

The Application of Line Balancing Technique and Simulation Program to Increase Productivity in Hard Disk Drive Components

Alonggot Limcharoen, Jintana Wannarat, Vorawat Panich

Abstract—This study aims to investigate the balancing of the number of operators (Line Balancing technique) in the production line of hard disk drive components in order to increase efficiency. At present, the trend of using hard disk drives has continuously declined leading to limits in a company's revenue potential. It is important to improve and develop the production process to create market share and to have the ability to compete with competitors with a higher value and quality. Therefore, an effective tool is needed to support such matters. In this research, the Arena program was applied to analyze the results both before and after the improvement. Finally, the precedent was used before proceeding with the real process. There were 14 work stations with 35 operators altogether in the RA production process where this study was conducted. In the actual process, the average production time was 84.03 seconds per product piece (by timing 30 times in each work station) along with a rating assessment by implementing the Westinghouse principles. This process showed that the rating was 123% underlying an assumption of 5% allowance time. Consequently, the standard time was 108.53 seconds per piece. The Takt time was calculated from customer needs divided by working duration in one day; 3.66 seconds per piece. Of these, the proper number of operators was 30 people. That meant five operators should be eliminated in order to increase the production process. After that, a production model was created from the actual process by using the Arena program to confirm model reliability; the outputs from imitation were compared with the original (actual process) and this comparison indicated that the same output meaning was reliable. Then, worker numbers and their job responsibilities were remodeled into the Arena program. Lastly, the efficiency of production process enhanced from 70.82% to 82.63% according to the target.

Keywords—Hard disk drive, line balancing, simulation, Arena program.

I. INTRODUCTION

THE technological revolution has influenced the traditional approach for data storage. That means that several companies have become awakened to using cloud storage increasingly. Consequently, the online storage providers have dramatically increased by 48% whereas data storage shrank by 21% [1]. Currently, hard disk drive manufacturers are

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confronted with many competitive problems such as price, quality, quick delivery and new technological inventions. Many enterprisers tend to reduce their price rather than reducing their cost, which affects their profitability. In fact, cost reduction is one of the most important aspects that helps to enable a business to survive and also relates to business revenues. That means that the more companies reduce their costs, the more their profitability will increase. Reducing the production time has been believed to be a method for reducing cost production. Hence, the production department needs to schedule the maintenance of the production line regularly.

II. LITERATURE REVIEW

A. Line Balancing

Line balancing can be described as leveling the workload through all of the processes in the value stream or cell to eliminate bottlenecks and excess capability. Pandit et al. proposed the application of line balancing to improve the productivity of components under consideration. The results obtained were at a satisfactory level. The actual performance against the target level was measured and it was observed that productivity improved with considerable reduction in the work process as well as raw material inventories [2]. Jaggi et al. used the line balancing to minimize the idle time of work stations in the production line [3].

B. Time Study

Motion and time study aims to design the most effective methods and procedures. Motion and time study consists of two parts [4]:

- (a) Motion study (work methods design) aims to find the preferred method of conducting work.
- (b) Time study (work measurement) aims to obtain the standard time to perform a specific task.

Standard time is the amount of time which allowed for an average skilled operator to perform a specified task using the standard method and working at a normal pace. This includes appropriate allowances to allow the operators to recover themselves from fatigue and an additional allowance to prevent contingent elements which may occur but have not been observed and is calculated by:

$$\text{Normal Time} = \text{Selected Time} \times \text{Rating} \quad (1)$$

$$\text{Standard Time} = \text{Normal Time} + \text{Allowance Time} \quad (2)$$

Earlier researches applied the time study to improve process productivity. Puvanasvaran et al. implemented time study to improve the Overall Equipment Efficiency (OEE) of the autoclave process [5]. Durana et al. proposed to adopt the work and time study to increase production efficiency. As a result of the study, where waiting time caused inefficiency in the work of the molder and in the content of work/time, efficiency was increased 53% and model production capacity reached 237 [6].

C. Takt Time

Takt time is the maximum amount of time in which a product needs to be produced in order to satisfy customer demand and is computed as [7]:

$$Takt\ Time = \frac{Available\ working\ time\ per\ day}{Daily\ required\ customer\ demand} \quad (3)$$

D. ECRS Principle

One exceptional approach in Lean is the framework of ECRS – Eliminate, Combine, Rearrange, and Simplify. It is used to improve the production line's efficiency. There are four activities in the ECRS concept as follows [8]:

- Eliminate (E): to eliminate wasted work at a normal pace found in the manufacturing such as unnecessary operation and avoidable delay.
- Combine (C): to combine redundant working steps to reduce the number of working steps and cycle time.
- Rearrange (R): to change the sequence of operations to reduce the distance of moving or the number of movements.
- Simplify (S): to make the working method easier and more comfortable. Sometimes, equipment such as jigs, fixtures, support tools, or machine modification is used to support the operator's work.

Many previous researches applied the ECRS principle to increase process efficiency. Sindhuja et al. adopted the ECRS to minimize the idle time of a machine at a bottleneck station or the line balance loss percentage, and the result showed that bottleneck time (crimping stage time) reduced from 23.04 to 16.65 seconds and the production rate increased from 156 to 216 pieces per hour [9]. Ongkunaruk et al. used the ECRS technique to improve the productivity of a large-sized frozen chicken manufacturer in Thailand. The results were as follows: The line efficiency was increased by up to 94.20%. It helped reduce the number of employees and the labor cost by 14 people and 356,160 baht/year respectively [10]. Kasemset et al. also applied Material Flow Cost Accounting (MFCA) and ECRS techniques to reduce material waste in the production of an electronic parts factory in Thailand. The results showed that total input cost was decreased from 22,444.46 to 22,300.92 THB and the negative product cost of MC was decreased from 2,557.10 to 2,437.21 THB. In addition, this solution could help in a material reduction of 465.50 g. and a gain in more products at 2,000 pieces per production lot [11].

E. ECRS Principle

Simulation is a suitable tool to study the behavior of technical processes such as: Chemical processes, environmental systems, complex manufacturing operations, biological processes, and similar technical functions. It is used for the design, development, analysis, and optimization of any process. An appropriate simulation tool can provide the best way to evaluate a process. This tool can show how the real process is affected by changes in policy. Moreover, the simulation can be used to monitor the effective factors in the system without testing in a real situation [12].

Trakultongchai et al. used simulation tools in the real production planning to reduce the bottleneck problem in a paint shop process [13]. Kasemset et al. applied the ECRS concept and simulation technique to improve the efficiency of a paper packaging factory and these techniques reduced the total process time from 4.99 hours to 3.94 hours which could be approximately accounted for as 28.06% [14].

III. METHODOLOGY

This research applied the Arena Program to balance the production based on the allocation of appropriate worker numbers. Procedures conducted in the research are shown as:

A. Finding Standard Time in Each Working Process

In this step, a researcher made initial timings and then the appropriate timings were calculated, and the exceeded timings were organized. This process enabled a researcher to obtain data containing 95% of confidence level and +5% of error. After that, the rating was evaluated based on Westinghouse principles, and then the researcher calculated for the standard time.

B. Creating a Model of the Original Production Process

The researcher started to analyze input data by applying the Input Analyzer before creating a model in the Arena program and set up a production process which was the same as the current production process. In process 8, the production would have to stop to check the Adhesive toughness, once every 1,250 pieces were produced. In process 10, the production would have to stop for five minutes to check measurements every four hours; and in process 13, the production would have to stop for five minutes to check the equipment. These conditions can be configured in the Arena Program as shown in Table I. At this point, the results from the invented program were run to find the model accuracy. The accuracy was checked by comparing the results from the invented program and the numbers from actual production.

TABLE I
 THE PROCESS CONTAINING FAILURES

Sub-Process	Failure Schedule	Failure Unit	Time Failure	Unit
8	1,250	Pcs	15	minutes
10	4	Hr.	5	minutes
13	800	Pcs	5	Minutes

C. Finding the Appropriate Number of Workers for the Production

The appropriate number of operators was calculated

according to the fourth equation in which Takt time was the Maximum Interval between finished products.

$$\text{Number of operators} = \frac{\text{Standard Time}}{\text{Takt Time}} \quad (4)$$

D.Improving Production Process by Balancing the Number of Workers

The model in the Arena Program was improved to be in accordance with the number of calculated workers. At this stage, the process which took less time than Takt time was adjusted by gathering workers to perform many functions in order to reduce wasted time.

E. Comparing the Results between the Production Process before and after Improvement

The efficiency of the production line was calculated before the improvement by finding LBE (Line Balance Efficiency) according to:

$$\text{LBE} = \frac{\text{Summation of cycle time for all activities}}{\text{No. of operators} \times \text{working time of bottle neck process}} \times 100 \quad (5)$$

F. Making Conclusions

The results of the experiment were concluded by whether or not they followed the objectives and aims of this research. Also, other suggestions were added as guidelines for the next research.

IV. RESULTS AND DISCUSSIONS

A. Finding the Standard Time of Each Process

The researcher had to time following the appropriate timings from calculating. In addition, by applying Westing house principles in rating calculation, the results showed that workers in this process could be working at the rate of 1.23 or 123 percent.

From the above data, standard time was found as follows.

$$\begin{aligned} \text{Regular time} &= 84.03 \times 123\% = 103.363 \\ \text{Standard time} &= 103.363 + (103.363 \times 5\%). \end{aligned}$$

Therefore, the standard time of this process was 108.53 seconds.

B. Creating a Model of an Original Production and Comparing the Results between the Model and the Actual Work to Confirm the Accuracy

A production model as shown in Fig. 1 was created by using certain data, a department name and timing data which was received from the analysis of statistical distribution value in work from various departments and is shown as in Table II. After that, the researcher compared the results received from the Arena Program and the actual process by considering the number of pieces in the outgoing process under similar conditions. If both results were not similar, the researcher would check the conditions and add something needed in

order to get similar results. Once the results from the program were similar to the actual one, the researcher then used the model in the Arena Program to develop or improve the production process.

TABLE II
 SUMMARY OF RESULTS IN STATISTICAL DISTRIBUTION VALUE ANALYSIS OF ENTITY ARRIVAL TIME

No.	Process	Statistical Distribution
1.	Coil Assemble Tube Blue	TRIA(4, 5.02, 5.36)
2.	Coil Assemble U lopp	4.43 + 0.8 * BETA(0.695, 0.861)
3.	Coil Assemble Tube Orange	4.47 + 0.87 * BETA(0.682, 1.19)
4.	Adhesive plotting tube	TRIA(4, 5.04, 5.35)
5.	Coil setting	0.83 + 1.17 * BETA(0.536, 0.32)
6.	Soldering	TRIA(1.61, 1.72, 1.77)
7.	Plasma	1 + 0.17 * BETA(1.32, 2.13)
8.	Comb stiffener setting	2.73 + LOGN(0.703, 0.314)
9.	Take off clamp and carriage	TRIA(2.44, 3.72, 4)
10.	Vision camera and coil height	NORM(5.1, 0.456)
11.	Appearance	TRIA(9, 10.1, 12.8)
12.	DI Cleaning	3 + WEIB(0.136, 1.57)
13.	Auto Tweek	14 + 9 * BETA(0.407, 0.946)
14.	Out going	NORM(8.14, 1.43)

C. Finding the Appropriate Number of Workers for the Production

Takt time is calculated from working duration in one day divided by customer needs in one day. The data used in calculation were explained as follows: 10,000 product pieces took a day to produce consuming 10.15 total working hours (8 hours for regular working hours and 2.5 hours for overtime, and 20 minutes for a break). The result from the calculation was 3.66 seconds per piece.

$$\text{Number of operators} = \frac{108.53}{3.66}$$

The appropriate number of workers was calculated in (3). It was found that 29.67 or 30 workers were the appropriate number in this production, whereas the current number of workers is 35.

D.Improving Production Process by Balancing the Number of Workers

The number of workers was adjusted to be the same number as the result from the calculation. In this research, a model created from the Arena Program would be improved to develop the production process. In this case, it meant adjusting the number of workers to be similar to the theory which had 30 people. Balancing the production line was then conducted by the following steps, and the procedures are described as:

- (1) The researcher combined workers from the Coil Assy Coil Setting department who took 1.56 seconds performing their work with those in the Coil Assy Soldering department who took 1.70 seconds performing their work. This is because the working time combined from both departments was less than Takt time and both of their activity stations of work were similar. Currently,

there are two workers in each station; however, this number could be reduced, which means one worker can

function in two stations.

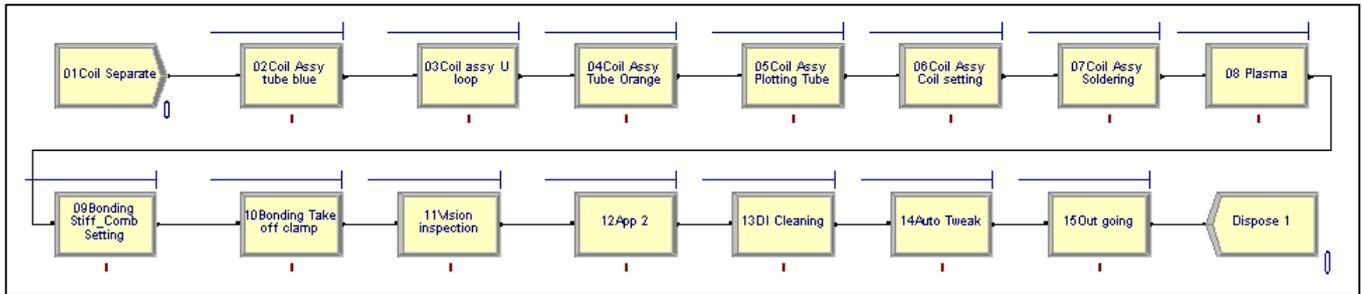


Fig. 1 Window displayed processes created in the Arena Program

- (2) The researcher combined workers in the Plasma department who took 1.07 seconds performing their work with those in the Bonding Stiffener Comb Setting department who took 2.07 seconds performing their work. This is because the working time combined from both departments was less than Takt time and both of their activity stations of work were similar. Currently, the Plasma department has one worker and Bonding Stiffener Comb Setting has two workers. The adjustment aimed to reduce the number of workers from three to two, and they could function in both departments.
- (3) The researcher combined workers from the Vision Inspection department who took 2.55 seconds performing their work with those in the Appearance department who took 2.66 seconds performing their work. This was because the working time combined from both departments was less than Takt time and both of their activity stations of work were similar. Currently, the Vision Inspection department has two workers and the Appearance department has four workers. Once they are combined, the number of workers could be reduced to five.
- (4) The number of workers in the Coil Separate department was reduced from five to three.
- (5) There was no change in the other eight departments.
- (6) Combining the workload could reduce the number of workers from 35 to 30. Apart from that, these 30 workers spent the same time as the former number of workers to produce 10,000 product pieces which responded to the customer's need.

E. Comparing the Results between the Production Process before and after Improvement

The efficiency of the production line before the improvement was calculated as:

$$LBE = \frac{84.03}{35 \times 3.39} \times 100$$

$$LBE = 70.82\%$$

The efficiency of the production line after the improvement was calculated as:

$$LBE = \frac{84.03}{30 \times 3.39} \times 100$$

$$LBE = 82.63\%$$

It could be seen that the performance of a new production process increased from 70.82% to 82.63%.

The working efficiency was increased from 70.82% to 82.63% by reducing five workers, and the quantity of products produced under the same conditions with the Arena Program was 10,644.

V.CONCLUSION

After implementing the line balancing and ECRS techniques, it was found that five operators should be reduced in this process. The production model was created and confirmed by comparing the output from the simulation model with the actual output from the original production. This study found that the number of product output was 10,644 pieces. Then the number of employees and the workload of employees were adjusted in the Arena Program. The efficiency of the production process increased from 70.82% to 82.63%.

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