, EE-03, EE-04, EE-06, EE-08
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Thursday 3 October 2013	09.00-12.00	1	AE-02, AE-04, AE-07, AE-08, AE-09, AE-12, AE-14
	09.00-12.00	2	AE-13, AE-15, CE-03, CE-16, CE-20
	09.00-12.00	3	ME-01, ME-16, ME-22, ME-24, ME-29, ME-30, ME-31, ME-32
	09.00-12.00	4	IE-08, IE-14, IE-15, IE-17, IE-24, UE-01, UE-02, UE-03

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LINE ASSEMBLY ANALYSIS FOR R-223 PRODUCT BY KILBRIDGE-WESTER HEURISTIC METHOD, HELGESON-BIRNIE METHOD AND MOODIE YOUNG METHOD AT PT. MULIA KNITTING FACTORY

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Abstract

PT. Mulia Knitting Factory is the oldest knitting textile industry of Indonesia. Line balancing is the important flow of production process and should be controlled to balance production process to fulfill the production target. The important balance delay to gain the efficiency and good productivity will result the design of production lines. This research are studying garment product type:R-223. This research using Kilbridge-Wester Heuristic methods, Helgeson-Birnie methods and Moodie Young methods. Beginning cycle time efficiency is 33.11%, while the line efficiency of Kilbridge-Wester Heuristic methods is 72.40%, the line efficiency of Helgeson-Birnie methods is 76.46% and Moodie Young methods line efficiency is 80.56%. The final result will reduce the cycle time from 4.17 seconds to 3.73 seconds. The best line balancing method is Moodie Young method that provide the higher level of line efficiency, balance delay, smoothness index for PT Mulia Knitting Factory.

Keywords: Line Balancing, Balance Delay, Line Efficiency, Cycle Time

INTRODUCTION

In many companies line balancing plays an important role and should not be ignored in production process. If there is no line balancing in production process at the company then will be no smooth delivery of material work in process to the next department, so the waiting time (delay time) and bottleneck become worst.

PT. Mulia Knitting Factory as the oldest knitting textile company in Indonesia and export market, the company must responsive to market demand inquiry. Market share of PT Mulia Knitting Factory in Indonesia had reached 35% demand of T Shirt in Indonesia, and the T Shirt product are often familiar to as the R-223 product. R-223 has reached the highest number of order each month such as 205.704 pcs/bulan. It often causes the late delivery and bottleneck.

In this research just concentrates in R-223 product and using line-balancing method such as: Killbridge-Wester Heuristic, Helgeson-Birnie and Moodie Young. The best line-balancing method will reach the shorter cycle time and will increase the production efficiency

Theoritical

1. Line Balancing

According Gasperz (2000) line balancing is a balancing task assignment with work station elements in assembly line to minimize the amount of work station and minimize the total idle time on all stations for a certain level of output, which in this line balancing the processing time per unit of product at specified for each task and the sequential relationship should be considered [1].

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2. Kilbridge-Wester Heuristic Method

Kilbridge-Wester is a method designed by M.Kilbridge and L.Wester as another approach to overcome the problems of equilibrium line [2]. In this method, performed of grouping elements into groups that have the same level of connectedness. The steps used method Kilbridge-Wester is as follows:

a. Produce the*precedence diagram from the problems*.
b. Grouping the precedence from left to the right in coloumn area
c. Grouping elements in many ways to reach the best grouping which has a best or almost the same time with the cycle time.
d. If any elements of work station have no grouping yet and the grouping time is less the cycle time, continue to group with the element in the next precedence.
e. Continue the gouping process until all the elements get the group.

3. Helgeson-Birnie Method

More populas as the the Ranked Positional-Weight Technique because this technique using ranked to make group elements and suggested by Helgeson and Birnie [3]. The steps in this method are as follows [2]:

a. Create a precedence diagram for each process.
b. Determine the weight of the position for each element of work related to the operation time for the longest processing time from the beginning to the rest of the starting operation after operation.
c. Rank each processing element is based on the weight of the position in step 2. Workmanship which has the greatest weight is placed on the first rank.
d. Determine the cycle time (CT).
e. Select the operating element with utmost weight i, allocated to a work station. If still viable, time station (ST) <(CT), allocate operation with the next highest weight, but this location should not make time station> CT.
f. If the allocation of a station operating elements make time> CT, then the rest of the time (CT - ST) is filled with the allocation of the operating element with the greatest weight and the addition does not make ST <CT.
g. If the operating element that allocated to make ST <CT is not there, go back to step e.

4. Moodie Young Method

Moodie Young method has two stages of analysis. Phase (phase) of the work station is made by grouping matrix elements of the relationship between work, such methods are ranked not Helgeson-Birnie. Phase two, to revise the results of phase one [2].

Phase one: Elements of workmanship placed on successive work stations in assembly lines using Largest-candidate rules. Largest-candidate rule consists of the placement of the elements are there for the purpose of reduction of time. From here, when the two elements work enough to be placed in the station, one of which has a larger time placed first. After each element is placed, the availability of elements to be considered for the purpose of reduction of the value of time for the next assignment. For example, matrix P indicates precursor workmanship of each element and the matrix F workmanship followers for each element for each assignment procedure.

Phase two: In phase two, trying to distribute idle time (idle) evenly (same) for each station. The steps in step two is as follows:

a. Determine the two elements of the shortest and longest time of rebalancing phase one station.
b. Determine the half of differences between the two goal value

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c. GOAL = $(ST_{max} - ST_{min})/2$.
d. Determine single element in ST_{max} which is less than two goal value and not more than predecessor element
e. Deterimine all the possible exchange of $ST_{max}$with single element of ST_{min} which reducing ST_{max} and get ST_{min} will smaller than 2 x GOAL Value.
f. Perform onsite indicated by the candidate with the smallest absolute difference between the candidates with GOAL value.
g. If there is no exchange or transfer is possible between the largest and smallest station, seeking exchange between rank on the following work:: N (station N has ranked the greatest amount of idle time), N-1, N-2, N-3, …, 3, 2, 1.
h. If exchange is not possible, do the restrictions on the value of GOAL and repeat steps a to f.

Methodology

Flowchart applied in research can be seen in Figure 1.

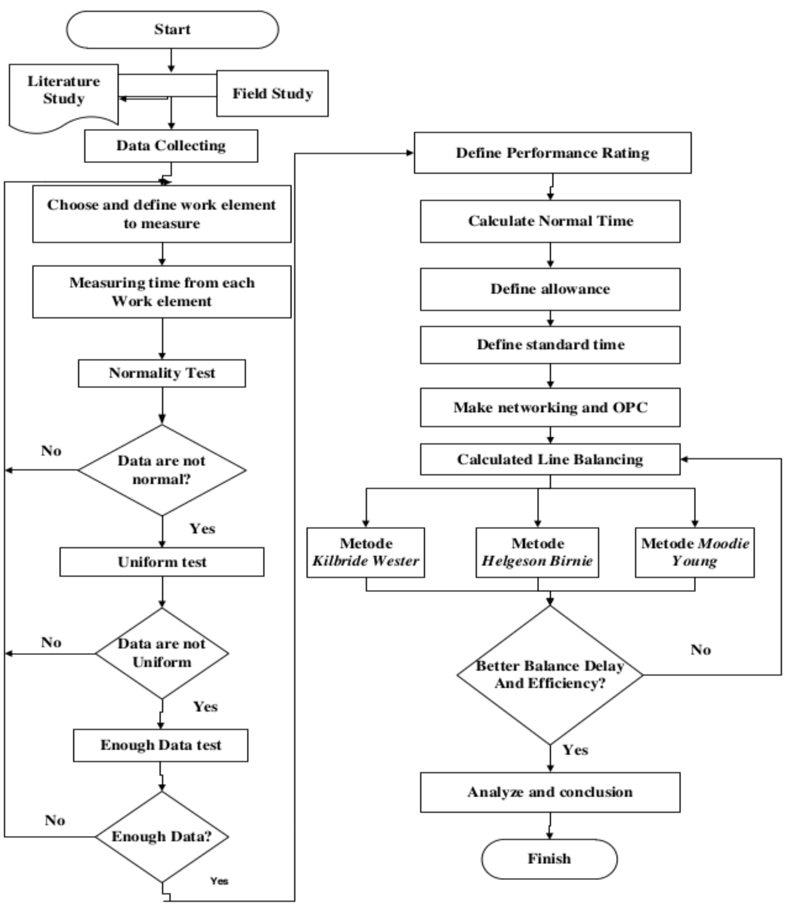

Figure 1. Reseach Flowchart

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Conducting research and direct interviews with workers at the plant has collected data. The data are taken base on the flow of production not only from fabric cutting division, sewing and packaging divisions, also data needed such as the motion time of each work elements, amount of work and the machine is used, the output at each piece and targets per day. If the company are not able to achieve the target, the balance line at the company level is very less.

Trying to apply the method of line balancing, take a few steps. The steps that should be performed include:

1. Collect data about the target output production each day and working hour per day.
2. Collect data about jobs, number or production, working time each elements in production.
3. Make the network of fabric cutting, sewing and packing.
4. Calculate the cycle time with below equation:

   $$\text{CT} = \frac{Working\ hour\ per\ year\ (second)}{Demand\ per\ year (pcs)}$$

   Calculate the minimal number of work elements (N) with equation:

   $$\text{N} = \frac{Total\ time\ of\ working\ element\ (second)}{cycle\ time\ (second)}$$

5. *Applying each line balance method, these three methods are used such as Kilbridge-Wester Heuristic methods, Helgeson-Birnie method and Moodie Young method*.
6. After all of the calculation from each method, calculate the line efficiency with equation[4]:

   $$\text{LE} = \frac{\Sigma TSi}{(K)(CT)} X\ 100\%$$

   Which:

   TSi = Work element time -i
   K = Total number of work element
   CT = Longest cycle time

7. Then calculated the balance delay (Balance Delay). Balance Delay is a measure of the inefficiency of the resulting trajectory of the actual time unemployed due to imperfect allocation between workstations. Balance Delay can be formulated as follows [4]:

   BD = 100% - LE

8. *Smoothness Index* is an index showing the relative smoothness of specific assembly line balancing. Furthermore Smoothness Index can be calculated by the formula:

   $$\text{SI} = \sqrt{\Sigma\ (TSi_{max} - TSi)^2}$$

9. This calculation results will be analyzed with the descriptive and the comparison with the original factory condition. So it can be applied to a method that improved its efficiency line of factory

COLLECTING AND ANALYZING DATA

1. Data Collection

Prime Data need to be analyze before making a line balancing calculation such as : develop work stations. The Networking in the Operating Process Chart could be found in Figure 2.

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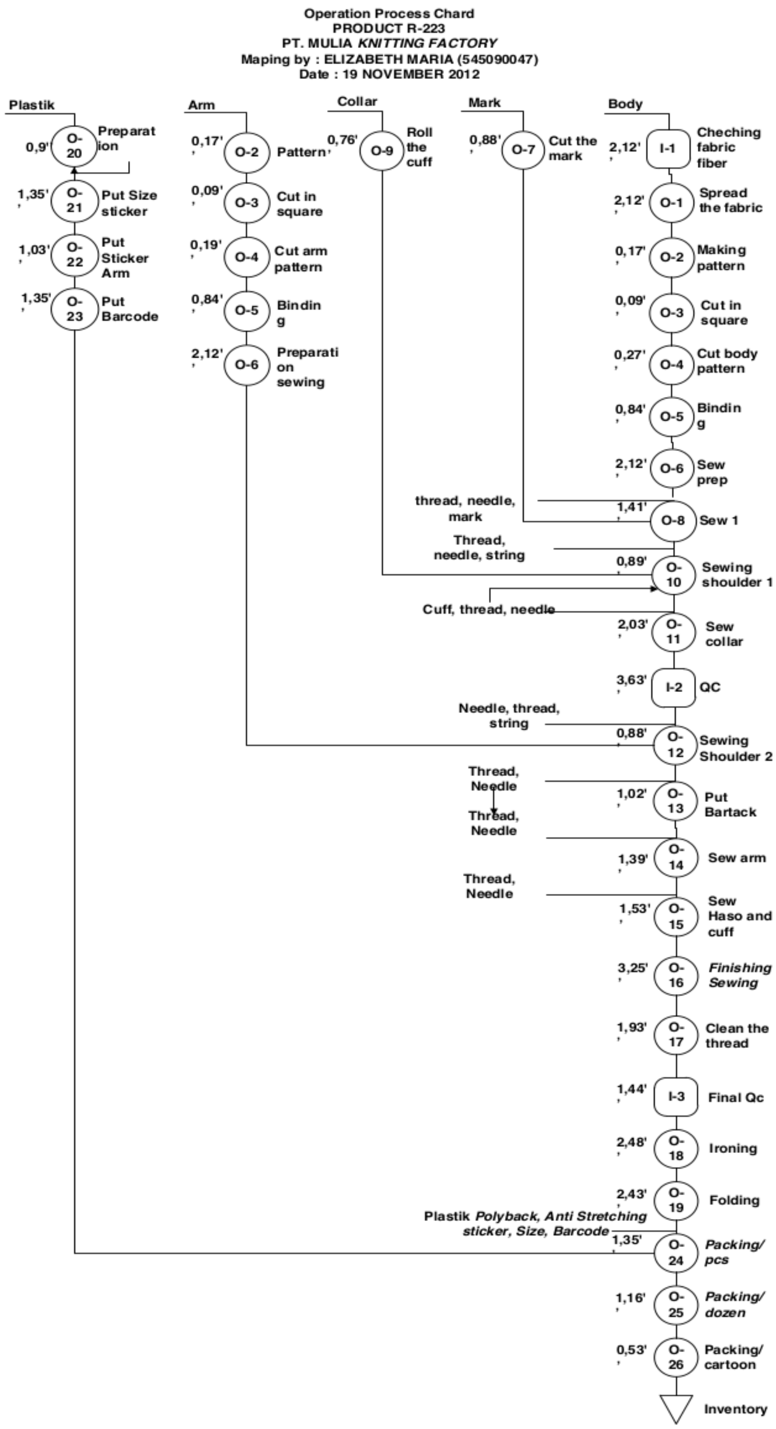

Figure 2. Operation Processing Chart R-223

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Time of each work element is obtained from the initial calculations motion time with normality test, uniformity test and adequacy of the data. Once the data is otherwise normal, pretty uniform and subsequent, then calculated normal time from standard time of each work element. Calculation the normal time and standard time as below equation [5]:

Normal Time = Average time measuremenet x *performance rating*

Standard time = Normal time (1+*Allowance*)

After getting the standard time for each work element, still need to calculate for each person and for each number of work in process as below table.

Table 1. Number of worker and number of work in process (pieces)

Element	Working/activity	Number people	Number part
1	Check the fabric fiber	4	1
2	Spread the fabric	2	126
3	Making pattern	1	126
4	Cutting fabric in square	1	126
5	Cutting body pattern	3	126
6	Binding	3	15
7	Prepare the sewing	1	3
8	Cutting mark	1	60
9	Check the fabric fiber	4	1
10	Spread the fabric	2	126
11	Making pattern	1	126
12	Cutting in square	1	126
13	Cutting arm pattern	3	126
14	Sewing cuff	9	3
15	Roll the cuff	1	504
16	Take plastic	4	7
17	Put Sticker*Size*	4	120
18	Put anti stretchy sticker	4	120
19	PutBarcode	4	120
20	Sew the mark	2	3
21	Sewing shoulder 1	3	3
22	Sewing collar	9	3
23	QC collar	2	3
24	Sewing shoulder 2	3	3
25	SewingBartack	2	3
26	Assembly the arm	16	3
27	Sewing Haso	5	3
28	Finishing	1	3
29	Clean from Yarn waste	11	1
30	Final QC	9	1
31	Ironing	13	1
32	Folding	8	1
33	Packing/Pcs	8	1
34	Packing/dozen	4	12
35	Packing/cartoon	4	12

Below table describe the average time, standard time for each element in networking, in table 2.

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Table 2. Standard time per pieces per work element

Element	Working/activity	Average time (second)	Standard time (second)	Standard time per *Pcs* (second)
1	Check the fabric fiber	3,46	4,42	1,10
2	Spread the fabring	30,49	36,79	0,14
3	Making pattern	47,08	64,67	0,17
4	Cutting fabric into square	9,35	12,06	0,09
5	Cutting body pattern	85,69	103,90	0,27
6	Binding	28,65	37,29	0,84
7	Prepare sewing	4,71	6,37	2,12
8	Cutting Mark	38,43	53,11	0,88
9	Checking fabric fiber	3,46	4,42	1,10
10	Spread the fabric	30,49	36,79	0,14
11	Making Pattern	47,08	64,67	0,17
12	Cutting fabric into square	9,35	12,06	0,09
13	Cutting arm pattern	60,48	73,33	0,19
14	Sewing the cuff	40,79	54,85	2,03
15	Roll the cuff	300,00	383,19	0,76
16	Take the plastic	16,80	23,69	0,90
17	Put size sticker	465,29	655,99	1,35
18	Put anti stretching sticker	425,20	599,47	1,03
19	Put Barcode	465,29	655,99	1,35
20	Sewing mark	6,14	8,49	1,41
21	Sewing shoulder 1	5,85	8,08	0,89
22	Sewing collar	40,95	55,06	2,03
23	QC collar	16,23	21,82	3,63
24	Sewing shoulder 2	5,77	7,97	0,88
25	Sewing Bartack	4,59	6,17	1,02
26	Assembly the arm	50,60	66,78	1,39
27	Sewing Haso	17,10	22,99	1,53
28	Finishing	7,22	9,76	3,25
29	Clean the yarn waste	18,19	21,26	1,93
30	Final Qc	10,45	12,97	1,44
31	Ironing	21,20	32,25	2,48
32	Folding	14,97	19,48	2,43
33	Packing/Pcs	7,45	10,85	1,35
34	Packing/dozen	38,94	55,68	1,16
35	Packing/cartoon	16,80	25,55	0,53

2. Data Calcuting

Cycle time has been calculated as below:

$$\text{Cycle time} = \frac{working\ hour\ per\ year\ (second)}{Demand\ R{-}223\ per\ year\ (pcs)} = \frac{7.509.600}{1.800.000} = 4{,}17 \text{ second}$$

According to Kusnadi (2009), the cycle time is defined as the time required to produce one unit of product, in this case determined from the longest process (bottleneck), whether it is human or machine work. This will determine of each method, the value of the cycle time to be obtained.

Total time is obtained from the sum of the work station tray time of some element of work in accordance with the method with respect to each work station so that the total

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time exceeds the cycle time none were used in the amount of 4.17 seconds. Division of the work done by the station Kilbridge-Wester Heuristic methods can be seen in Table 3.

Table 3. Grouping work element by Kilbridge-Wester Heuristic Method

Work Station	Work Element	Standard Time(second)	Total Work Station time(s)
1	1	1,10	3,84
	8	0,88	
	9	1,10	
	15	0,76	
2	16	0,90	4,08
	2	0,14	
	10	0,14	
	17	1,35	
	3	0,17	
	11	0,17	
	18	1,03	
	4	0,09	
	12	0,09	
3	19	1,35	2,65
	5	0,27	
	13	0,19	
	6	0,84	
4	14	2,03	4,15
	7	2,12	
5	20	1,41	2,30
	21	0,89	
6	22	2,03	2,03
7	23	3,63	3,63
8	24	0,88	3,29
	25	1,02	
	26	1,39	
9	27	1,53	1,53
10	28	3,25	3,25
11	29	2,93	3,37
	30	1,44	
12	31	2,48	2,48
13	32	2,43	3,78
	33	1,35	
14	34	1,16	1,69
	35	0,53	

Kilbridge-Wester Heuristic methods calculated efficiency of line balancing is obtained by an average of 72.40% with 14 work stations of the early work stations 35 stations and station longest time of 4.15 seconds.

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Tabel 4. Grouping work elementby Helgeson-Birnie Method

Work Station	Working Element	Std Time (second)	Total Work station time (second)
1	1	1,10	2,61
	2	0,14	
	3	0,17	
	4	0,09	
	5	0,27	
	6	0,84	
2	7	2,12	3,00
	8	0,88	
3	20	1,41	2,30
	21	0,89	
4	22	2,03	2,03
5	23	3,63	3,63
6	9	1,10	2,45
	15	0,76	
	10	0,14	
	11	0,17	
	12	0,09	
	13	0,19	
7	14	2,03	3,93
	24	0,88	
	25	1,02	
8	26	1,39	2,92
	27	1,53	
9	28	3,25	3,25
10	29	1,93	3,37
	30	1,44	
11	31	2,48	2,48
12	32	2,43	3,33
	16	0,90	
13	17	1,35	3,73
	18	1,03	
	19	1,35	
	33	1,35	
14	34	1,16	3,04
	35	0,53	

By Helgeson-Birnie method calculation about efficiency of line balancing reached 76.46% with 14 work stations of the early work stations 35 stations and the longest time was 3.93 second station

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Tabel 5. Grouping Working station by Metode Moodie Young Method

Work Station	Work Element	Std Time (second)	Total Work Station time (second)
1	1	1,10	2,61
	2	0,14	
	3	0,17	
	4	0,09	
	5	0,27	
	6	0,84	
2	7	2,12	3,00
	8	0,88	
3	20	1,41	2,30
	21	0,89	
4	22	2,03	2,91
	24	0,88	
5	23	3,63	3,63
6	25	1,02	3,19
	15	0,76	
	9	1,10	
	10	0,14	
	11	0,17	
7	12	0.09	3,70
	13	0,19	
	14	2,03	
	26	1,39	
8	27	1,53	1,53
9	28	3,25	3,25
10	29	1,93	3,37
	30	1,44	
11	31	2,48	2,48
12	32	2,43	3,33
	16	0,90	
13	17	1,35	3,73
	18	1,03	
	19	1,35	
14	33	1,35	3,04
	34	1,16	
	35	0.53	

By Moodie Young methods, calculation about efficiency of equilibrium trajectories obtained of an average of 80.56%, 14 of the work station and the longest time of 3.73 seconds.

RESULT AND ANALYSIS

The data processing has been done can be seen by comparing the calculated and the method can be seen in Table 6.

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Table 6. Comparison between Initial Line, *Kilbridge-Wester Heuristic*, *Helgeson-Birnie* and *Moodie Young*

Comparison Method	Initial	*Kilbridge Wester*	*Helgeson-Birnie*	***Moodie Young***
Line Efficiency(%)	33,11	72,40	76,46	80,56
Balance Delay (%)	66,89	27,59	23,53	19,43
Smoothness Index	232,63	5,33	4,02	3,49
Cycle Time (second)	4,17	4,15	3,93	3,73
Number of Work Station	35	14	14	14
Total Idle Time (second)	84,98	16,12	12,95	10,15

From the results of the calculations by Young Moodie method gives the highest efficiency line. Comparing to the initial conditions by 33.11% to 80, 56% of this meant an increase of 47.45%. In addition to Young Moodie value method balance delay and smoothness index produces the smallest value and gives a good result.

CONCLUSION

Moodie Young method has a better line balancing method when compared with the Kilbridge-Wester Heuristic method and Helgeson-Birnie method. Moodie Young method can produce the best line efficiency of the factory is equal to 80.56% compared to the initial line efficiency of 33.11%. Moodie Young method is able to provide new workstation and minimize the cycle time from 4.17 seconds to 3.73 seconds. The number of workstations reduces from 35 workstations to 14 workstations and reduces work balance delay value from 66.89% to 19.43%. That means a more balanced equilibrium line. With Moodie Young method also produces smoothness index value of 3.49 and the best idle time at the factory changed from 84.98 seconds to 10.15 seconds.

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