Mathematical Statistician and Engineering Applications
ISSN: 2094-0343
2326-9865

Process Improvement in Sugar Packing Process by using Simulation Techniques.

[1] PUTIS WITTAYASIN, [2] PAVEE SIRIRUK

[1] Student of School of Industrial Engineering, [2] Chair, School of Industrial Engineering
Institute of Engineering
Suranaree University of Technology
Nakhon Ratchasima, Thailand
[1] putiss999@gmail.com, [2] pavee@g.sut.ac.th

Article Info
Page Number: 6392-6404
Publication Issue:
Vol. 71 No. 4 (2022)

Article History
Article Received: 25 March 2022
Revised: 30 April 2022
Accepted: 15 June 2022

Abstract

This research aims to improve the sugar packing process to increase the rate of sugar production using simulation techniques based on the concept of line balancing. The current production line has bottlenecks, which result in the turnover of the product unit exceeds the time target. The study began with the study of the behavior in each process. The cycle time data of each process was collected and found that one process exceeded the standard cycle time of this product. Therefore, causes of the problems in sugar packing process were analyzed to increase production rates by using simulation techniques. A total of seven alternative cases were studied, compared to the current production line. The results show that the best investment option is option 5 by installing one automatic stacker and running at a speed of 140 bags/min will have a production rate that is 8.53% higher than the current line. Installing only one automatic stacker has lower cost and faster payback period than adding 2 machines, which is just 11.92% higher than the current line.

Keywords: Line Balancing, Simulation

1. INTRODUCTION

Over the past two decades (2000-2019), global sugar production and consumption has continued to increase as a result of the world population increased to 7.7 billion in 2019 from 6.1 billion in 2000, and Increased demand for sugar from other industries (such as food, beverages, and ethanol).

In 2021-2023, Thailand's sugar industry tends to improve accordingly. The world economy and Thailand gradually recovered. Sugar consumption in the country will be around 2.5-2.6 million tons per year, an average increase of 2.0-3.0% per year, driven by the gradual recovery of the domestic economy. As the spread of COVID-19 became pandemic, the demand for sugar increases, which is used to make alcohol disinfectants, and demand for ethanol in the transportation sector that will increase in line with the recovery of economic activities. Moreover, The government measures to support the use of ethanol as an ingredient in gasohol. The export of sugar will be at 7-8 million tons per year, an average increase of 10.0-15.0% per year due to the recovery of the global economy. [Source of business/industry Year 2021/2023 Sugar Industry, Bank of Ayudhya Research Center.]

The case study of a sugar factory, producing raw sugar, white sugar, and refined sugar, is considered. The production process of refined sugar that is used to pack 1 kg bags consists of the following production processes: 1. Raw sugar dissolving process 2. Color reduction process 3. Filtering process 4. Evaporation boiling process 5. Crystallization simmering process 6. Spinning process 7. Dehumidification drying process 8. Packing process 9. Storage process 10. Transportation process, respectively. From the production data of 1 kg of refined sugar in 2020, the production plan is 11,762 tons but the actual production capacity is 10,525 tons, or 89.48%. In addition, the production data for the year 2021, the production plan is 18,250 tons but the actual production is 15,097 tons, representing 82.72%, which is lower than the target.

Using the production line balancing technique, it was found that the actual production time of the filling process exceeded the target. The packaging process consists of the following sub processes: 1.Packing process 2. The process of arranging sugar bags into sacks 3. Sack sewing process 4. The process of carrying a sling line.

Therefore, the factory has an objective to improve the layout of packing department in production process and comparing with an alternative of buying an automatic machine to sort 1 kg bags and stack them in 25 kg sacks by using simulation techniques. With simulation, operators involve in the packing process can understand the packing process workflow, observe wastage in the process, and find methods to improve the packing process without the need to experiment with real systems. This saves experimentation time than other modern improvement techniques. Cause and effect diagram together with line balancing technique are used to analyze problems and causes to find and solve the bottleneck problem in production process. Therefoe, the production process meets factory target.

1.1 Objectives

This research aims to study the production process, applying a simulation software to improve a production process. The study focuses on the process of packing 1 kg of sugar to increase the production capacity by 5% and reduce the number of employees.

2. Literature Review

At present, the production efficiency is increased because the production rate is not according to the customer's requirements. Most of the process improvement methods use line balancing technique and ECRS principles to improve production process. The differences are problem analysis, root causes, and design of experiment to get results.

Sanguansap (2017), using VA, NNVA, NVA method to analyze problems in the production process, collect data, and experimentally improve from the actual site [1].

Kiatnukul (2018), Jongjun (2012), and Jongjun (2017) are analyzed for the problem causes by using fishbone chart and design equipments to reduce wastes in the production process. Data collection and improvement are developed in real workspaces [2] [3] [4].

As for Kesarapong (2008), uses techniques of fishbone chart, 5W1H, right and left hand chart, man machine chart to analyze the problems and the causes of the problems. Data were collected from real working environment and use the Storm software to analyze data [5].

Chueprasert and Ongkunaruk (2015) analyzed the causes of the bottleneck in workplace. Data was collected and improve experiments from real locations by comparing methods that provide optimal production line efficiency for a reasonable reduction in direct labors and reasonable costs. The results are compared before and after the improvement. All experimental results can help reduce cycle times resulting in a more balanced production line [6].

Currently, simulation software is being used for experimentation because it can save time and does not have to be tested from a real location. Islam, Sarker, and Parvez (2019) used Tecnomatix simulation software to experiment with layout improvements to find the right balance of production line and cost [7]. Amit, Suhadak, Johari, and Kassim (2012) used simulation ARENA software to experiment with layout improvements to find the best solution [8].

Flexsim Simulation is a program that is recently popular in layout experiments to find bottlenecks. Syahputri, Sari, Rizkya, Tarigan, and Agustin (2021) used Flexsim simulation software to compare the actual workflow simulation with the program values. The result showed that there was a deviation of 12% [9]. Sangsawang (2021) uses Flexsim Simulation program to experiment and analyze the cause by balancing the production line technique. This results in the best choice in the production process [10]. Hassan, Muhammad, and Dagwa (2020) uses Flexsim simulation software to find the bottleneck and to improve the layout of the production process by adding machinery in the bottleneck point, resulting in increased production capacity in the production process process [11]. Kumar and Narayan (2015) also used Flexsim simulation software to improve the layout of the production process by reducing the distance between the stations along with cost analysis. Results showed that the best choice in production can increase production capacity [12].

In this research, the case study of sugar packing process in a factory is considered. The line balancing technique, fishbone diagram, and Flexsim simulation software are used to analyze the problem root casuses, bottlenecks, and layout improvement in the production process.

3. Methods

3.1. Data Collection

The packaging process consists of the following sub processes: 1.Packing process 2.The process of arranging sugar bags into sacks 3. Sack sewing process 4. The process of carrying a sling line.

The packing room is divided into 2 production lines. The auto packing machine lines 1, 2, and 3 as well as auto packing machine lines 4 and 5. As shown in Figure 1,2,3

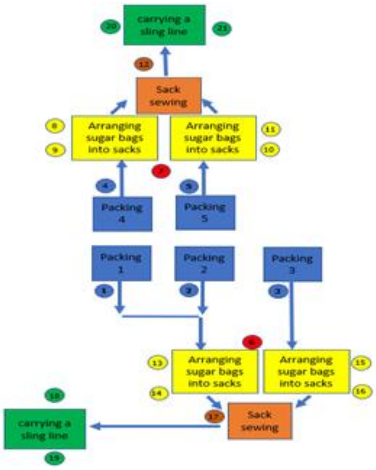

Figure 1. Current production line layout inside the packing room.

Figure 2. Packing process ,The process of arranging sugar bags into sacks and Sack sewing process

Figure 3. The process of carrying a sling line.

From the survey of the current production process, data of inputs, process, and time of sugar packing process are shown in Table 1. The daily target of 145,000 bags (Kg) is set, while the actual output is 123,125 bags per day.

Process	**Man**	**Machine**
Packing	5	5
Arranging sugar bags into sacks	8	-
Sack sewing	2	2
Carrying p-sling	4	-
	Time (minute/day)	
Working time	1,140	
Set up of the machine	60	
Change the film roll	60	
Change the tape	50	
Change the ribbon	24	

Table 1. shows data of the current state

3.2 Line Balancing

The cycle times of current production process of auto lines 1, 2, 3, 4, and 5 are shown in Figure 4, 5

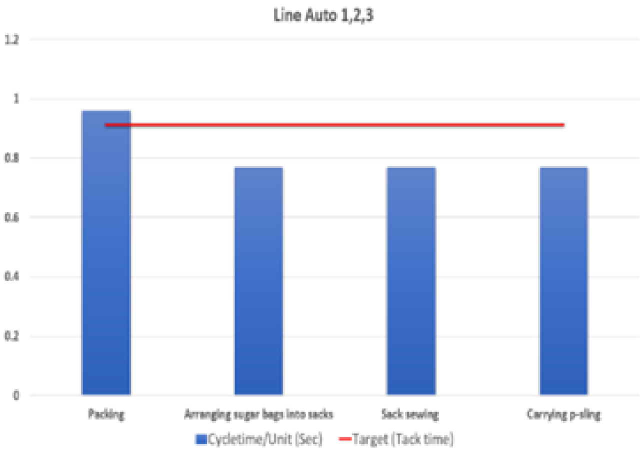

Figure 4. Production cycle time of line auto 1,2,3

ISSN: 2094-0343
2326-9865

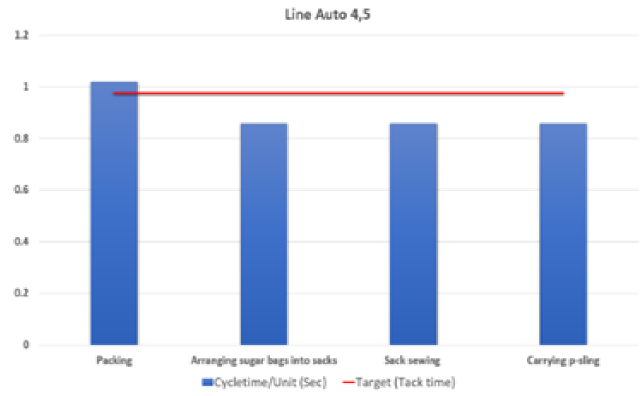

Figure 5. Production cycle time of line auto 4,5

3.3 Cause and Effect diagram

A cause-and-effect diagram (Fish bone diagram) is a tool that shows the relationship between a problem and all possible causes. It was first developed in 1943 by Professor Kao. Ruishikawa of the University of Tokyo. The Japanese Industrial Standards Agency (JIS) defines the meaning of this fishbone chart as: It is a diagram used to show the systematic relationship between possible causes that affect one problem.

From the study and causal analysis with fishbone chart about packing that did not meet the target, it was found that There are important reasons: 1. From the environment is improper layout 2. From the method is that the working hours of factory workers and contractors are different 3. From improper production line balance. As shown in Figure 6.

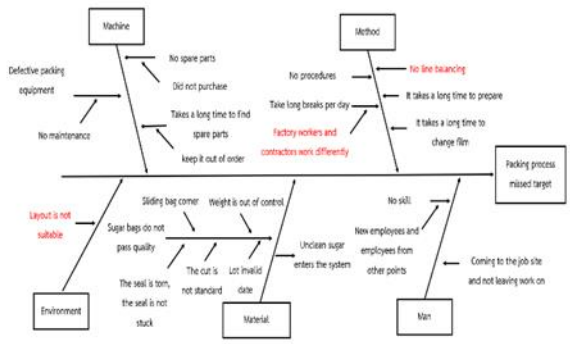

Figure 6. Causes and effects diagram of packing process missed target

3.4 Flexsim Simulation

Flexsim is a program to create 3D simulation scenarios in real time of various working systems. It is generally used to improve production process to reduce costs and time and increase the efficiency of work as well.

The study will gather sample data and insert data into the Flexsim program by dividing the simulation into 7 cases and run the program in all 7 cases to find the best alternative, comparing with the current production process as follows.

1. Simulate the current production process by increasing the working time by 1 hour

2. Simulate the process by rearranging the layout and adding an automatic 1 kg bag sorting machine into a 25 kg sack, running the machine at a speed of 110 bags/min.

3. Simulate the process by rearranging the layout and adding an automatic 1 kg bag sorting machine into a 25 kg sack, running the machine at a speed of 120 bags/min.

4. Simulate the process by rearranging the layout and adding an automatic 1 kg bag sorting machine into a 25 kg sack, running the machine at a speed of 130 bags/min.

5. Simulate the process by rearranging the layout and adding an automatic 1 kg bag sorting machine into a 25 kg sack, running at a speed of 140 bags/min.

6. Simulate the process by rearranging the layout and adding two 1 kg bag sorting machines into a 25 kg sacks, running at a speed of 110 bags/min.

7. Simulate the process by rearranging the layout and adding two 1 kg bag sorting machines into a 25 kg sacks, running at a speed of 120 bags/min.

4. Result and Discussion

The study will gather sample data and insert data into the Flexsim program by dividing the simulation into 7 cases and run the program in all 7 cases to find the best alternative, comparing with the current production process.

The current production process is simulated in the program. Test results show that the quantity of 25 kg sugar sacks, produced from line 1, 2, and 3, equals to 2,601 sacks and line 4 and 5 equals to 2,324 sacks as shown in Figure 7.

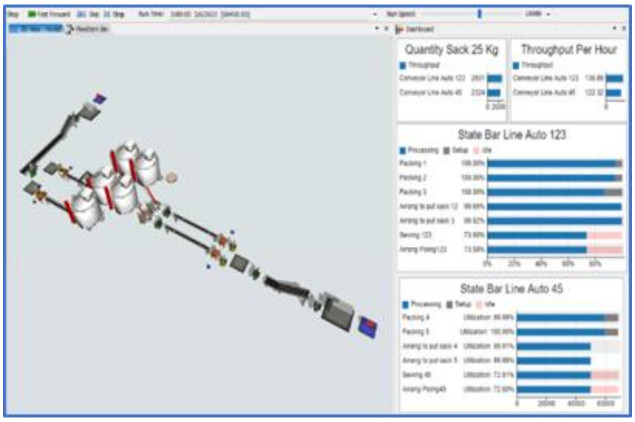

Figure 7 Simulates the current packing process.

Case 1 simulates the current process situation. by increasing the working time by 1 hour. The test results showed that The quantity of 25 kg sugar sacks produced from line auto 1,2,3 is 2,751 sacks and line auto 4,5 is 2,465 sacks, as shown in Figure 8. The resulting increase production rate (%) is 5.91%, Employee (man/day) is 42, Payback period is 0.2 year.

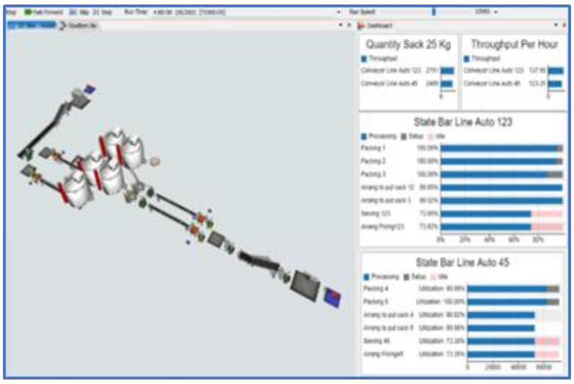

Figure 8 Case 1.

Case 2 simulates the situation by rearranging the layout and adding a 1 kg bag sorter, an automatic 25 kg sack, and runs the machine at a speed of 110 bags/min. The test results show that The quantity of 25 kg sugar sacks produced by combining Line Auto 1,2,3,4,5 is 4,699 sacks as shown in Figure 9. The resulting increase production rate (%) is -4.59 % , Employee (man /day) equals 26 , Payback period is 15.1 years.

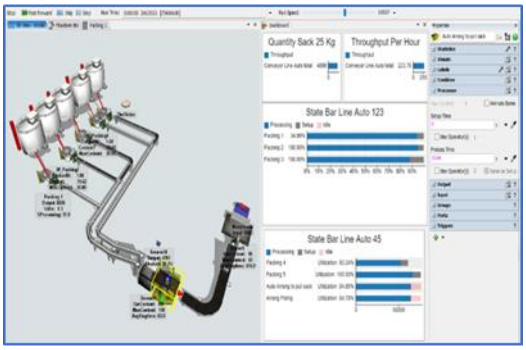

Figure 9 Case 2.

Case 3 simulates the situation by rearranging the layout and adding a 1 kg bag sorter, an automatic 25 kg sack, and runs the machine at a speed of 120 bags/min. The test results show that The quantity of 25 kg sugar sacks produced by combining Line Auto 1,2,3,4,5 is 4,959 sacks as shown in Figure 10. The result is increased production rate (%) equal to 0.69 % , Employee (man/ day) is 26 , Payback period is 5.8 years.

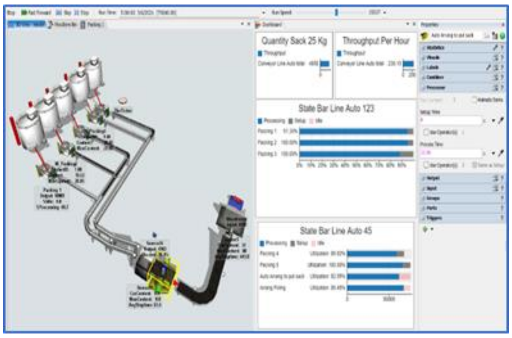

Figure 10 Case 3.

Case 4 simulates the situation by rearranging the layout and adding a 1 kg bag sorter, an automatic 25 kg sack, and runs the machine at a speed of 130 bags/min. The test results show that The quantity of 25 kg sugar sacks produced from the integration of Line Auto 1,2,3,4,5 is equal to 5,190 sacks as shown in Figure 11. The result has increased production rate (%) is 5.38 % , Employee (man/ day) is 26 , Payback period is 3.8 years.

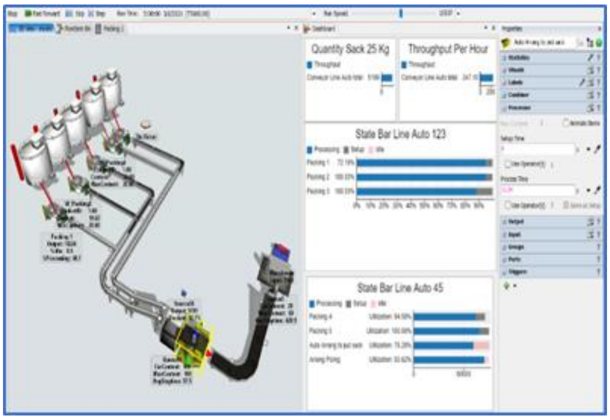

Figure 11 Case 4.

Case 5 simulates the situation by rearranging the layout and adding a 1 kg bag sorting machine, an automatic 25 kg sack, and running the machine at a speed of 140 bags/min. The test results show that The quantity of 25 kg sugar sacks produced from the integration of Line Auto 1,2,3,4,5 equals 5,345 sacks as shown in Figure 12 Increase production rate (%) is 8.53 % , Employee (man/day) is 26 , Payback period is 3 years.

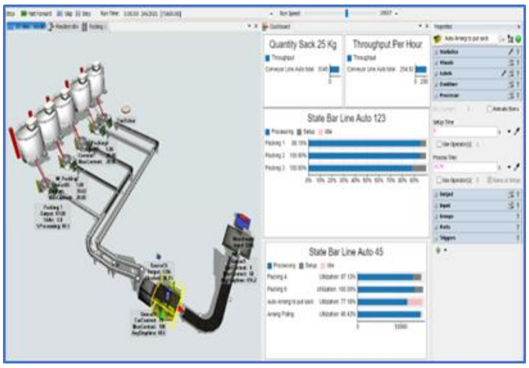

Figure 12 Case 5.

Case 6 simulates the situation by rearranging the layout and adding a 1 kg bag sorting machine, automatically inserting 2 25 kg sacks and running the machine at a speed of 110 bags/min. The test results show that The quantity of 25 kg sugar sacks produced from the integration of Line Auto 1,2,3,4,5 are 5,512 sacks as shown in Figure 13. Increase production rate (%) is 11.92 % , Employee (man/day) is 30 , Payback period is 4.7 years.

Figure 13 Case 6.

Case 7 simulates the situation by rearranging the layout and adding a 1 kg bag sorting machine, automatically inserting 2 25 kg sacks and running the machine at a speed of 120 bags/min. The test results show that The quantity of 25 kg sugar sacks produced from the integration of Line Auto 1,2,3,4,5 are 5,512 sacks as shown in Figure 14. Increase production rate (%) is 11.92 % , Employee (man/day) is 30 , Payback period is 4.7 years.

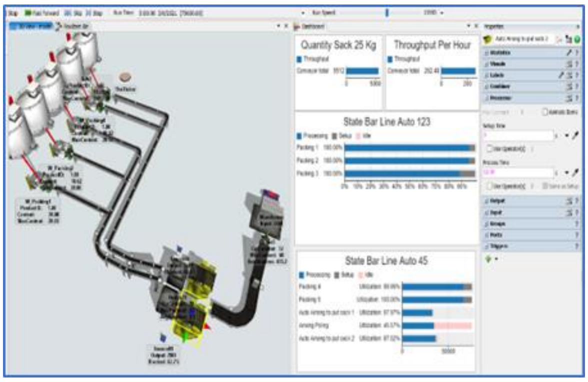

Figure 14 Case 7.

The results in all 7 cases after improvement in production efficiency, using simulation programs with the payback period, can be summarized as shown in Table 2 And Table 3.

Table 2. shows volume simulation results

Case	**Process**	**Infeed Speed (bags/min)**	**Packaging (bags/day)**	**Sugar (ton/day)**	**Sugar (ton/year)**	**Sugar recovery (ton/year)**
	Current production line		4,925	123.12	36,938	
1	**Increase working time (1 hour)**		5,216	130.4	39,120	2,182.50
2	**Install secondary**	110	4,699	117.47	35,243	-1,695
3		120	4,959	123.97	37,193	255

4	**packing machine 1 set**	130	5,190	129.75	38,925	1,987.50
5		140	5,345	133.625	40,088	3,150.00
6	**Install secondary packing machine 2 set**	110	5,512	137.8	41,340	4,402.50
7		120	5,512	137.8	41,340	4,402.50

Table 3. shows payback period and employee results

Case	**Process**	**Increase production rate (%)**	**Employee (man/day)**	**Reduce Employee (%)**	**Payback period (year)**
	Current production line		42		
1	**Increase working time (1 hour)**	5.91	42	-	0.2
2	**Install secondary packing machine 1 set**	-4.59	26	38.10	15.1
3		0.69	26	38.10	5.8
4		5.38	26	38.10	3.8
5		8.53	26	38.10	3.0
6	**Install secondary packing machine 2 set**	11.92	30	28.57	4.7
7		11.92	30	28.57	4.7

The comparison between installing 1 automatic machine (cases 2, 3, 4, and 5) and installing 2 automatic machines (cases 6 and 7) indicates that installation of 2 automatic machines has higher investment and longer payback period (4.7 years comparing with 3 years) than installing 1 automatic machine. Installing 2 automatic machines requires larger working areas and the number of employees increase from 26 to 30.

Installing 2 automatic machines can increase the production rate by 11.92%, comparing with the current production line. While installing 1 automatic machine, we can increase the production rate by 8.53% comparing with the current production line. The best alternative is to install 1 automatic machine as installing 2 automatic machines gains little production rate (3.39%) but an investment is much higher. Therefore, case 5 (installing 1 automatic machine and running at a speed of 140 bags/min) is chosen as the best alternative with 26 employees and 3 years of payback period.

5. Conclusion

In this research, the problem encountered in the case study factory was that the production volume was not meeting the target. The data was collected from the actual location. The fishbone diagram and line balancing technique are used to identify problems and process bottlenecks. Flexsim simulation program is used to simulate the situations in all 7 cases. Comparing current production line with all case studies, the best alternative is case number 5 which installs additional 1 automatic sorting machine with a speed of 140 bags per minute, which increases the production rate by 8.53% with 26 employees per day and a payback period of 3 years.

REFERENCES

[1] .Sompratana Saisanguamsub Process Improvement By Production Line Balancing Case Study of Closed Circuit Television Assembly Process. An Independent Study The Degree of Master of Engineering Industrial Development Department of Industrial Engineering Faculty of Engineering Thammasat University Academic Year ,2017.

[2] .Warin Kiatnukul . A Line Balancing of the Aluminium Frame Assembly Processes Case Study: A Sample Company. Department of Industrial Engineering, Faculty of Engineering, Mahanakorn University Thai Industrial Engineering Network Journal Year 4 Issue 1 January-June ,2018

[3] Yuthanarong jongjun. Yodnapha ketmuang. Nara buripun. Production Balancing Line for Reducing Waste In Process Production Maintain Mounting Dump. Department of Industrial Engineering, Faculty of Engineering, Thonburi University. Industrial Engineering Network Academic Conference 2012 October 17-19, 2012.

[4] Yuthanarong jongjun, Methee Promsila, Seksan Singthanu, Peema Pornprasert. An Improvement of Car Seat Grips Assembly ProcessBy Applying the Line Balancing Principle. Thai Industrial Engineering Network Journal.Year 3 Issue 2 July–December , 2017.

[5] Suphattra Ketsarapong. Enhance Productivity in Cooker Production Line by Applying Work Improvement Method and Line Balancing. Department of Industrial Engineering, Faculty of Engineering, Sripatum University. 2008 Industrial Engineering Network Academic Conference 20-22 October , 2008.

[6] Chueprasert, M. and *Ongkunaruk, P. Productivity improvement based line balancing: a case study of pasteurized milk manufacturer. International Food Research Journal 22(6): 2313-2317 , 2015.

[7] Md. Sadekul Islam . Production Efficiency Improvement by Using Techomatix Simulation Software and RPWM Line Balancing Technique. A Case Study. American Journal of Industrial and Business Management, 9, 809-820, 2019.

[8] Norani Amit, Nurulzulaiha Suhadak, Norzarina Johari and Assoc. Prof. Dr. Isahak Kassim .Using Simulation to Solve Facility Layout for Food Industry at XYZ Company . 2012 IEEE Symposium on Humanities, Science and Engineering Research, 2012.

[9] K Syahputri*, RM Sari, I Rizkya, U Tarigan, Agustina .Simulation of vise production process using Flexsim Software. IOP Conf. Series: Materials Science and Engineering 1122 (2021) 012036, 2021.

[10].Phtcharee Sangsawang. The Productivity Improvement in Seat Sewing Process by using Simulation Techniques Project The Degree of Master of Engineering of Industrial Engineering, System Engineering Program Suranaree University of Technology Academic Year, 2021.

[11] Nuruddeen Abdulhakeem Hassan, Ibrahim Dauda Muhammad, Ishaya Musa Dagwa. Simulation and Optimization of a Process Layout for Dehydrated Fruit and Vegetables Processing Plant Using Flexsim. Bayero Journal of Engineering and Technology (BJET) Vol.15 No.1, pp 99-106 , Jan, 2020.

[12] Sravan Kumar, Y. Shivraj Narayan .Productivity Improvement in a Windows Manufacturing Layout Using Flexsim Simulation Software. International Journal of Research in Advent Technology, Vol.3, No.9, E-ISSN: 2321-9637 September, 2015.