Line Balancing Analysis of a Multi-Products Processing with a Single Type of Supply

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Abstract

To compete in an ever growing manufacturing environment, companies have to improve their productivity. This study describes the improvement activities of an SME company in Kuantan, Pahang by using a line balancing technique. With these improvement techniques, the company managed to reduce the total time required to 70% and increased the production to 5%. This study also proposes processing line improvements, using simulation methods, by focusing on re-layout the workstations from an unsystematic arrangement of workstation to a single production line for each type of product and managing the workload distribution on the operators. Using a process simulation approach, this paper compares the performance of the production model using unsystematic arrangement production line with the single systematic arrangement of production lines. The feasibility of this solution is then discussed.

Keywords: line balancing, productivity, simulation, modelling, layout.

1. Introduction

Fish cracker is one of the famous and highly relished snack foods in Malaysia and it is well known and highly demanded. The high requirement of fish cracker in the market urge entrepreneurs to increase their production but they face a lot of problem to fulfill the market demand. In the production of fish cracker, most manufacturers are still using traditional manufacturing practices with low competitiveness and poor efficiency which limit the daily production of the fish cracker. As a result, these manufacturers cannot meet the demand of the customer.

Other challenge that will be faced by SME entrepreuners is the variability of demand and variability of product request from the customers. It is a dynamic situation to manage to avoid an excessive inventory. Some modification and improvement must be done to make the production system more flexible, so that it can satisfy the verification of customer demand . (Garn & Aitken, 2015)

One of the technique to optimize the production is by doing line balancing approach. It means put all of the working operation to the workstations on a specific way so that the workloads will be done optimally and remove bottleneck.(Zupan & Herakovic, 2015). With this line balancing process, the production time and cost can be reduced while the production output will be increased.(Mohamad, Ito, Salleh, & Nordin, n.d.)

2. Description of the existing system

In this study, two types of fish cracker have been produce which are keropok lekor and, keropok losong. In order to keep the quality while meeting the high production to provide the consumer demands of fish cracker, manufacturers need to apply a standard processing procedure. There are several stages of processing that are needed to be taken to make fish cracker as shown in Figure 1.

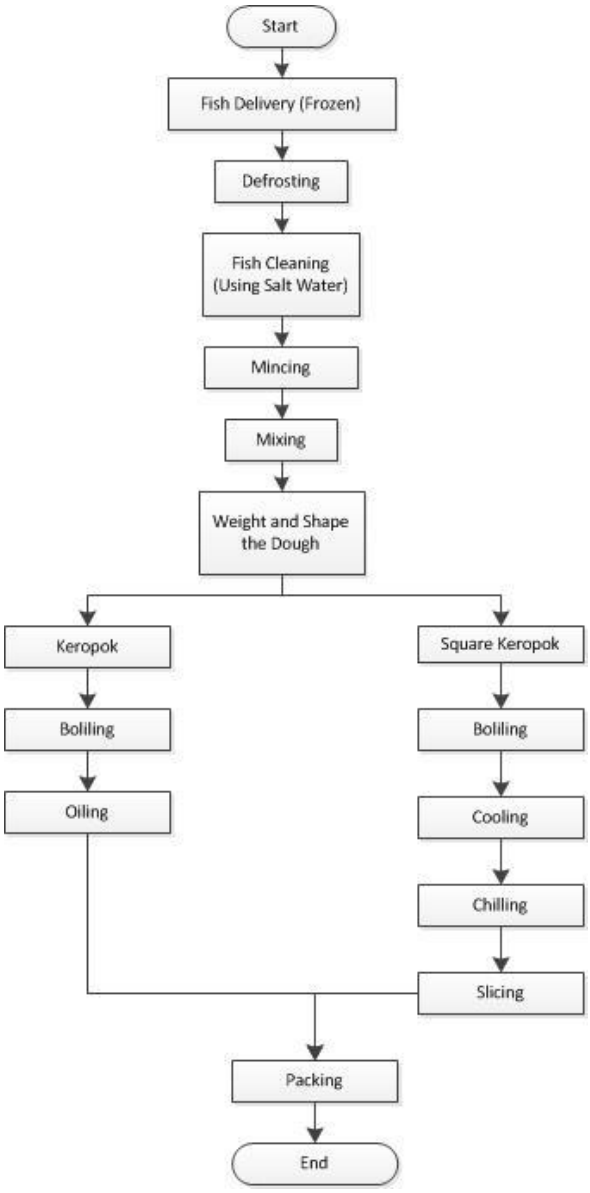

Figure 1. Process sequence in fish cracker manufacturing

These types of fish crackers produced at the same line and the production need to be analysed and optimized. Therefore, a line balancing method used to determine the problem occurred in the production line. A data of cycle time of all the process collected to perform line balancing technique. The total cycle time of each type of fish cracker are showed in Table 1 ,and Table 2 below.

Table 1: Time study for Keropok Lekor

Workstation	Process	Avg. Time Study (sec)
WS1	Mixing recipe	420
WS2	Weighing dough into specific weight	6.066
WS3	Dough shaping	11.4
WS4	Cooking	1380
WS5	Cooling and oiling process	480
WS6	Packaging	48.4
Total Cycle Time (sec)		2345.866

Table 2. Time study for Keropok Losong

Workstation	Process	Avg. Time Study (sec)
WS1	Mixing recipe	690
WS2	Weighing dough into specific weight	6.38
WS3	Dough shaping	10.44
WS4	Cooking	720
WS5	Cooling and oiling process	480
WS6	Packaging	55.2
Total Cycle Time (sec)		1962.02

The total cycle time for all types of fish caracker ,keropok lekor, keropok losong and keropok petak are 2345.87 sec and 1962.02sec. Working time per day is 6 hours including rest time which is equivalent to 129 600 sec/week. While the demand of Keropok Lekor is 1,000 pieces per week and Keropok Losong is 1363 pieces per week. Takt time for Keropok Lekor is 129.6sec/piece and 95.08sec/piece.

Table 3. Workstation capacity to produce fish crackers

(a) Keropok Lekor

Workstation (WS)	Cycle Time (sec)	Product Produced (working time/ cycle time)
WS1	420	309
WS2	6.066	21365
WS3	11.4	11368
WS4	1380	94
WS5	480	270
WS6	48.4	2678

(b) Keropok Losong

Workstation (WS)	Cycle Time (sec)	Product Produced (working time/ cycle time)
WS1	690	188
WS2	6.38	20313
WS3	10.44	12414
WS4	720	180
WS5	480	270
WS6	55.2	2348

Table 3 shows the capacity of the production line for both type of fish cracker. It shows the bottleneck yielded at cooking station (WS4) for both types because it can just produced only 94 and 180 pieces per week if compared to the demand (1,000 pieces and 1453 pieces)

3. Proposed Modifications of The Existing System

Based on the graph in Figure 2 below, WS4 which is cooking process is the highest cycle time yielded form the current production. An improvement can be made by modified the cooking system.

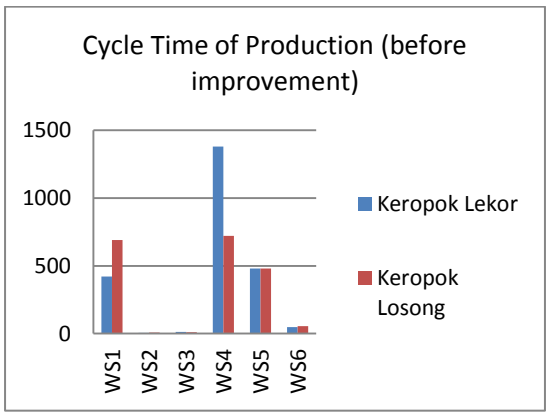

Figure 2. Cycle time of production

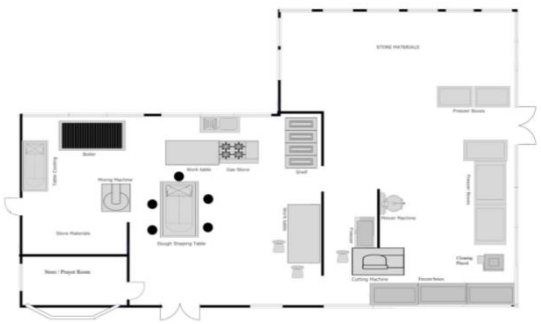

Figure 3. Original Plant Layout

Current cooking process is using the biggest conventional cooking pot in the market and just can cook 40 units of keropok lekor at one time. Therefore, a bigger cooking pot must be prepared to solve this problem without losing the quality of the cooking process.

Another problem in this plant is also the unsystematic arrangement of the production line as shown in Figure 3. In having an efficient production, facilities layout also a crucial element that need to be concerned. Good layout gives a lower cost and reduces unnecessary material handling. It also increases the utilization of the machines and the capacity of the shop floor. With limited number of workers in the SME, the machines need to be arranged safely to allow the operators move easily around the plant (Khan, Tidke, & Scholar, 2013).

To solve this probem, a software is used which is a true process about the simulation and modeling tool can be manipulated. With this software, the optimization of the manufacturing floor layout, with respect to material flow. It is used to simulate about the full production runs, over an arbitrary time period, so that by using this software, will allows users to designing a facility to get a glimpse of how the production lines might operate in reality (Markt & Mayer, 1997).

4. Modelling and Simulation Experiments

Aim of this study is to increase the production volume for all three types of fish cracker and by using the data recorded; further study can be done by using a simulation software. This software used to study the processes configuration. It is focused on the number of shipping product volume, the idle time for the whole system, the buffering time, the percent of the busy time and the percent of the blocked area on the whole system.

4.1. Simulation using Software

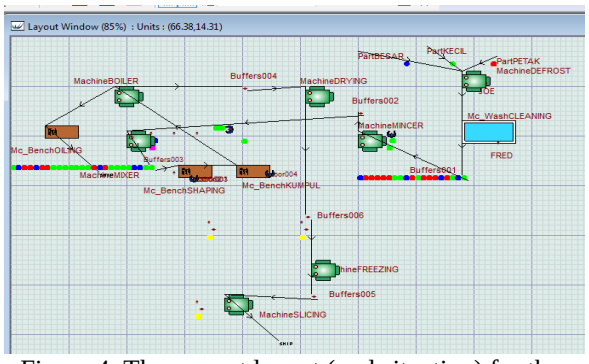

Figure 4. The current layout (real situation) for the full process using oftware

Figure 4 shows that there are many stations blocked with the product waiting and it will increase the percentage of blocked station. It also shows that the system for the full layout has the highest percentage of busy time, so it is not idle for the system and it is not good for the machines there and at the same time, it will decrease the number of production volume produced.

When the percentage of the busy time increase, the process time for full processes are also will high and the entire machine fortunately are not be in rest mode which means the machines will be easily to breakdown and interrupt the production.

4.2. Result for Actual Industry using Software

The average production output is shown in Table 4. It shows the average time for all three types of fish crackers to complete the process for a week.

From the result, it shows that nearly eight thousands of fish crackers being produced by the company for eight hour working per day every week. Using the software, it also shows the percentage of the machine in idle time, busy time and blocked with the product stated as shown in Table 5.

Table 4. Result from the current process layout

Name	Square Type	Round Type (Small)	Round Type (Big)	Total
No. Assembled	64	60	30	154
Sigma Rating	6.00	6.00	6.00	
Avg W.I.P.	50.45	52.17	21.55	
W.I.P.	105	94	44	243
No. Shipped	600	6944	408	7952
No. Entered	199	266	86	551
Avg Time (s)	131415	101667	129924	363007
No. Rejected	518202	444027	310892	

*Avg W.I.P: Average work in progress

*All the time is in unit seconds (s)

Table 5. Result for idle time, busy time and blocked area for the whole process

Name	% Idle	% Busy	% Blocked	No. Of Operations
Mixer	0.35	62.67	0.00	361
Shaping	0.47	65.12	34.37	234
Stock	1.02	1.63	52.97	234
Boiling	10.02	89.71	0.00	77
Oiling	55.62	44.38	0.00	77
Total time (%)	34.72	50.07	35.12	

By using the software, it similarly shows that the result for the production volume using the software is closely with the actual situation in the industry as shown in the Table 6. All the time that being set into the software is guided from the actual situation.

Table 6. Comparison between software and actual conditions

Types of Fish Cracker	Volume Shipped (Actual)	Volume Shipped (Software)	Process Time (sec) (Actual)	Process Time (sec) (Software)
Keropok Losong	1363	1413	1962.02	3158.8522
Keropok Lekor	1000	670	2345.866	4902.85994
Total	2363	2083	4307.886	8061.71214

There are some different in the production volume using the software if compared with the actual as shown in equation (1) and (2) below. The productivity improvement between actual and the simulation is about 1.31% and for the process time is about 1.10%.

4.3. Increase number of boilers

Due to the small error yielded, the simulation was reliable and other options of improvement can be analysed based on the obtained results. Most reliable findings can be seen from the Figure 5. By using the same formula of production improvement the result of each case can analyze.

For the first case, by adding one unit of mixer machine, the total volume production also dropped by 3.14%. And by this type of layout option, it just gave a big positive improvement on the big type of fish cracker by 75% increment. The square fish cracker remains in the same volume and 8.3% reduction for the small fish cracker.

The second improvement was by adding a unit of boiler. The total production volume increased for 4.9%. The gain was caused by the increment of all type of fish cracker which is 33.3% for the square type, 1.8% for the small type and 16.7% for the big type.

There are three conditions that can be assigned to the machines and equipment during the production process in the simulation. Idle - the machines and the equipment are in inactive state. Busy – the machines and the equipment are in working state. Blocked - the machines and the equipment are not able to run smoothly due high workload condition.

The graph in Figure 6 below shows the different condition of the machine and the equipment at different improvement for each set of simulation. For

the first condition, by adding up the machines and equipment, the idle time increases except for the additional of boiler. Additional unit of mixer increased 5.1% of idle time from the current layout. This status means that the machines and the equipment have more time in inactive mode and it drives to low maintenance cost of the machines.

The idle condition also related to the busy condition. The higher rate of the busyness, the more cost will be spend on the machines. In busy status, additional of the mixer shows the lowest percentage of busy time (43%) if compared to the current layout (50.7%). The situation follows with the additional of mincer machine, boiler and cooling shelf.

Other than that, adding some machine also will reduce the number of waiting part for the product. As shown below, with an additional boiler to the current layout, the percentage of blocked area decreased about twelve percent (12%). The number of process time also dropped about seventy percent (70%) from current layout as shown in Figure 7. It is a big improvement for the industry in terms of to increase their production.

Based on the study, it shows that by adding a boiler machine will give a higher impact for the production rate compared to the other option of layout improvement. It will increase the number of production volume and reduce the process time and number of blocked.

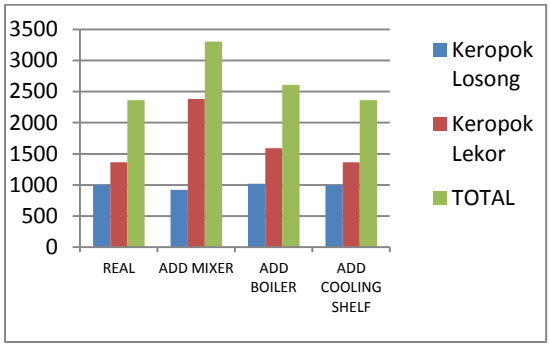

Figure 5. Production volume improvement of fish cracker

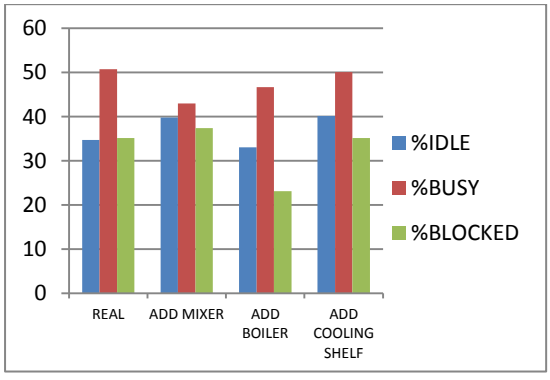

Figure 6. State of machine in simulation

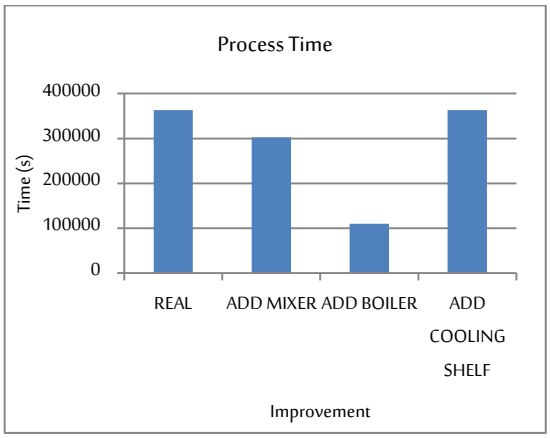

Figure 7. Time process result in simulation

5. Conclusions and Recommendation

The line balancing process by using the simulations show that the single line fish cracker production process can be improved buy redesigning the layout and by having additional of machines absolutely gave a high difference in the production volume.

The simulation concludes that the boiler of the fish cracker plays an important factor in having an optimum production volume and process time by having a big reduction by 70%.

The fish cracker entrepreneur can apply this simulation result by investing for extra boiler or a bigger size of boiler in having an optimum production rate.

Instead of above, there are other approaches that can increase the productivity volume that can be examined such as by rearrange the workstation closer and merging the workstation into a single workstation. This improvement is able to reduce process time and give a higher productivity in fish cracker processing.

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