JURNAL IPTEK
MEDIA KOMUNIKASI TEKNOLOGI
homepage URL : ejurnal.itats.ac.id/index.php/iptek

Increased Production and Assembly Efficiency of Electronic Products with Yamazumi Diagrams and Heuristic Methods

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ARTICLE INFORMATION

Jurnal IPTEK – Volume 26 Number 2, December 2022

Page:
91 – 98
Date of issue :
December 30, 2022

DOI:
10.31284/j.iptek.2022.v26i2.2818

ABSTRACT

The Manufacturing Industry is one of the important sectors, over time, the competition is increasing where to stay afloat; it must be able to provide satisfaction to customers with the required product development, efficient production, and good quality. Electronic Manufacturing Service (EMS) companies compete on quality, cost, and customer satisfaction. In the case study, the company tried to meet customer demand with a production capacity of more than 2,000 units per day, a line balancing calculated using the Yamazumi Diagram and several heuristic methods, namely the Largest Candidate Rule (LRC), Kilbridge and Wester Column (KWC), and Ranked Positional Weight (RPW). The most optimal results were obtained with the LCR which can reduce 1 workstation, increase production by 546 units to 2,182 units per day, and increase the efficiency of the assembly line balance by 25%.

Keywords: *ems; heuristic; balancing; yamazumi.*

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ABSTRAK

Industri Manufaktur merupakan salah satu sektor yang penting, seiring waktu persaingan semakin meningkat dimana untuk tetap bertahan harus bisa memberikan kepuasan kepada pelanggan dengan pengembangan produk yang dibutuhkan , produksi yang efisien, dan kualitas yang baik. Perusahaan jasa perakitan produk elektronik bersaing dalam kualitas, biaya dan kepuasan pelanggan. Dalam studi kasus yang diangkat perusahaan berusaha untuk memenuhi permintaan pelanggan dengan kapasitas produksi diatas 2,000-unit perhari dilakukan perhitungan jalur keseimbangan dengan menggunakan Diagaran Yamazumi dan beberapa metode *heuristic* yaitu *Largest Candidate Rule (LRC), Kilbridge and Wester Column (KWC),* dan *Ranked Positional Weight (RPW).* Hasil yang paling optimal didapatkan dengan *LCR* dimana mampu mengurangi 1 stasiun kerja, meningkatkan produksi sebesar 546 unit menjadi 2,182 unit per hari, serta meningkatkan effisiensi keseimbangan jalur perakitan sebesar 25%.

Kata kunci: *Diagram Yamazumi; keseimbangan jalur; Metode Heuristic; Perusahaan jasa perakitan elektronik.*

PUBLISHER

LPPM- Institut Teknologi Adhi Tama Surabaya
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Jl. Arief Rachman Hakim No.100,Surabaya 60117,
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INTRODUCTION

The manufacturing industry is one of the important industrial sectors and has a significant influence on the growth of a country. Increasing competition between products requires effort from the company to provide satisfaction to customers[1] and fulfill customer needs[2]. Manufacturing companies in their operations are under great pressure on competitiveness and are looking for ways to utilize their resources more efficiently[3], and carry out product development, of better quality[5]. The industrial revolution encourages quality improvement with digitalization[6] and more advanced technology, especially in engineering in the manufacturing industry. The balance of the assembly line has a crutialrole in increasing process efficiency[7] and increasing the average number of productions[8].

All manufacturers including producers in the electronics industry also experience the same thing. The electronics industry has faced fierce competition among competitors on product variety, high production volume, product quality and cost. Due to the intense competition, all electronics industries have to come out with solutions to stay on their best performance[9]. The electronics assembly industry which is part of the manufacturing industry faces challenges related to workstations on its production line. Several cases occur where work stations experience bottlenecks and product buildup for processing and there are work stations with long waiting times[10].

In today's era, many industries choose to do core business and carry out the assembly process or outsource to vendors. For product owners, outsourcing of production to external sources has a significant effect on how manufacturing companies develop, produce, and deliver products to their customers[11]. This research raises a case study on one vendor of an electronic product assembly company in Indonesia. This research is exciting because the amount of daily production is still below the target set by the Production Planning and Inventory Control (PPIC) section to meet consumer needs, which is 2,000 units per day (14.4 seconds tack time per station). One day in the operation of the assembly company is 8 hours of work and by using 11 workstations. If the company cannot produce 2,000 units of assembly per day, the sales momentum will be lost, and consumers will move or share the assembly of the product with competitors.

The purpose of this study is to provide regulatory recommendations to be able to meet or even exceed the production targets set by the company with the most optimal use of resources. The problem faced is that there is a work process that should not be combined with other work processes, so this of course can reduce the options for setting production stations. In general, balanced assembly line planning can result in optimal processes and maximize productivity. There are 3 main heuristic assembly line planning techniques, namely the Largest Candidate Rule (LRC), Kilbridge and Wester Column (KWC), and Ranked Positional Weight (RPW) and the use of Yamazumi Diagrams.

LITERATURE REVIEW

The line balance efficiency is obtained by dividing the total cycle time by the multiplication between the number of work stations and the longest work station time[13]. The balance of the assembly line to get production output with the smallest delay time where previously made a priority diagram which is a visualization of work priority data[13], namely elements that must be done first before other elements[14].

In the LCR method, the work elements are arranged in descending order according to the time of the work elements. The KWC method selects work elements for assignment to workstations according to their position in the priority diagram. This overcomes one of the difficulties with the LCR rule where an element can be selected because of the element's high working time but regardless of its position in the priority diagram. Finally, the RPW method was introduced by Helgeson and Bernie in 1961, considering the time of the work elements and their position in the priority diagram. All of these methods are heuristic.

METHOD

Heuristic meaning that they are based on common sense and experimentation rather than mathematical optimization[14] and Yamazumi Diagrams as a visual presentation that makes it easy to monitor working time on all work stations[12]. The research began by collecting data from companies related to the product assembly process. The data collected is initial assembly configuration data, processing time data for each work element, priority data between work elements and special conditions of work elements if any. The overall research flow is shown in the flow chart in Figure 1.

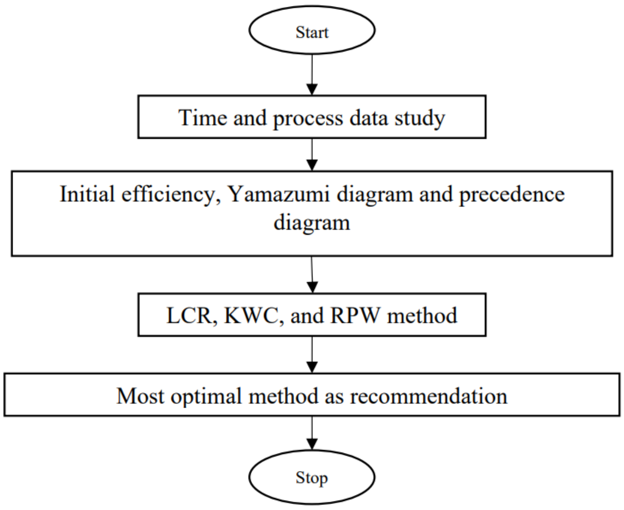
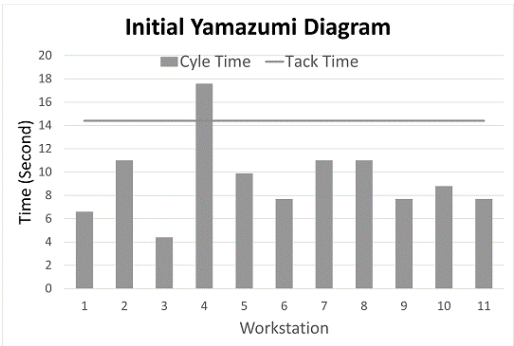


Figure 1. Flowchart of Research Flow

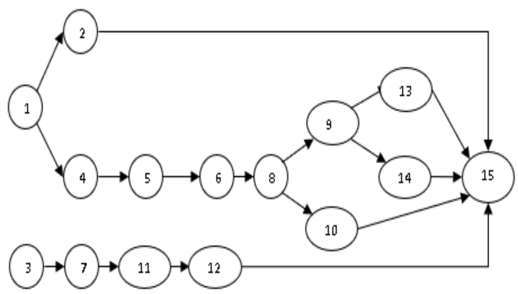
The initial data from the company is shown in Table 1, so that the working time of each workstation and the number of stations is obtained, the total production is 1,636 per day, the efficiency is 53% and the initial Yamazumi diagram and precedence diagram are as in Figures 2a and 2b.

Table 1. Initial Data for the Preparation of Work Stations and Cycle Times

Workstation	Working Element	Working Element Description	Cycle Time (Second)	Precedence
1	1	Main PCB check	3.3	
	2	Install Waterproof label	3.3	1
2	3	Install cover protection	11.0	
3	4	Instal Front Camera	4.4	1
4	5	Install conductive foam	8.8	4
	6	Install rear camera assy	8.8	5
5	7	Install FPC speaker	9.9	3
6	8	Install Shield Copper Foil	7.7	6
7	9	install coaxial	6.6	8
	10	Print PID	4.4	8
8	11	Install Side key FPC+Press	11.0	7
9	12	Install Camera Seal Rubber	7.7	11
10	13	Install Sensor Rubber	2.2	9
	14	Termal Gel attachment	6.6	9
11	15	Install Main PCB + Screw	7.7	2,10,12,13,14
		Total	103.4	



(a)



(b)

Figure 2. a) Initial Yamazumi Diagram, b) Precedence Diagram.

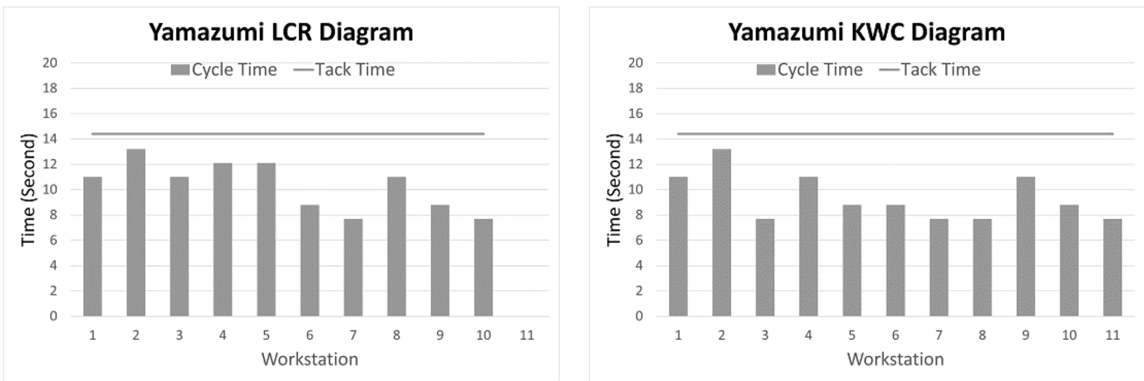
RESULTS AND DISCUSSION

Largest Candidate Rule (LCR) Method

The steps in this method are as follows: (i) assigning elements to workers at the first workstation by starting from the top of the list and selecting the first element that satisfies the priority requirements and does not cause the total amount of work element time of that workstation to exceed the allowable tack time; (ii) when no more elements can be supplied without exceeding the takt time, then proceed to the next station; (iii) repeat steps 1 and 2 for as many additional workstations as necessary until all elements have been defined and the results of the workstation settings in Table 2a and the Yamazumi diagram in Figure 3a are obtained defined [14].

Table 2. Work station settings LCR method and KWC method

Workstation	LCR method		KWC method	
	Working Element	Cycle Time (Second)	Working Element	Cycle Time (Second)
1	3	11.0	3	11.0
2	7	9.9	1	3.3
	1	3.3	7	9.9
3	11	11.0	4	4.4
4	12	7.7	2	3.3
	4	4.4	11	11.0
5	5	8.8	5	8.8
	2	3.3	6	8.8
6	6	8.8	12	7.7
7	8	7.7	8	7.7
8	9	6.6	9	6.6
	10	4.4	10	4.4
9	14	6.6	14	6.6
	13	2.2	13	2.2
10	15	7.7	15	7.7
	Total	**103.4**		**103.4**

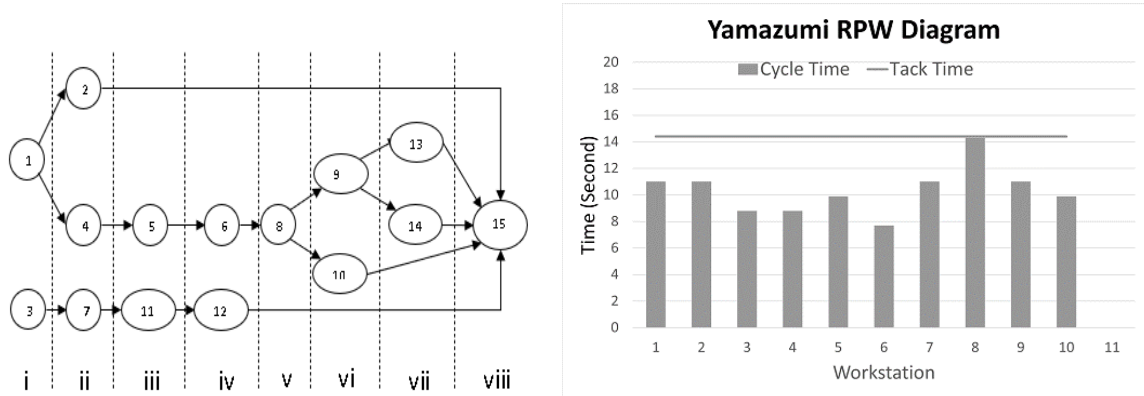


(a) (b)

Figure 3. Yamazumi diagram a) RCL method, b) KWC method

Killbridge and Wester Column (KWC) Method

In this method, the work elements on the priority diagram are arranged into columns as shown in Figure 4a. Elements can then be organized into lists by column, with the elements in the first column listed first. The LCR method has been applied to each column, this is useful when assigning elements to stations, as it ensures that the larger element is selected first, thereby increasing the possibility of making the amount of work element time at each station closer to the allowable tack timeout. After the list was created, the same three-step procedure was used as before[14] and the results of the workstation setup in Table 2b and the Yamazumi diagram in Figure 3b were obtained.



(a) (b)

Figure 4. a) Column arrangement of KWC method, b) Yamazumi diagram of RPW method.

Ranked Positional Weight (RPW) Method

In Specifically, the RPW is calculated by adding up the time of the work element and all other times for the element that follows the time of the work element in the arrow chain of the priority diagram. Elements are compiled into a list according to their RPW values, and the algorithm continues using the same three steps as before[14] and obtains the workstation setup results in Table 4 and the Yamazumi diagram in Figure 4b.

Table 3. RPW Method Work Station Settings.

Workstation	Working Element	Cycle Time (Second)
1	1	3.3
	4	4.4
	2	3.3
2	3	11.0
3	5	8.8
4	6	8.8
5	7	9.9
6	8	7.7
7	11	11.0
8	9	6.6
	12	7.7
9	14	6.6
	10	4.4
10	13	2.2
	15	7.7
	Total	103.4

Assembly line balance method comparison

In the calculation with the heuristic method above, all of them can meet the production target of more than 2,000 units per day, but each method has some differences.

The LCR method can reduce 1 workstation from the initial setting and produces a total production of 2,182 units per day and the highest efficiency is 78%. The KWC method, although it has the same production yield as LCR have lowest efficiency 71% because the number of workstations is more than other method. The thing that causes the number of KWC workstations to be more is there is a limit for the 3rd work element which cannot be combined with other work elements. Finally, for the RPW method, although it can reduce the number of workstations such as LCR, one of the workstations has a longer cycle time than LCR. For more details can be seen in Table 4 about the comparison of each method.

Table 4. Comparison of assembly line balance settings

Parameter	Initial Value	Method		
		LCR	KWC	RPW
Workstation Quantity	11	**10**	11	10
Production Quantity each day (unit)	1636	**2182**	2182	2014
Largest Workstation Cycle Time (second)	17.6	**13.2**	13.2	14.3
Line Balancing Efficiency (%)	53%	**78%**	71%	72%

CONCLUSION

From the description above, it can be concluded that in the case study adopted in this study, the use of the LCR method showed the most optimal results, which was able to reduce 1 workstation from 11 to 10, increasing production by 546 units from 1,636 units to 2,182 units per day (above the target of 2,000 units per day) and increased assembly line balancing efficiency by 25% from 53% to 78%. Although the LCR method is the earliest method found, it turns out that for this case study it produces the most optimal setting compared to the KWC and RPW methods. For different case studies, it is possible that the KWC and RPW methods will have better workstation settings.

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