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Balancing Coffee Kit Assembly Line: a Case Study of a Sample Factory

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ABSTRACT

This research aims to increase productivity of the coffee kit assembly process of a case study. The procedure are as following: production recording, analyzing and improving, new jobs balancing and new working methods designing by using techniques of ECRS (Eliminate, Combine, Rearrange, Simplify), line balancing techniques and motion study. They were used in real production and performance was measured for process improvements. The results obtained from the recording and analysis of data were found that there were 13 stations of coffee kit making process, straight line, and each step took very different time. This has resulted in some waiting stations and loss of production. There were 24 workers in manual coffee assembly line which was unsuitable. A processing time (takt time) took 1.266 second. The assembly line performance is 74.97 percent. To reduce a cycle time in workstation, an assembly line was balanced in order to meet the required production rate. The results showed that one workstation and 2 workers could be eliminated. Labor savings were 8.3 percent and takt time was reduced to 1.20 second. Productivity was increased by 5.2 percent. Moreover, the assembly line performance was increased to 84.93 percent.

Keyword: Coffee kit, Assembly Line, Balancing, Increase productivity.

1. Introduction

Currently, coffee has been known to have effect to people. Finland and Norway are the top of the world's biggest coffee drinkers, 12 kg and 9.9 kg per capita per year respectively. Today, Thailand is one of the top coffee producers and has exported roasted coffee bean to Poland and United State, 82 percent of total coffee exports. A coffee export amount to the United States is higher than to Poland. Vietnam has become the second largest and one of the fastest growing coffee exporters, which has become our major coffee export's competitor. Vietnam had become the world's second coffee producer after Brazil and Vietnam Robusta has been exported worldwide. However, the coffee business in Thailand is still growing because Thai people enjoy drinking coffee. If the price of coffee is not much expensive, they will be able to drink coffee everyday so that the coffee business in Thailand will continue to grow strongly in the years ahead. Thailand produces both Robusta coffee and

Arabica coffee. The South of Thailand had already become big players in the coffee industry growing Robusta, in Krabi, Surat thani, Chumphon, and Ranong provinces and Arabica coffee is grown mainly in the north, Chiang Mai and Chiang Rai provinces. Thailand produces more tons of Robusta than Arabica. That is why coffee Arabica price is higher than coffee Robusta and the Arabica coffee grown in Thailand is mainly consumed in Thailand. Agricultural Research Development Agency (ARDA). A mixture of instant coffee or 3 in 1 coffee is mostly produced by small and midsize enterprises with the support of Thai government. In 2016, Thai government launched the project namely [1], "Increase Manufacturing Production Capacity in an Industry". The aim of the project is to support small and midsize enterprises for increasing production capacity. There were a number of expertizes and researchers who participated in this project and helped the companies by giving useful recommendations about the causes of production losses in manufacturing in order for them to enhance productivity and decrease losses in each stage of the product life cycle or service. There were 8 companies that participated in the project. One of the company is an instant coffee company. The company needs to increase its production in each stage of the product life cycle. Interestingly, this company has been certified by ISO : 22000 : 2005 - Food safety, Good Manufacturing Practices (GMP), Hazard Analysis Critical Control Point (HACCP), Corporate Social Responsibility(CSR). The sample of instant coffee mix and coffee cups are shown in Figure 1.

Fig. 1. Instant coffee products

This company uses a conveying machine for making a complete set of instant coffee or coffee kit (including cocoa, and other products). An instant coffee kit consists of instant coffee, non-dairy creamer, coffee cup, and coffee stirrer. The company still uses workers working in each stage of the assembly line (manual packing). Nowadays, the company is facing some problems such as low productivity, number of workers, and high cost of employee. The aim of this research is to measure and increase productivity at the assembly lines by making a balanced workflow. The productivity must be improved and increased at least 5 percent and number of workers can be reduced. Figure 2 presents a group meeting and figure 3 presents the problem investigation in the assemble line. The productivity must be improved and increased at least 5 percent

Fig. 2. A group meeting

Fig. 3. Problem investigation in the assembly line

The aim of assembly line balancing is to minimize production cycle time and create a well-balanced operation to each station [2]. Assembly line balancing using Differential Evolution (DE) techniques in garment production or textile industry can be used to solve variety of textile problems and productivity is increased [3]. Assembly line efficiency can be determined. An efficient heuristic method for the assembly line balancing problem was proposed. Researchers applied the maximum acceptable time to meet the demands of the customer and minimize the balance delay of an assembly line[4]. Finally, productivity was increased by 27.18 percent.

2. Research Methodology

The process of organizing consists of following 6 steps.

2.1 Study the existing process of making an instant coffee kit, observe and evaluate a workers' performance in assembly line from VDO recorder, analyze processing time allocated for each process to determine the proper time interval

2.2 Propose suitable solutions by analyzing the balance of making coffee kit in an assembly line (using method study for Reducing cycle time) by Heuristic method and Largest Candidate Rule and find maximize performance by using equation (1). Total cycle time (Tj) ; Number of workstations (m) Maximum time (Max(Ti)) [5], [6]

$$\text{Max P} = \text{Max}\left[\frac{\sum_{j=1}^{n} Tj}{m \cdot \text{Max(Ti)}} X100\right] \quad (1)$$

2.3 Train the workers to understand the process of the performance improvement plan

2.4 Monitor the outputs after amendment and revision process

2.5 Evaluate the expected outcomes

2.6 Make a final conclusion

3. Data Collection

The flow process of making instant coffee kit as shown in figure 4 consists of the followings: prepare coffee, coffee stirrer, non-dairy creamer, sugar; put them into a paper coffee cup; lid on a coffee cup; wrap a cup with shrink film and fill them in a paper tray and wrap it with shrink film; put them into box and put the box on a palette and transported by roller conveyor. The assembly line consists of 13 steps.

The number of workers in each step or workstation were collected as shown in Table 1. We found that we have many workers in steps 5-8, which leads to operations having to wait for product to be delivered due to delays (the waste of waiting). We investigate the impact of controlled imbalance levels on assembly lines.

It can be found that there are 24 assembly line workers in charge of producing product.

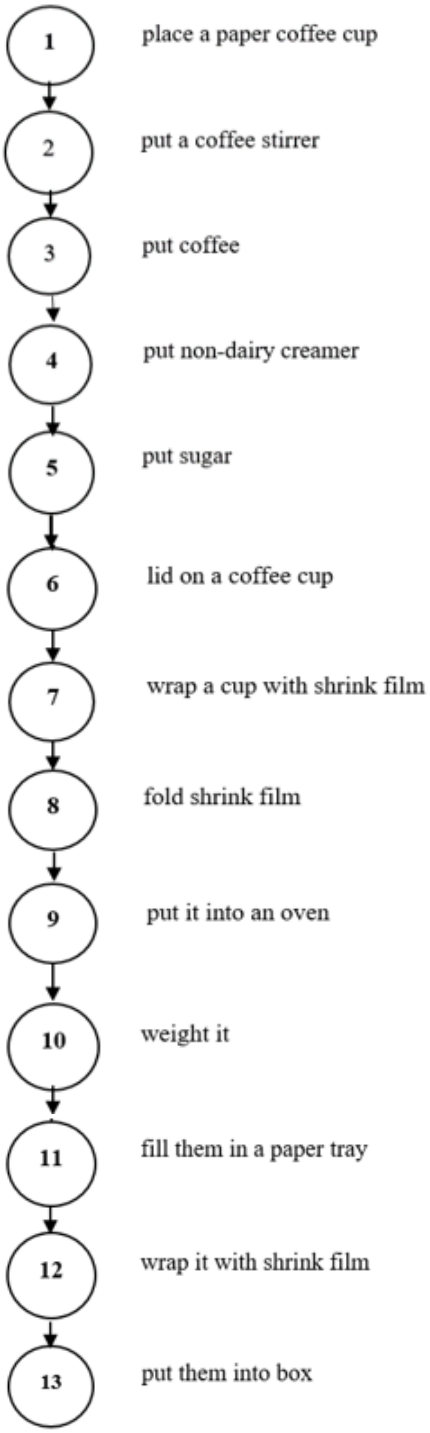

Fig. 4. The flow process of making instant coffee kit

Next, we measure the time of each step and also total time for a complete set on production. We measure 10 times and compute the average using equation (2) and find samples size using equation (3) at a 95% confidence level[7], [8].

TABLE I

No. of workers in each step (Existing procedure)

Step	Procedure	No. of worker(s)
1	place a paper coffee cup	1
2	put a coffee stirrer	1
3	Put coffee	1
4	Put non-dairy creamer	2
5	put sugar	3
6	lid on a coffee cup	2
7	wrap a cup with shrink film	4
8	fold shrink film	4
9	put it into an oven	1
10	weight it	2
11	fill them in a paper tray	1
12	wrap it with shrink film	1
13	put them into box	1
Total		**24**

$$\text{Mean} = \frac{\sum_{i=1}^{n} Xi}{N} \quad (2)$$

$$\text{Sample Sizes (N)} = \left[\frac{40\sqrt{n\sum X^2 - (\sum X)^2}}{\sum X}\right]^2 \quad (3)$$

Table 2 shows that step 6 (lid on a coffee cup) uses 1.266 seconds which can cause the bottleneck and delay further steps. It has a significant impact on the overall performance of an assembly line.

TABLE II

Average time for each step (Existing procedure)

Step	Procedure	Average Time Seconds
1	place a paper coffee cup	1.136
2	put a coffee stirrer	1.083
3	Put coffee	1.056
4	Put non-dairy creamer	1.181
5	put sugar	0.720
6	lid on a coffee cup	1.266
7	wrap a cup with shrink film	0.587
8	fold shrink film	0.593
9	put it into an oven	1.200
10	weight it	0.688
11	fill them in a paper tray	1.014
12	wrap it with shrink film	0.893
13	put them into box	0.923
Total cycle time		**12.34**

The overall performance of an assembly line (P) is computed as shown in equation. Total cycle time (Tj) = 12.34 seconds. Number of workstations (m) = 13 stations. Maximum time (Max(Ti)) = 1.266 seconds

$$P = \frac{(12.34)(100)}{(13)(1.266)}$$

$$= 74.97\ \%$$

4. Acknowledgement Improvement of the overall performance of an assembly line

The overall performance of an assembly line was analyzed by observing on production line behavior and workers' behavior through VDO recorder[9], [10]. Then the processing time of each station was recorded and analyzed by using the principle of ECRS (Eliminate, Combine, Rearrange, Simplify)[11]. It was used at the level of process, operation and motion. ECRS is one of the motion study technique used to improve production lines. ECRS processes activities with the following core principles: E = Eliminate unnecessary work, C = Combine operations, R = Rearrange sequence of operations, S = Simplify the necessary operations[12], [13]. The proposed solution was built for target product and process to identify and improve the bottleneck[14], [15]. There were 8 workers who worked in the step 7 (wrap a cup with shrink film) and step 8 (fold shrink film) so that both steps could be combined (see figure 5). We can see that the step 7 and 8 spent less time on the average. When both steps were combined, we needed only 6 out of 8 workers and took 1.180 seconds which required less processing time than step 6 (lid on a coffee cup). In step 5 (put sugar), there were 3 workers and spent 0.720 seconds per unit. When it was compared with the total average time, we found that the processing time in step 5 was the lowest. We could reduce the number of workers from 3 to 1. The processing time was increased by 0.956 seconds. Then we could move 1 worker to work in step 6, the

processing time in step 6 was reduced from 1.266 to 0.924 seconds[16], [17].

Fig. 5 Step 7 (wrap a cup with shrink film) and step 8 (fold shrink film)

We also offered to conduct training for workers on what performance loss and Kaizen, which are shown in Figure 6. They will be able to measure the process time and burden in each step. The detail is shown in the list below.

Fig. 6 Training for workers on what performance loss and Kaizen

- Place a paper coffee cup into a box, we should adjust the proper position of the box placement by adjusting the height of the box placement.

- Put the coffee and non-dairy creamer, the working styles in these 2 steps looks similar but they are not. We study the characteristic of both steps based on accuracy and processing time and then we select the best one as the standard process used for both steps.

- Lid on a coffee cup, damaged lids are separated and placed into another box to avoid mixture of damaged and good ones.

- Put into an oven, a place is prepared for a basket before putting it into an oven to ensure that it will not fall down.

5. Results

After improving the overall performance of an assembly line and training workers, the processing time for each step was presented in Table3 as shown below. The overall performance of an assembly line is computed again after improvement as shown in equation (3).

Total time (Tj) = 12.216 seconds

Number of work stations (m) = 12 stations

Maximum time (Max(Ti)) = 1.2 seconds

TABLE III

Comparison of the performance of an assembly line (before and after improvement)

Step	Procedure	Average Time Seconds(s)		Number of Worker (s)	
		Before	After	Before	After
1	place a paper coffee cup	1.136	1.136	1	1
2	put a coffee stirrer	1.083	1.083	1	1
3	Put coffee	1.056	1.056	1	1
4	Put non dairy creamer	1.181	1.181	2	2
5	put sugar	0.720	0.956	3	2
6	lid on a coffee cup	1.266	0.924	2	3
7+8	wrap a cup with shrink film + fold shrink film	0.587 0.593	1.181	8	6
9	put it into an oven	1.200	1.200	1	1
10	weight it	0.688	0.688	2	2
11	fill them in a paper tray	1.014	1.014	1	1
12	wrap it with shrink film	0.893	0.893	1	1

13	put them into box	0.923	0.923	1	1
Total cycle time		12.320	12.216	24	22

So that ; P = $\frac{(12.216)(100)}{(12)(1.20)}$

= 84.83 %

(increasing 9.86 %)

Labor saving = $\frac{(24-22)(100)}{(24)}$

= 8.30 %

Increased productivity = $\frac{1.266-1.20}{1.266}(100)$

= 5.20 %

Comparison of average time and number of workers before and after improvement at each workstation can be shown as a graphical presentation in Figure 7 and Figure 8.

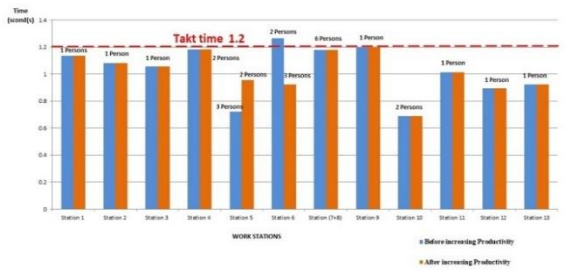

Fig. 7 Comparison of average time and number of workers before and after improvement.

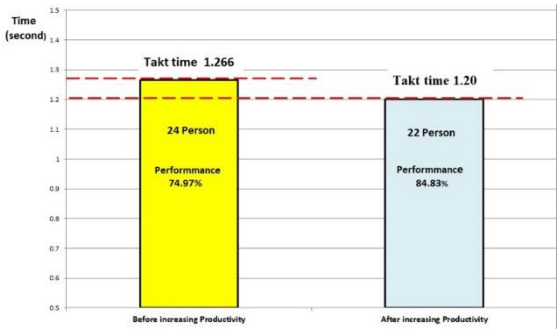

Fig. 8 Comparison of Takt time, number of workers and performance before and after improvement.

6. Conclusion

There are 13 stations for making instant coffee kit in a straight assembly line. The processing time spent for each step or workstation is different. It leads to operations having to wait for product to be delivered due to delays (waiting in queue). It causes in a loss in production time. Before improvement, there are 24 assembly line workers (manual packing). After improvement, we found that the step 7 (wrap a cup with shrink film) and step 8 (fold shrink film) can be combined. There are 22 out of 24 workers in an assembly line. Labor cost saving decreases by 8.3 percent. Maximum time is 1.2 seconds. Productivity has been increased by 5.2 percent. The overall productivity has been increased by 13.5 percent. Further study, the processing time in step 9 (put it into an oven) should be reduced. We need to improve worker performance and skill in the process that has been expensive and time-consuming.

References

[1] Department of Skill Development, Pathum Thani. “Project to Increase Labor Productivity to SME 4.0,” 2016.

[2] M. A. H. Riyadh and Y.A.M. Jassim, “Selection of balancing method for manual assembly line of two stages gearbox,” Global Perspectives on Engineering Management, vol. 2, pp. 70-81, 2013.

[3] R. Wilaiwan, “Line Balancing in a small Diesel Engine Assembly Plant with Consideration on the Local Content Government Regulations,” AIT, Thesis, AIT, Bangkok Thailand, 1976.

[4] P. Lalhitaporn, “Planning System and Production Control,” Edition 8th. Bangkok: Technology Promotion Association (Thailand-Japan), 2002.

[5] J. Krunkarn , “Heuristic Method for Assembly Line Balancing a Case Study in Refrigerator Factory,” Journal of Kasem Bundit University, 5(2), pp. 56-68, 2015.

[6] C. Saroungkarasiri.”Production and Planning Control,” Edition 15th. Bangkok: Technology Promotion Association (Thailand-Japan), 2007.

[7] A. L. Arcus, “COMSOAL: a computer method of sequencing operations for assembly lines,” International Journal of Production Research, vol. 4, pp. 277-259, 2012.

[8] J. Heap, “Stormy productivity weather ahead,” International Journal of Productivity and Performance Measurement, 56(2), pp. 170-177, 2007.

[9] S, Biswas, A. Chakraborty and N. Bhowmik, “Improving Productivity Using Work Study Technique,” International Journal of Research in Engineering and Applied Sciences, vol. 6, pp. 49-55, 2016.

[10] Hamid TKA., “The slippery path to productivity improvement,” IEEE Software, vol.13, pp. 43-52, 1996.

[11] RS. Raut and HM. Deshmukh, “Productivity improvement of a prestress concrete pole plant using work study technique,” International Journal of advanced Technology in Engineering and Science, vol.2, pp. 496-508, 2014.

[12] PA. Ozor, LOO. Chibuike, O. Orji and KO. Chimaobi, “Productivity Improvement of Small and Medium Scale Enterprises using Lean Conceptâ :Case Study of a Bread actory,” European Journal of Business and Management, vol. 7, pp.73-84, 2015.

[13] PV. Chandra, “An Effort to Apply Work and Time Study Techniques in a Manufacturing Unit for Enhancing Productivity,” International Journal of Innovative Research in Science, Engineering and Technology, vol. 2, pp.4050-4058, 2013.

[14] PP. Kulkarni, SS. Kshire and KV. Chandratre, “Productivity Improvement Through Lean Deployment and Work Study Methods,” International Journal of Research in Engineering and Technology, vol. 3, pp.429-434, 2014.

[15] KN. Hassanali, “A Productivity Model Utilising a Work Study Approach for Performance Measurement,” The Journal of the Association of Professional Engineers of Trinidad and Tobago, vol. 40, pp.13-25, 2011.

[16] N. Kumar and D. Mahto, “Productivity Improvement through Process Analysis for Optimizing Assembly Line in Packaging Industries,” Global Journal of Researches in Engineering Industrial Engineering, vol. 13, pp. 1-17, 2013.

[17] M. Khatun, Murshida, “Effect of Time and Motion Study on Productivity in Garment Sector,” International Journal of Scientific and Engineering Research, vol. 5, pp. 825-833, 2014.