

Productivity Improvement Through Line Balancing at Electronic Company – Case Study

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Abstract. A good manufacturing practice for production assembly can result in better productivity for the organization. This study focusses on productivity improvement of Electronics Manufacturing Service Company (EMSC) production assembly. It also aims to reduce waste and to propose a leaner line balancing with the elimination of non-value-added activities during the assembly. This study also aims to utilize current workstation to cater for the needs of the workstation to achieve 39 seconds takt time. Time study has been conducted for all workstations and found that all of the cycle time for each workstation exceeds the required takt time of 39 seconds. The bottleneck is at workstation number two with a recorded standard time of 54.1 seconds to complete the assembly thus causes high work in progress at workstation number two and excessive operator idle time to subsequent workstations. The main issue of EMSC is high volume demands from the customer and committing to the shipment plan. By adding one additional operator to workstation number two and a proper distribution of tasks may help EMSC to increase their production output. Time study is recorded in standard work form for future improvement.

1. Introduction

The electronics industry has been facing fierce competition among competitors on product varieties, high production volume, product quality and cost. Due to stiff competition, all electronic industries have to come out with a solution to stay at their top performance.

In this paper, work standardization is implemented as to improve the current process, reduce cycle time, increase output to meet customer's demand and add discipline to train new operators. Standardised work also includes the documentation of the current process. Later it will be used for further Kaizen activities based on takt time. It is to ensure all operators are performing the task within takt time. Work standardization is part of lean manufacturing tools which could increase motivations among workers to deliver higher efficiency and quality at a minimum cost [1].

The studied organization in this paper is facing high volume with low part number varieties. The standard procedure of product assembly in this company is called Work Instructions (WI) and Temporary Process Change Notice (TPCN) when there is a need to change the procedure at short notice. Currently, the company produces an electronic part version 1.2 (V.12). The newly developed and improved design product with additional features and new functions is called version 1.2+ (V1.2+). This version needs to be assembled and shipped out according to the shipment plan. During the study, the production assembly sequence and manpower utilization for a new version are the same as old version V1.2. However, due to additional parts number to be assembled and other functional test need



to be carried out, the production line was imbalance thus increases cycle time, work in progress (WIP), the idle time of operator and overall output decreases by 26.3%. In summary, this company has facing high cycle time, work in progress and inefficient resource utilization. Therefore, this paper is aim to balance the distribution of workload of each workstation through line balancing technique. Any non-value-added activities will be identified and eliminated as to achieve optimum cycle time.

This paper is structured into five sections, with section one highlight brief introduction regarding the paper, followed by literature study regarding the concept related to the case study, the method to carry out research study and data analysis. The fifth and final section will describe the conclusion and future work.

2. Literature Review

Many companies had turned to lean manufacturing to improve their performance [2-4]. Lean manufacturing is a system that focuses on elimination of wastes such as time reduction. Through this implementation, the company could sustain competitive advantages which gained from Kaizen and will improve stakeholder value [5, 6]. Apart from that, the operations efficiency also could be improved tremendously [7]. Due to electronics products has a short product cycle and evolves rapidly from various customer needs and unpredictable had caused many companies to adopt lean manufacturing philosophy [8]. One of the critical lean tools is standard work as part of continuous improvement. Standard work is the standardization of procedures in production operation. As cited by Masaki Imai, *"there can be no Kaizen without standardization"* [9].

2.1. Standardized work

Standardisation is the most powerful lean tools but least used in the production [1]. It is by documenting current production best practice to form the fundamental baseline for Kaizen [1]. It provides a routine for consistency of an operation or a process and a basis for improvement. According to Johansson [9], there are eight steps in developing standardized work [9] such as forming an improvement team, identifying production takt time, identifying cycle time, identifying production assembly sequence, identifying standard quantity for work in progress (WIP), providing standardised workflow, providing standard operations sheet and continuing to improve standard operations.

The goal of production standardization is to implement all processes right at the first time with zero waste. There are five characteristics need to be followed for standardization. Firstly, work instruction has to contain the only necessary process for the operator to follow. Work instruction has to be simple and provide visualization for easy understanding. Next is the possibility of immediate changes in process parameter. Fourthly, to ensure that every assembly operator has relevant activities which tie to the process and finally able to monitor operations standard and the impact it has on process area. [1]

2.2. Time Study

Time study is identifying required time by a qualified assembly operator working at a normal pace to the assembly operation. Time study is also described as an assembly measuring technique where the times are recorded and the rate of the specific assembly is carried out under a specified condition. The data is then analyzed to obtain the optimum time to carry out the production assembly. The result obtained from time study is called standard time [10]. Line balancing is a way to minimise imbalance workloads between workers as to achieve the desired output. Workstation assembly line should be analyzed in terms of the assembly process, layout and also cycle time [11].

3. Methodology

Firstly, the research area is identified and agreed based on preliminary observation of production yield. During the visit, work instruction is studied to understand the upgraded process from V1.2 to V1.2+. Cycle time data is then collected by using a stopwatch for ten times for each workstation to get the accurate average value based on the company standard work format. Then, data evaluation is evaluated to perform line balancing for each of the workstations. The company considered the performance rating for the operator is 100% at its normal pace with 15% allowed allowances. A prior

study, the operator was explained clearly details of the process need to be carried out. This operator is well trained and has good experience in this process and training records had been provided by human resource department to signify that the operators are qualified for the task. Apart from that, a team was formed to study the current process and propose possible action should be carried out. This team was led by senior engineer and four members. All activities were recorded for reviewing process. Interview also had been conducted to the workers for data clarification. Table 1 shows the average of cycle time for each of workstation. Then, after four months, new cycle time data is collected, recorded and analysed in standard work to compare before and after improvement implementation to the line cycle time. Next, normal time and standard time are calculated as Eq. 1 Normal Time (s)=Average Time \times Rating Factor and Eq. 2 Standard time (s)=(Normal Time)/(1-Allowance Factor) [12]. Table 1 shows the averages of assembly time study for 7 workstations.

Table 1. Summary Of Standard Time For All Assembly Workstations

Assembly Station	Average Cycle Time (s)	Operator's Efficiency (%)	Standard Time (s)
1	42.0	100	49.4
2	46.0	100	54.1
3	42.0	100	49.4
4	40.0	100	47.1
In-Line potting	23.0	100	27.1
5	36.0	100	42.4
6	34.0	100	40.0
Total	263	100	309.5

In this study, the takt time is calculated based on Rohani & Zahraee as in Eq. 3 Takt Time=(Available time for production)/(Required unit of production) which produces takt time of 39.6s [13]. The highest standard time is 54.1s at assembly workstation 2 which equivalent of producing 737 devices per cell per day. This performance shows the achievement of workstation number 2 is about 73.7% of required target per day. The cycle time is imbalance and most of the assembly workstations are above than takt time except in-line potting. Workstation 2 shows the highest cycle time which causes high work in progress (WIP) of 28% and affects production flow.

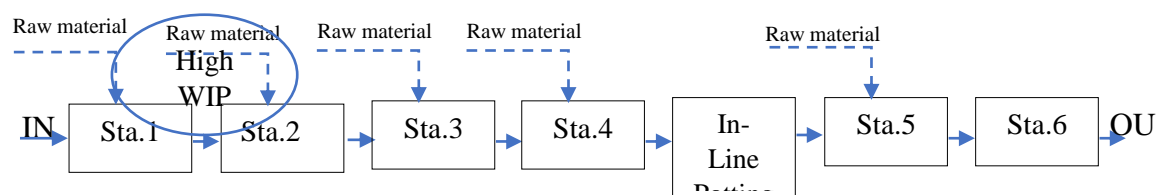


Figure 1. Production Process Flow

The assembly flow is shown as in

. From the illustration, it is clear to see that the existence of WIP at workstation 2. The reason for high WIP at workstation 2 is due to the additional vibration motor soldering and heater wire soldering onto the heater PCBA. The previous process of version 1.2 is no vibration motor needed to be soldered to the PCBA board and the design of heater frame is different and need more soldering time to solder heater wire to the area.

Below is the calculation of production efficiency by using Eq. 4 Efficiency=(\sum Task time)/(Actual number of workstation \times Largest assigned cycle time) [11]. The calculated line efficiency is 81.7%. Although the efficiency is quite good, the company still want to improve line efficiency as to increase production output. There are 42 electronic device assembly workstations to carter estimated annual demand of 12 million devices per year. Each cell is required to produce 1000 devices per day. Currently, there are seven assembly workstations per cell including the automated machine for in-line

potting. From time study, the highest standard time of 54.1s is used to calculate the total output. Daily production target is to assemble 1000 electronic devices. Based on the highest standard time 54.1s, it takes 15.03 hours to assemble 1000 devices. Current workers used for assembly are two workers. Thus, the current productivity is calculated by using Eq. 5 Labour hour per unit= (15.03 hours)/ (1000 devices) and Eq. 6 Labour productivity= 1/ (labour hour per unit). By substituting Eq. 5 and Eq. 6, Eq. 7 is produced Labour productivity= 1/ (labour hour per unit) which shows a productivity of 67 devices/hr. Thus, in one day, EMSC is only able to produce 737 assembled electronic devices per cell in one day.

4. Discussion

The desired cycle time was calculated based on maximum availability capacity 17,688 assembled devices per month per cell and monthly target output 24,000 devices per cell per month. This was based on 24 working days. Desired cycle time is calculated by using Eq. 8 $C_d = (\text{Productivity time available}) / (\text{Desired units of output})$ which then resulted in 39s desired cycle time. Based on the desired cycle time and measured cycle time, a minimum number of workstation can be determined by using Eq. 9 $N = (\sum_{i=1}^n t_i) / C_d$. The calculation shows the minimum number of workstation should be 8.

Table 2. Work Element And Precedence Step.

Assembly Station	Element No.	Work Element	Precedence	Standard Time (s)
1	1	Contact PCBA Soldering Heater + Press Fit Jig	-	49.4
2	2	Heater wire to Heater PCBA Soldering	1	54.1
	3	Vibration Motor to Heater PCBA Soldering + Insert to Frame	2	
	4	Pneumatic Press Fit Jig	3	
	5	Heater PCBA to Frame Soldering	4	
3	6	Heater PCBA 6 Points Soldering	5	49.4
	7	Battery to Frame Soldering	6	
4	8	MT 4	7	47.1
	9	Frame to Middle Part Insertion	8	
	10	Middle Part Press Fit Jig	9	
In Line potting	11	In Line Potting	10	27.1
5	12	Ring Insertion	11	42.4
	13	Button Insertion	12	
	14	Staple Insertion	13	
	15	Rear Housing Press Fit Jig	14	
	16	Front Housing	15	
6	17	Vibration Test	16	40
	18	MT 5	17	
	19	TSH Test Using MU	18	

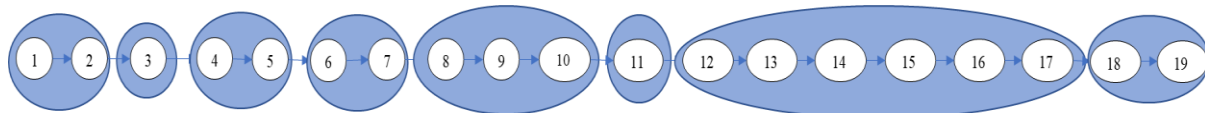


Figure 2. Line Balancing.

Figure shows the group of eight workstations. The blue coloured region is indicating one assembly workstation. The difference in this assembly workstation compared with the old assembly workstation is an additional one operator based on line balancing calculation to do the assembly at workstation number 2. Soldering of heater wire to heater PCBA process is moved to assembly workstation number 1 to balance out the process. At workstation number 2, the operators have to insert vibration motor to the heater PCBA and solder it in place. While at workstation number 3, the operator has to peel off vibration sticker, add the heater PCBA to frame and solder 5 points on the heater PCBA. As for operator at workstation number 4, one-point soldering to connect heater PCBA and contact PCBA is carried out at this station. There is also a combination of workstation 7 and part of assembly

procedure from assembly station 8 (Vibration test), a 5s manufacturing test that was moved to workstation 7.

It is identified that at assembly workstation 4 and 6 are longer cycle time due to the server has reached its maximum capacity, thus causes the scanning process and testing time become higher. In the midst of server migration, it is expected to cause longer cycle time. Once the migration is completed, the cycle time at that station will be twice faster than recorded. Four months later after an additional operator, the new cycle time is measured. The time had significantly improved over the past months after improvement. With server's migration, the scanning process at station 4 and 6 also improves. On average, the cycle time has improved by 45.5%. The new standard time after improvements were calculated as shown in Table 3.

Table 3. Summary Of Standard Time For After Improvement.

Assembly work station	Standard time (s)
Station 1	37.13
Station 2	29.53
Station 3	32.75
Station 4	30.20
Station 5	32.20
In-Line potting	30.87
Station 6	36.82
Station 7	26.49
TOTAL	255.99

Line efficiency is calculated using Eq. 4. New production efficiency is 86.2% compared to 81.7% before the improvement. This show new production efficiency is increased by 4.5%. The increment may seem quite small, but based on labour productivity as shown below, the impact has increased the production. Using the highest standard time which is 37.13s at assembly station 1, it will take 10.31 hours to complete 1000 devices per day for one cell. The improved productivity calculation calculated as in Eq. 7. Therefore, by improving line balancing, EMSC productivity is 97 devices per hour. Previously, before improvement, EMSC productivity is 67 devices per hour. Based on this improvement, EMSC productivity has increased from 67 devices per hour to 97 devices per hour with an increment of 44.8% in terms of productivity that is more than required production goal of 1000 devices per day. The excess of 67 devices will be accounted as a buffer which may be used when there is a part shortage or production line down or production off day.

5. Conclusion

In this study, the aim was to improve the productivity of an electronic device produced by EMSC. The real problem is identified and it is found to be associated with the line balancing and standardization. Time study was conducted and process flow is analysed thoroughly. The study shows some processes were above and below takt time. Improvement on the production line is applied through line balancing techniques. This study also focused on the improvement of high work-in-progress of 28% which disrupted the production flow. The additional operator in workstation number 2 and segregate assembly flow accordingly to each assembly workstation have increased the productivity. In addition, this improvement also has eliminated WIP at assembly workstation number 2 by balancing the work segregation to operator 3. Time study is recorded in standard work form for future research in reducing the number of operators through the integration of automation to the assembly line. After improvement, the production efficiency has increased from 81.7% to 86.2%. The productivity also has increased from 67 units per hour to 97 units per hour. As overall the line balancing technique in this study has improved the efficiency and productivity of this company.

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