Analysis Line Balancing at Moslem Clothing Producer
Case Study: X Convection

Mokh. Adib Sultan, Chairul Furqon and Winda L. Putri
Faculty of Economic and Business Education, Universitas Pendidikan Indonesia, Bandung, Indonesia
{adiebsultan, c_furqon}@upi.edu, windalies@gmail.com

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Abstract: X Convection is a moslem clothing producer which the production process determined by orders. X Convection has to increase the output of the production to follow market demand. On the other side, the convection has limited capacity to supply it. The problem arises due to the imbalance of line production in the Convection. The aims of line balancing implementation are to understand the current line production, to understand the advantage of line balancing towards the current line production, and to understand the optimal labours as to reach target production. Based on the matters, the use of line balancing method is to measure standard time and arrange flow of production process on each line. The heuristic method is used in this study, namely *Large Candidate Rules*, *Region Approach*, and *Ranked Positional Weight*. Based on heuristic method, the highest line efficiency is 65.03% and balance delay 34,97% with the use of *Large Candidate Rules (LCR)* approach. The results indicate that [1)] The most optimum of line balancing method is LCR which turns out the alteration in the number of work stations from 5 to 4 work stations and [2)] the change of labour allocation.

1 INTRODUCTION

X Convection is a private company located in Cigadung, Bandung. Muslim clothing are produced by X convection, including dress and koko. Production system is conducted by orders or known as made by order. In a month, X convection is able to produce over 600 pieces which are done by five workers. To produce one piece of dress, it takes about two hours through several stages of the production process for marking, cutting, machine hemming, sewing, ironing, mounting accessories/pairing of studs, controling quality (qc), steaming and packing.

In the process, the production process are divided into five work stations, which are work station 1 for marking and cutting, work station 2 for machine hemming 1 and sewing 1, work station 3 for ironing, sewing 2, and machine hemming 2, work stations 4 for pairing of studs and qc, and work station 5 for steaming and packing.

In practice, any organization or certain business are faced particular problems or obstacles. Similarly, experienced by X convection. The main problem in this convection is not achieving the production targets. It is influenced by many things.

Prior to the study, the researchers are conducted a pre-study and discovered the phenomenon that indicated the problem of line balancing in X convection, namely the existing of idle time, the hoarding of the product on several work stations (bottleneck), and the waiting time caused by the product retained on previous work station (starfing). These things are the factors which cause the X convection could achieve companies' target production.

Based on that phenomenon, it is necessary to plan a strategy to produce a decision to achieve efficiency of production processes. One of them is the decision regarding the layout. To produce an effective layout, line balancing analysis can be used as analysis method. There are several approaches in line balancing, such as heuristic methods (Kholil and Mulya, 2014).

The problems experienced by X convection can be solved by using the method of line balancing, heuristic approach. With the application of line balancing is done, it is expected Convection X can streamline production lines and increase production output.

Pursuant to the problems that occurred in Convection X, the purpose of this study is to optimalize production process by using line balancing analysis method.

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2 LITERATURE REVIEW

Line balancing is a method for balancing tasks in each work stations to minimize the number of work stations and the number of idle time.

There are several terms to calculate line balancing as follows (Kholil and Mulya, 2014).

- Presedence Diagram
  Presedence diagram is a graphical representation of the sequence of work operations and the dependency on other work operations.
- Assemble Product
  Assemble product is the product that passes through the work station.
- Work Element
  Work element / work operation / task / is part of the whole assembly process that is undertaken
- Operating Time (Ti) and Time Standard (Wb)
  Operating time is the time standard for completing an operation which is including and considering adjustment and allowance factors. In this research, both factors are not included in the calculation, so the time standard (Wb) is equal to the normal time (Ws).
- Station Time (SI)
  Station time is the amount of time of work elements or tasks completed at the same work station. Wti<Ws
- Average time of work station ($\overline{\overline{Wt}}$)
  ($\overline{\overline{Wt}}$) = $\frac{\sum Wti}{N}$
- Work Station (K)
  Work station is a place on the assembly line where the assembly process is performed. After determining the cycle time then the number of efficient work stations can be determined by dividing the total amount of the work time of each element with cycle time as follows.
  K min = $\frac{\sum Wti}{Ws}$
- Cycle Time (CT)
  Cycle time is the maximum time allowed to complete every task on each work station.
  To calculate line production performance, there are some parameters or indicators that can be used to measure performance of assembly line (Elsayed and Boucher, 1994; in Azwir and Pratomo, 2017).
- Line Efficiency (LE)
  $$LE = \frac{\sum_{i-1}^{k} Wti}{(K)(Ws)} x\ 100\% \qquad (1)$$
- Balance Delay (BD)
  $$BD = \frac{(K)(Ws) - \sum_{i-1}^{k} Wti}{(K)(Ws)} x\ 100\% \qquad (2)$$
- Smoothness Index (SI)
  $$SI = \sqrt{\sum_{i-1}^{k} (Ws - Wti)^2} \qquad (3)$$
- Idle Time
  $$\text{Idle Time} = (K)(Ws) - \sum_{i-1}^{k} Wti \qquad (4)$$

In line balancing, there are three basic methods commonly used in line balancing analysis, such as mathematical method, probability method, and heuristic method (Kholil dan Mulya, 2014). In this study, heuristic method is used to analyze production process without special tools are needed for calculating. This methods are consist of Large Candidate Rules (LCR), Region Approach (RA), and Ranked Positional Weight (RPW) (Saiful and Rahman, 2014).

3 RESEARCH METHOD

This study is included as descriptive analysis used line balacing analysis. The target population of this study is line production activity for ‘A’ dress model and the number of sampling as many as 1 batch production.

The research stages can be illustrated in the research methodology as in Figure 1 in Appendix.

4 RESULTS AND DISCUSSION

Based on observations, there are several conditions found, such as number of cycle, production line process, and the number of efficiency. In Table 1, It shows that to produce one dress, it takes around 55,8 minutes which known as one cycle.

Table 1: Calculation of time standard.

Work Stations	Number of Work Element	Work Element	Time Standard (Minutes)
1	1A	Marking	2,65
	1B	Cutting	4,33
2	2C	Obras 1	1,53
	2D	Sewing 1	21,45
3	3E	Ironing	0,58
	3F	Sewing 2	10,23
	3G	Obras 2	3,27
4	4H	Pairing of studs	3,12
	4I	QC	3,85
5	5J	Steaming	3,75
	5K	Packing	1,05
Total			55,8

The calculation of Table 1 can be described in presedence diagram as seen on Figure 2.

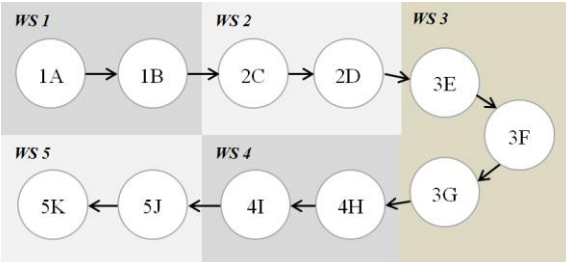

Figure 2: Current presedence diagram.

From the table and presedence diagram, the current work stations performance can be calculated by parameters of line balancing, such as idle time, efficiency, balance delay, and smoothness index. Table 2 shows perfomance of current work stations.

Table 2: Current work stasions.

Work Stations	Number of Work Element	Idle Time	Efficiency	Balance Delay
1	1A	347,35	32,52%	67,48%
	1B			
2	2C	-36,67	107,12%	-7,12%
	2D			
3	3E	176,83	65,65%	34,35%
	3F			
	3G			
4	4H	347,55	32,48%	67,52%
	4I			
5	5J	399,68	22,36%	77,64%
	5K			
Total		1234,75	52,03%	47,97%
Smoothness Index		658,64		

As seen on Table 2, it is obtained that the number of idle time is equal to 1234,75 minutes, line efficiency 52,03%, balance delay 47,97%, and the smoothness index 658,64.

To reach the best performance can be done by calculation of work station proposal based on line balancing method of heuristic approach, which large candidate rules, region approach, and ranked positional weight.

First, Large Candidat Rules Approach (LCR) is calculated by time element (te) whether the number of sequence of processing time as seen in Tabel 3.

Table 3: The sequence of work element based on Te.

No.	Number of Work Element	Work Element	Time Standard (Minutes)
1	2D	Sewing 1	21,45
2	3F	Sewing 2	10,23
3	1B	Cutting	4,33
4	3H	QC	3,85
5	5J	Steaming	3,75
6	3G	Obras 2	3,27
7	4I	Pairing of studs	3,12
8	1A	Marking	2,65
9	1C	Obras 1	1,53
10	5K	Packing	1,05
11	3E	Ironing	0,58
Total			55,8

The sequence of the tabel above is an ideal task by LCR appoach, yet it cannot be applied to production line because there are some unflexible tasks which cannot be changed easily. So that, the sequence of work operations can be seen on Table 4.

Table 4: Proposed work station based on large candidat rules approach.

Work Stations	Number of Work Element	Idle Time	Efficiency	Balance Delay
1	1A	296,70	42,36%	57,64%
	1B			
	2C			
	3E			
2	2D	0	100%	0%
3	3F	190,82	62,93%	37,07%
	3G			
4	4I	232,46	54,84%	45,16%
	4H			
	5J			
	5K			
Total		719,98	65,03%	34,97%
Smoothness Index		422,47		

In Table 4, the result shows that WS 2 is the most efficient work station because it did not have idle time and balance delay. By using LCR, total number of idle time, balance delay, and smoothness index will be decreased while line efficiency will be increased.

It indicates that to get this line balancing, work element 2C should be moved from WS 2 to WS 1 and 3E from WS 3 to WS 1, so the efficiency could be achieved.

Then, the second method in line balancing is Region Approach (RA) which the calculation count by dividing work networking region from left to right based on work position in presedence diagram.

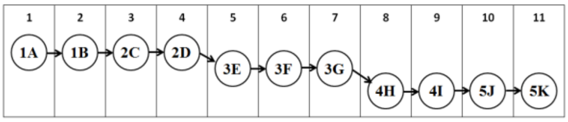

Figure 3 : Dividing work networking region.

After obtaining a sequence of work operations based on the division of the region, then the proposed work station can be calculated as Table 5.

Table 5: Proposed work station based on region approach.

Work Stations	Number of Work Element	Idle Time	Efficiency	Balance Delay
1	1A	310,68	39,65%	60,35%
	1B			
	2C			
2	2D	0	100%	0%
3	3E	176,83	65,65%	34,35%
	3F			
	3G			
4	4H	232,46	54,84%	45,16%
	4I			
	5J			
	5K			
Total		719,98	65,03%	34,97%
Smoothness Index		426,42		

The result from using RA method shows that WS 2 is the most efficient work station because of idle time and balance delay did not occur. By applying RA, total number of idle time, balance delay, and smoothness index will be decreased while line efficiency will be increased.

Some changes need to be applied to get this efficiency which are moving out work element 2C from WS2 to WS1, and merging WS 5 to WS4.

As for the last, the third approach is Ranked Positional Weight (RPW) method which generated the calculation of positional weight of work element. The following matrix of positional weight from each work element can be seen in Figure 4.

Previous Operations	1A	1B	2C	2D	3E	3F	3G	4H	4I	5J	5K	Wb (Minutes)	Total Weight
	Operation Process												
1A	0	1	1	1	1	1	1	1	1	1	1	2,65	55,8
1B	0	0	1	1	1	1	1	1	1	1	1	4,33	53,2
2C	0	0	0	1	1	1	1	1	1	1	1	1,53	48,8
2D	0	0	0	0	1	1	1	1	1	1	1	21,45	47,3
3E	0	0	0	0	0	1	1	1	1	1	1	0,58	25,9
3F	0	0	0	0	0	0	1	1	1	1	1	10,23	25,3
3G	0	0	0	0	0	0	0	1	1	1	1	3,27	15,0
4H	0	0	0	0	0	0	0	0	1	1	1	3,12	11,8
4I	0	0	0	0	0	0	0	0	0	1	1	3,85	8,7
5J	0	0	0	0	0	0	0	0	0	0	1	3,75	4,8
5K	0	0	0	0	0	0	0	0	0	0	0	1,05	1,1

Figure 4 : Matrix of positional weight of work element.

Based on the calculation of positional weight of work element on the Figure 4, it is obtained that the sequence of work element can be seen as Tabel 6.

Table 6: The sequence of work element based on positional weight.

Number of Work Element	Work Element	Weight	Time Standard (Minutes)	Previous Work Element
1A	Marking	56	2,65	0
1B	Cutting	53	4,33	1
2C	Obras 1	49	1,53	2
2D	Sewing 1	47	21,45	3
3E	Ironing	26	0,58	4
3F	Sewing 2	25	10,23	5
3G	Obras 2	15	3,27	6
4H	Pairing of studs	12	3,12	7
4I	QC	9	3,85	8
5J	Steaming	5	3,75	9
5K	Packing	1	1,05	10

As seen on Table 6, line balancing performance by RPW method can be calculated as follows (Table 7).

Table 7: Proposed work station based on ranked positional weight approach.

Work Stations	Number of Work Element	Idle Time	Efficiency	Balance Delay
1	1A	310,68	39,65%	60,35%
	1B			
	2C			
2	2D	0	100%	0%
3	3E	176,83	65,65%	34,35%
	3F			
	3G			
4	4H	232,46	54,84%	45,16%
	4I			
	5J			
	5K			
Total		719,98	65,03%	34,97%
Smoothness Index		426,42		

In Table 7, by using RPW method, It is shows that WS 2 is the most efficient work station because it did not have idle time and balance delay. By implementing RPW, total number of idle time, balance delay, and smoothness index will be decreased while line efficiency will be increased.

The position of work element in work station by RPW approach as same as by RA which are moving out work element 2C from WS2 to WS1, and merging WS 5 to WS4.

After calculating performance of line balancing by using Large Candidate Rules, Region Approach, and Ranked Positional Weight, it shows that every approaches has different results from the current work station. These result can be compared as seen on Table 8.

Table 8: Comparation of current work station and proposed work station by heuristic methods.

Performance	Current Condition	Large Candidate Rules	Region Approach	Ranked Positional Weight
Number of Work Station	5	4	4	4
	WS 1 1A, 1B WS 2 2C, 2D WS 3 3E, 3F, 3G WS 4 4H, 4I WS 5 5J, 5K	WS 1 1A, 1B, 2C, 3E WS 2 2D WS 3 3F, 3G WS 4 4H, 4I, 5J, 5K	WS 1 1A, 1B, 2C WS 2 2D WS 3 3E, 3F, 3G WS 4 4H, 4I, 5J, 5K	WS 1 1A, 1B, 2C WS 2 2D WS 3 3E, 3F, 3G WS 4 4H, 4I, 5J, 5K
Idle Time	1234,75	719,98	719,98	719,98
Line Efficiency (LE)	52,03%	65,03%	65,03%	65,03%
Balance Delay (BD)	47,97%	34,97%	34,97%	34,97%
Smoothness Index (SI)	658,64	422,47	426,42	426,42

In table 8, it shows that large candidate rules generated the best performance among others. It has the smallest number of smoothness index which is the number of SI has decreased up to 236,17 point while RA and RPW only decreased up to 232,22 point.

On the other side, all these heuristic methods have the same number of idle time, line efficiency, and balance delay. By looking the current condition of work station, the number of idle time has decreased up to 514,77 minutes and also balance delay that has decreased up to 13% whereas the number of line effiency has increased up to 13%.

Therefore, the design of work station by LCR approach is choosen as recomendation work station as follows in the presedence diagram below.

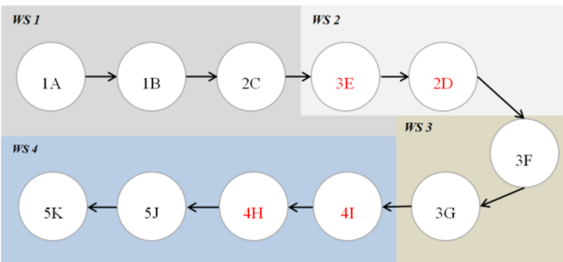

Figure 5 : Presedence diagram of recomendation work station.

After obtaining the best design of work station, then calculating for allocation of labor as follows (Table 9).

Table 9: Calculation of labor's allocation.

Work Stations	Work Element	Unit/ Month/ Labor	Demand per Month	Quantity of Cumulative Labor Needs	Roun-ding Up
1	Marking	3968,50	600	0,52	1
	Cutting	2425,02	600		
	Obras 1	6872,73	600		
	Ironing 1	18021,45	600		
2	Sewing 1	489,54	600	1,23	2
3	Sewing 2	1026,76	600	0,77	1
	Obras 2	3209,51	600		
4	Qc	2727,27	600	0,67	1
	Pairing of studs	3365,38	600		
	Steaming	2800,00	600		
	Packing	10046,52	600		

In Table 9, it is seen that company should have 5 persons to fill the work stations, which are distributed in work station 1 as many as 1 person, work station 2 as many as 2 person, work station 3 as many as 1 person, and work station 4 as many as 1 person. This allocation is the ideal number of labor. So, in Table 10, it can be seen recomendation allocation of labor to achieve an effiency production line.

Table 10: Recomendation allocation of labor.

Work Station	Work Element	Current Labor	Recomendation Labor	Info.
1	Marking	1	1	-
	Cutting			
	Obras 1			
	Ironing 1			
2	Sewing 1	1	2	-1
3	Sewing 2	1	1	-
	Obras 2			
4	Qc	2	1	+1
	Pairing of studs			
	Steam			
	Packing			

Table 10 shows that work station 2 was lack of labor while work station 4 was excesse of labor, so it is necessary to change the allocation of labor, namely the transfer of labor positions from work station 4 into work station 2 as many as 1 person.

5 CONCLUSIONS

Based on the analysis of the discussion in the previous part, there are several conclusions. First, the current production line is not effective, so the company has to do some changes. The results show that company should reduce the number of work station from 5 to 4. Second, the calculation based on the time standard and the number of requests in every month, company need to make changes of the structure of labor as many as one person, from work station 4 to work station 2. By applying several changes, the company may increase the number of production as well as reach the target production.

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APPENDIX

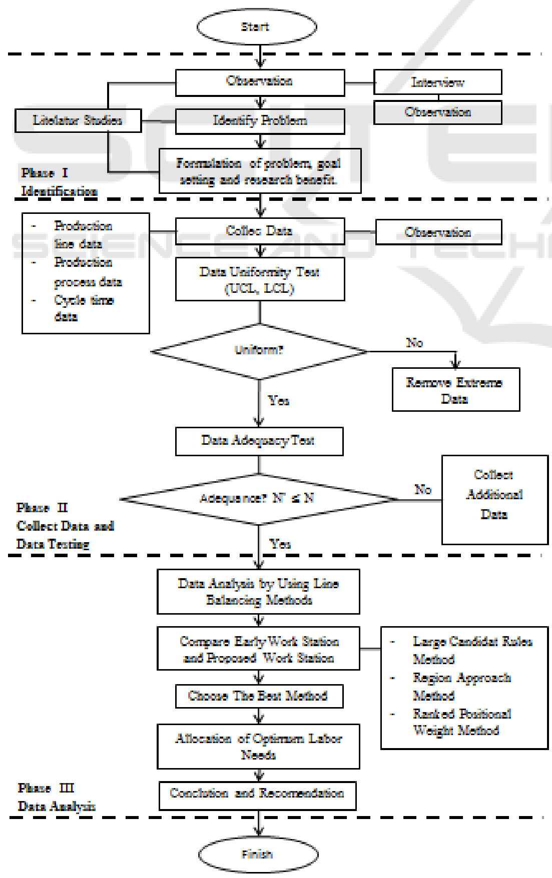

Figure 1: Research methodology.