Improvement of Work Method with Eliminate, Combine, Re-arrange, and Simplify (ECRS) Concept in a Manufacturing Company: A Case Study

A K Nisa¹ ¹, Hisjam M² and S A Helmi³ ³

¹ Undergraduate Program of Industrial Engineering Department, Faculty of Engineering, Sebelas Maret University, Surakarta 57126, Indonesia
² Department of Industrial Engineering, Faculty of Engineering, Sebelas Maret University, Surakarta 57126, Indonesia
³ Faculty of Engineering, School of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 UTM, Johor Bahru, Malaysia
⁴ Center for Engineering Education (CEE), Universiti Teknologi Malaysia, 81310 UTM, Johor Bahru, Malaysia
⁵ Corresponding author: ayusyanisa@gmail.com

Abstract. The study was conducted in a data storage manufacturing company that currently produces more than ten types of hard disk component products both internal and external. Based on observations of their manufacturing lines, it indicates an imbalance in the production line. Balancing the production line minimizes idle time at all work stations. One component of a work system that can be improved is the work method. In this study, work method improvements were carried out by applying the concepts of Eliminate, Combine, Re-arrange, and Simplify (ECRS). The benefit obtained from this research is that the company can improve the work system on its production line based on the improvement of the proposed work methods so that it can ultimately increase company productivity. There is an increase in line efficiency after the improvement. The line efficiency value before and after improvement are 65.62% and 74.43%, respectively.

1. Introduction

This company is one of the hard disk drive manufacturing company that produce hard disk components for both the national and international markets. The company has now produced more than ten types of hard disk component products both internal and external namely baseplate, solid state drive enclosures, covers, hard disk drive covers, separator plates, heat sinks, actuators arm body, steel connectors, etc. This study focuses on an actuator arm body of 15 types of actuator arm body that are produced every day. The actuator body arm is important parts because ordered by one of their major customer. To meet existing demand, the company of course must ensure that their production can meet the demand.

The final production process or the final gate of the actuator arm body is VMI. In this final process, quality control is carried out with visual checking, machining checking, inspection checking, and pin assembly. There are 15 final process lines for each type of arm body actuator on the final
process area at the company. This research focuses on one of the final process lines with one type of actuator which has 11 work stations.

Based on observations on these lines, some unfavorable conditions were found in this actuator arm body line such as material shortage, idle time, bottleneck, machine trouble, uncomfortable work station, and reject parts. This situation indicates an imbalance in the production line. Track balance is very important in a production process, balancing the production line minimizes idle time at all work stations (1). On a balanced production line, material will move smoothly and no time is wasted waiting for work or idle (2).

A good track balance can minimize waste, one of which is the bottleneck [3]. Waste is an indication of suboptimal use of resources. Waste minimization efforts can increase efficiency so that it can increase production output [4]. If the company has low efficiency, the company must spend a lot of costs in order to pursue production targets. These costs include the cost of electricity used for plant and machine operations, costs for employee wages when overtime, and other overhead costs [5]. If the low line efficiency on the production line is left on continuously, the company will find it difficult to compete with other companies that have higher efficiency. Even longer companies with low productivity due to low line efficiency in their production lines can lose out in market competition.

Based on these problems, it is necessary to make improvements as soon as possible on the final process line of the company so that the line efficiency of that line can increase. One component of a work system that can be improved is the work method [6]. The aim of this research is to know the value of line efficiency before improvement and know the factors that cause the low value of line efficiency so that it can propose improvements to work methods that are carried out to increase line efficiency.

In this study, work method improvements were carried out by applying the concepts of Eliminate, Combine, Re-arrange, and Simplify (ECRS). The ECRS concept is applied to work stations to reduce waiting times for other stations, one of which is bottleneck [7]. With this concept we can analyze and improve the production process, then the company can improve the work system on its production line based on the improvement of the proposed work methods so that it can ultimately increase company productivity. ECRS is one of the Just in Time (JIT) concepts in Toyota Manufacturing where the concept aims to make the production line perfectly balanced and to have a resource utilization that reaches one hundred percent [8]. This concept has been widely used by some researchers to improve line efficiency and productivity performance.

2. Research Method

2.1 Initial Observation

Initial observations are the initial stages carried out in this study. At this stage, the observations were made at one type of actuator arm body line work stations in the final process area. These initial observations were conducted by researchers for 4 days in the initial period of practical work. The purpose of this initial observation is to identify problems that occur in the production line and then determine the focus of research.

2.2 Determination of Line Efficiency Value Before Repair

At this stage, data collection and processing are carried out to determine the value of line efficiency before improvement and analysis and interpretation of the results of data processing that has been done. This stage was carried out by the researcher after determining the focus of the research at the observation stage. The data collected in this stage are primary data and secondary data. The primary data is the data obtained by the researchers directly, including shift 1 work time data and cycle time data of all work stations on the one type of actuator arm body line in the final process area. While the secondary data is the data obtained by the researchers through pre-existing sources, including productivity targets for actuator arm body line in the final process area. After data collection, data processing was then performed to determine the cycle time, total cycle time, maximum cycle time, takt
time, production capacity, production/head/hour (PHH), process time, idle time, line efficiency, recapitulation of calculation results, and comparisons productivity. Analysis and interpretation were then performed after processing the data.

2.3 Development of Work Method Improvements
At this stage the process of developing work methods using the Eliminate, Combine, Re-arrange, and Simplify (ECRS) concept is carried out. This approach is used to obtain efficient work elements at each work station on the final process line. The ECRS concept can be used to eliminate unnecessary work elements where these unnecessary work elements can be a source of waste of labor, machinery, equipment and materials. Besides, combining the work elements can also be done so as to reduce the waste. The process of re-arranging work elements can also be carried out to get the most efficient sequence of work elements. Then the process of developing work elements can also be carried out to obtain safe and easy work steps. To apply the concept of the ECRS in the preparation of working methods improvement requires several stages. The first step is to identify the elements of work that are not efficient. After that, the stages of the implementation of the ECRS are carried out to minimize the inefficient movement elements. After the ECRS process is carried out, an experiment is carried out for work stations that experience changes in work elements due to the application of ECRS. This experiment was carried out to see whether the proposed new work elements could be implemented well on the production line.

2.4 Determination of the Effect of Improved Working Methods
At this stage, the line efficiency value is calculated after the proposed working method improvement has been given. Then a comparison is made between the company's target line efficiency, line efficiency before improvement and line efficiency after improvement. There are several indicators that will be a comparison between the situation before the work method is being improved and the condition after the work method has been improved. These indicators include takt time, production capacity, production per head per hour, process time, and line efficiency. Then an analysis of the results and the effect of working method improvements on the value of line efficiency is performed.

2.5 Conclusions and Suggestions
The next step is to make conclusions and suggestions. The conclusions of this study answer the objectives to be achieved in the study. After getting conclusions, further improvements will be given suggestions that are expected to benefit the company and further research.
3. Results and discussions

The observations were made at the final process area where this section is divided into two parts, quality control and assembly. Quality control performed in this section is visual checking, mechanical checking, and inspection. While the assembly is the part in charge of assembling components, namely the insert pin. The quality control and assembly sections that have been observed include all stations on the final process line which consists of 11 stations. The production working hours data for shifts 1 and 2 were obtained from the production section and the final process area at the company.

Table 1. Observation Results in Final Process Line.

| VMI Work Station | Observation Results                                      |
|------------------|----------------------------------------------------------|
| Station 1. Swage hole dented/step/rought | There are material shortage that hindering the process production and reject parts |
| Station 2. White spot/dented | Reject parts |
| Station 3. Swage hole ball gauge nogo | Reject parts |
| Station 4. Swage hole slip gauge nogo | There are reject parts and machine trouble |
| Station 5. Bearing hole ball gauge nogo | There are idle time and reject parts |
| Station 6. Insert slug pin & slug pin test | Bottleneck |
| Station 9. Coil height | The uncomfortable work station and reject parts |
| Station 10. Laminate | Reject parts |
| Station 11. Final | There are bottleneck, reject parts, and the uncomfortable work station |

Figure 1. Research Method Flowchart.
Table 2. Nett Working Time Final Process Area

| Type               | Explanations                      | Time (minutes) |
|--------------------|-----------------------------------|----------------|
| Working Time       | Shift 1 (07.00 am - 07.00 pm)     | 720            |
|                    | Shift 2 (07.00 pm - 07.00 am)     | 720            |
| Time Fixed Loss    | Break 1 shift 1                   | 40             |
|                    | Break 2 shift 1                   | 40             |
|                    | Break 1 shift 2                   | 40             |
|                    | Break 2 shift 2                   | 40             |
|                    | Allowance                         | 20             |
| **Nett Working Time** |                                  | **1260**       |

Table 3. Company’s Productivity Target of Actuator Arm Body

| Indicator                        | Company Target | Unit  |
|----------------------------------|----------------|-------|
| Nett Working Time                | 1260           | minute|
| Takt Time                        | 7              | second|
| Production Capacity (line/day)   | 8000           | pcs   |
| Production/Head/Hour (PHH)       | 35             | pcs   |
| Process Time                     | 104            | second|
| Line Efficiency                  | 90%            |       |

Table 3 explains the productivity target data for the actuator arm body products obtained from the final process area of the company. Cycle time is the time used to complete a work cycle with a predetermined work standard. The following is displayed a cycle time table for each work station that has been calculated based on observations directly using a stopwatch. The value of the cycle time taken is the average of the five data retrieved for each work element.
Table 4. Cycle Time Each Stations in Final Process Line Actuator

| ACTUATOR ARM BODY PEBBLE BEACH | Cycle Time (second) | Step | Process Element | Work Station |
|--------------------------------|---------------------|------|-----------------|--------------|
| 1                             |                     | Step 1 | Insert slug pin & slug pin test | 6B            |
|                               |                     | Step 2 |                 |              |
|                               |                     | Step 3 |                 |              |
|                               |                     | Step 4 |                 |              |
|                               |                     | Step 5 |                 |              |
|                               |                     | Step 6 |                 |              |
|                               |                     | Step 7 |                 |              |
| 2                             |                     | Step 1 | Swage hole dented/step/rough | 6B            |
|                               |                     | Step 2 |                 |              |
|                               |                     | Step 3 |                 |              |
|                               |                     | Step 4 |                 |              |
|                               |                     | Step 5 |                 |              |
|                               |                     | Step 6 |                 |              |
|                               |                     | Step 7 |                 |              |
| 3                             |                     | Step 1 | Swage hole ball gauge nogo | 6B            |
|                               |                     | Step 2 |                 |              |
|                               |                     | Step 3 |                 |              |
|                               |                     | Step 4 |                 |              |
|                               |                     | Step 5 |                 |              |
|                               |                     | Step 6 |                 |              |
|                               |                     | Step 7 |                 |              |
| 4A                            |                     | Step 1 | Swage hole slip gauge nogo (A) | 6B            |
|                               |                     | Step 2 |                 |              |
|                               |                     | Step 3 |                 |              |
|                               |                     | Step 4 |                 |              |
| 4B                            |                     | Step 1 | Swage hole slip gauge nogo (A) | 6B            |
|                               |                     | Step 2 |                 |              |
|                               |                     | Step 3 |                 |              |
|                               |                     | Step 4 |                 |              |
| 5                             |                     | Step 1 | Bearing hole ball gauge nogo | 6B            |
|                               |                     | Step 2 |                 |              |
|                               |                     | Step 3 |                 |              |
|                               |                     | Step 4 |                 |              |
| 6A                            |                     | Step 1 | Insert slug pin & slug pin test | 6B            |
|                               |                     | Step 2 |                 |              |
|                               |                     | Step 3 |                 |              |
|                               |                     | Step 4 |                 |              |
|                               |                     | Step 5 |                 |              |
|                               |                     | Step 6 |                 |              |
|                               |                     | Step 7 |                 |              |
|                               |                     | Step 8 |                 |              |
|                               |                     | Step 9 |                 |              |
|                               |                     | Step 10|                 |              |

| 9A                            |                     | Step 1 | Coil height (A) | 6B            |
|                               |                     | Step 2 |                 |              |
|                               |                     | Step 3 |                 |              |
|                               |                     | Step 4 |                 |              |
|                               |                     | Step 5 |                 |              |
|                               |                     | Step 6 |                 |              |
|                               |                     | Step 7 |                 |              |
|                               |                     | Step 8 |                 |              |
|                               |                     | Step 9 |                 |              |
|                               |                     | Step 10|                 |              |

| 10                            |                     | Step 1 | Laminate | 6B            |
|                               |                     | Step 2 |                 |              |
|                               |                     | Step 3 |                 |              |
|                               |                     | Step 4 |                 |              |
|                               |                     | Step 5 |                 |              |
|                               |                     | Step 6 |                 |              |
|                               |                     | Step 7 |                 |              |
|                               |                     | Step 8 |                 |              |
|                               |                     | Step 9 |                 |              |
|                               |                     | Step 10|                 |              |

The total cycle time can be calculated by summing the cycle times of all stations. From the sum, the value obtained for a total cycle time is 122.81 seconds. Based on the cycle time data, it can also be known that the maximum cycle time or cycle time with the highest value is 10.49 seconds at the final 11B work station. The known maximum cycle time can be used to determine the stations that have been congested with material / product or commonly referred to as bottlenecks. Based on the calculation results, it can be seen that stations 6 and 11 are stations where bottlenecks occur in the track. Cycle time at both workstations has a value that exceeds the company's takt time target of 7 seconds. This is certainly the cause of line efficiency value far from the company's target, resulting in suboptimal productivity. 

The known maximum cycle time can be used to determine the stations that have been congested with material / product or commonly referred to as bottlenecks.
Table 5. Result of Process Time and Idle Time calculation

| No. | Process                                      | Cycle Time (second) | Idle Time (second) |
|-----|----------------------------------------------|---------------------|--------------------|
| 1   | Swage hole dented/step/rought                | 5.24                | 5.24               |
| 2   | White spot/dented                            | 6.90                | 3.59               |
| 3   | Swage hole ball gauge nogo                   | 5.56                | 4.92               |
| 4A  | Swage hole slip gauge nogo (A)               | 5.94                | 4.54               |
| 4B  | Swage hole slip gauge nogo (B)               | 6.99                | 3.50               |
| 5   | Bearing ball gauge nogo                      | 4.32                | 6.17               |
| 6A  | Insert slug pin & slug pin test (A)           | 8.20                | 2.28               |
| 6B  | Insert slug pin & slug pin test (B)           | 8.71                | 1.78               |
| 7A  | Insert datum pin (A)                         | 7.31                | 3.18               |
| 7B  | Insert datum pin (B)                         | 7.43                | 3.06               |
| 8A  | Insert ground pin (A)                        | 7.20                | 3.28               |
| 8B  | Insert ground pin (B)                        | 7.02                | 3.46               |
| 9A  | Coil height (A)                              | 7.45                | 3.03               |
| 9B  | Coil height (B)                              | 7.90                | 2.58               |
| 10  | Laminate                                    | 5.82                | 4.67               |
| 11A | Final (A)                                    | 10.33               | 0.16               |
| 11B | Final (B)                                    | 10.49               | 0.00               |

Figure 2. Graph of Process Time and Idle Time in Final Process Line

The highest idle time occurs at the 5th station, the nogo ball hole bearing gauge station. This is because the workload at the station is too low compared to the other stations. While the lowest idle time occurs at station 11, the final station which is the station where the bottleneck occurs. From Picture 2, it can be seen that the idle time that occurs is still quite high even reaching 6.17 seconds. Idle time that occurs at the actuator arm body work station line shows that the workload received by each operator is uneven, so there are operators who are always working and operators who are waiting for other operators’ work. This causes the low line efficiency in the final process line.
This section discusses the analysis of proposed improvements to increase the value of line efficiency in the final line by improving work methods using the ECRS concept. The data used in the ECRS concept are work element data and time of completion of the work element.

In the re-arrange method, changes are made to the composition of the work elements. The change occurred at the final 11 work station, the sixth work element is the hold gripper area to the operator and checking from the gripper and fantail area, this work element is moved into the seventh work element, and it shifts the ninth work element, hold opposite datum side swage pad area to the operator and checking swage hole and swage pad area, onto the fifth work element. The removal of this work element aims to make the work element movement of workers more effective.

In the combine method, the work elements are combined. The merging of the work elements is carried out at the final 11 work stations, namely the second work element (hold FCB surface to operator and ground pin checking, FCB surface, latch pin, and camel back) and the seventh work element (hold tubing slot to operator and checking from tubing slots) are combined into the second working element (FCB Surface Hold to operator and ground pin area checking, FCB surface, latch pin, ground pin, and camel back). Whereas the third work element (Hold Datum Surface to operator and checking from bearing hole & datum pin) and the fourth (Hole body arm to operator and checking gripper, body arm and swage pad area) are combined into the third working element (Hole datum surface to operator and checking bearing hole, datum pin, gripper, body arm and swage pad area). Combining these work elements aims to reduce the working time of the motion elements that are considered ineffective. The combination of these working elements can save time of 1.86 seconds at station 11A and 1.98 seconds at station 11B.

In the eliminate method, removal of the third work element of take part is carried out at the insert pin work station, those are: the work station 6 insert slug pin & slug pin test, work station 7 insert datum pin, and work station 8 insert ground pin. The removal of the work element is carried out because of the ineffective work element, the taking of parts from the conveyor has been done on the first work element, but there is a work element repetition in the work instruction, then the elimination of the third work element is carried out.

In improving the work element with the ECRS concept for this research, the simplify process was not carried out. This is because the work elements present in the process in the final process line are work elements that cannot be simplified.
From the results of the calculation of line efficiency above which is done after the improvement, the takt time value is 8.94 seconds, where the takt time is included with the allowance for bottleneck of 5%, then the process time is 98, and line efficiency of 74.43%.

Based on the line balance graph after repairs, it can be seen that the time for each work station becomes more balanced compared to before the repair because several stations have met the company's takt time target. This means that the distribution of workloads for each work station is more evenly compared to the conditions before the repairs, but there needs to be further improvements.

### Table 7. Recapitulation Line Efficiency After Improvement

| Work Station | Line Balance Line VMI (Pebble Beach Actuator) |
|--------------|------------------------------------------------|
| Actuator A | Takt Time : 8.94 s |
| | Target Takt Time : 7 s |
| | Production Capacity : 8000 pcs |
| | Production/Head/Hour (PHH) : 35 |
| | Process Time : 58.28 |
| | Line Efficiency : 90.00% |

| Work Station Name | Cycle Time of Each Element (second) | Actual Takt Time | Target Takt Time | Line Efficiency |
|-------------------|-------------------------------------|-----------------|-----------------|----------------|
| Insert slug & slug pin test (A) | 4.62 | 8.94 | 7.00 | 90.00% |
| Insert slug & slug pin test (B) | 5.37 | 8.94 | 7.00 | 90.00% |
| Datum | 2.07 | 8.94 | 7.00 | 90.00% |
| Swage hole (A) | 4.62 | 8.94 | 7.00 | 90.00% |
| Swage hole (B) | 5.37 | 8.94 | 7.00 | 90.00% |
| White spot gauge | 2.07 | 8.94 | 7.00 | 90.00% |
| Bearing | 2.07 | 8.94 | 7.00 | 90.00% |
| Insert slug | 4.62 | 8.94 | 7.00 | 90.00% |
| Insert slug pin & slug pin test | 5.37 | 8.94 | 7.00 | 90.00% |
| Ground pin | 2.07 | 8.94 | 7.00 | 90.00% |
| Ground pin (A) | 4.62 | 8.94 | 7.00 | 90.00% |
| Ground pin (B) | 5.37 | 8.94 | 7.00 | 90.00% |

### Table 8. Comparison of Productivity in Final Process Lines

| Indicator | Target | Before Improvement | After Improvement | Unit |
|-----------|--------|--------------------|-------------------|------|
| Takt Time | 7      | 11.01              | 8.94              | second |
| Production Capacity | 8000 | 6866               | 8461              | pcs  |
| Production/Head/Hour (PHH) | 35 | 30                 | 37                | pcs  |
| Process Time | 104 | 121                | 98                | second |
| Line Efficiency | 90.00% | 65.62%             | 74.43%            |      |

From Table 8, it can be seen that there are differences in productivity between targets, conditions before improvement and conditions after improvement. Based on these data, it can be seen that an increase in line efficiency in conditions after repair compared to conditions before repair. This is because the causes of not achieving the company's target line efficiency in the Actuator Arm Body line on the methods has been improved on the uneven distribution of work elements but there are several company targets that have not been achieved. There was an increase in production capacity from 6866 pcs to 8461 pcs. Even the production capacity can exceed the company's target of 461 pcs more. This certainly has a big impact on the company, especially in terms of production costs. However, this study did not analyze the costs after repairs were made. This increase in production capacity is due to reduced process time after repairs. In addition there was an increase in PPH, before repairing 30 pcs and after repairing 37 pcs, exceeding the company's target of 2 pcs more.

However, the line efficiency generated after the repairs has still not reached the company's target of 90%. For this reason, other improvements need to be made that can overcome the causes of not achieving the company's target line efficiency in the Actuator Arm Body line from other factors such as man, environment and material.
4. Conclusions
Based on the results of data processing and analysis that have been done before, it can be concluded that on the final process line, the line efficiency value is obtained before improvement of 65.62%. Based on the identification of the cause of the problem that has been done, an improvement in work methods is carried out to increase line efficiency on the final process line. The proposed improvements made are to improve the work elements by using the concept of ECRS (Eliminate, Combine, Re-arrange, and Simplify). After repairs are made, a comparison is obtained between the company's line efficiency targets, line efficiency before repairs and line efficiency after repairs, as well as their productivities. After improvement, the tact time value is 8.94 second, production capacity is 8461 pcs, production/thead/hour is 37 pcs, process time is 98 seconds, and line efficiency is 74.43%. There is an increase in line efficiency and productivity in the condition after the improvement compared to the condition before the improvement. Further improvements need to be made, not only from the work method factors but also from the other factors such as human, environmental, machine, and material factors.

References
[1] Groover M P 2007 Automation Production Systems and Computer Integrated Manufacturing 3rd ed (New Jersey Prentice Hall) p 840
[2] Ahmed S and Chowdhury SI 2018 Increase the Efficiency and Productivity of Sewing Section Global Journals 8(2):43–60
[3] Kumar N and Mahto D 2013 Assembly Line Balancing A Review of Developments andTrends in Approach to Industrial Application Global Journals13(2):29–50
[4] Sofyan H Nadeak M and Prasetyo TB 2018 Perbaikan Proses Assembling Priming Set Departement Blood Tubing Set (BTS) Pada Perusahaan Manufaktur Alat Kesehatan Prosiding KITT 1:334–41
[5] Gaspersz V 1998 Production Plan & Invent Control (Jakarta: PT Gramedia Pustaka Utama) p 356
[6] Didiharyono 2016 Penerapan Metode Statistical Processing Control Untuk Menganalisis Pengendalian Kualitas Produk pada PT. Asera Tirta Posidonia, Kota Palopo. Jurnal Equilibrium 2(4):325–32
[7] Ongkunaruk P and Wongsatit W 2014 An ECRS-based line balancing concept: a case study of a frozen chicken producer. Business Process Mgmt Journal 20 (5):678–92
[8] Joelianto E and Kadarusman L 2010 Industrial Control Quality Improvement using Statistical Process Control Tennessee Eastman Process Simulation Case IIJ 2(1):23–8
[9] Fajrianto M I, Amran T G and Azmi N 2017 Rancang Bangun Model Lean Productivity dengan Pendekatan Objective Matrix-Value Stream Mapping-ECRS (Studi Kasus: PT. X) j teknik industri 5 (3)
[10] Al-Saleh KS 2011 Productivity improvement of a motor vehicle inspection station using motion and time study techniques. Journal of King Saud University - Engineering Sciences 23 (1):33–41.
[11] Amran TG and Wibowo NC 2018 Perbaikan Proses Produksi Sistem Pengereman Kendaraan Bermotor dengan Metode ECRS-Based Line Balancing Seminar Nasional Pakar 1 12.