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Capacity Study Of A Food Processing Company Using Arena Simulation Software

Abdul Syukur Abu Kasim[1], Salleh Ahmad Bareduan[1,*], Ibrahim Masood[1], Fu Haw Ho[1], Haslina Abdullah[1]

[1]Faculty of Mechanical and Manufacturing Engineering
Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, MALAYSIA.

*Corresponding Author Designation

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Abstract: Small and medium enterprises (SME) contribute significantly to the country's growth, especially in the food manufacturing industry sector. Fast Kitchen Sdn. Bhd. Parit Raja is one of the SME for food processing company that is currently having problem to achieve the daily output in meeting the demand. The lack of standard production rate as the main indicator in the management may lead to the problem that occurred. The aim of the study was to build and simulate the Arena Simulation model for the production process of the food processing company and to analyse the capacity of the production process using the simulation report. The data was collected based on the actual production line to be inserted into the system setting for validation purpose. The model was run for the 10 replications to achieve accuracy in the result. The alternative models were then developed with different configurations to improve the production capacity. This was done by observing the simulation result that would provide higher production output within acceptable resource utilization. This study indicated the productivity improvement between 5.11% to 21.47% can be achieved through minor manipulation of working time or additional one manpower. Overall, the simulation finding could be a guideline for the owner to decide for any improvement in their production capability.

Keywords: Arena Simulation Software, Capacity Study, Food Processing, Production Process

1. Introduction

To ensure sufficient capacity and resources are available to achieve the demand forecast it is necessary to produce a capacity plan which is also known as resource plan [1]. Normally this is done by looking at the aggregate product family forecast and translating that into the capacity and resources needed, e.g. how much machine time, how much time in an assembly process, how much transport capacity and so on. Capacity which also involves the flexibility to produce work in given time must be measured in the unit of work [2].

Small and medium enterprises (SME) contribute significantly to the country's growth, especially in the food manufacturing industry sector. SME in food processing need to be more proactive in supporting

Corresponding author: saleh@uthm.edu.my

the ever-growing food demand. The food industry must enhance its production system performance and capacity utilization to increase production output. SME should take advantage of this opportunity based on the potential in the food production subsector that has been identified.

This study's focus is to build and simulate the model for the production process of a food processing company and to analyze the capacity of the production process using Arena Simulation Software. Fast Kitchen Sdn. Bhd. Parit Raja is one of the SME for a food processing company which produces frozen pizza and several other pizza related products. However, due to unforeseen bottlenecks, the company's daily output rates are inconsistent, and hard to achieve the target. The lack of standard production rate as the main indicator in the management may lead to the problem. The management also has difficulty making a proper decision, which eventually deteriorates the company's productivity.

Simulation is one of the most popular methodology to model the operations and manufacturing systems. These includes the reports on simulation studies on process flow [3] and production planning and control [4]. Simulations are also found utilized in line balancing [5] and output optimization model [6,7,8] to improve the balancing performance.A simulation model was developed for this project based on the actual processing of the company. The medium used is Arena Simulation Software by Rockwell Automation Technologies, Inc. because it provides better solutions and can easily interpret the data [9]. With these results, companies can be recommended with improvement from the problem occurred to increase their production output.

2. Methodology

The purpose of this project was to study the capacity of food production process at Fast Kitchen Sdn. Bhd. using Arena Simulation Software. Firstly, information and data which include all the criteria for the case study from the beginning to the final phase of the product is collected. Before the simulation model is developed, it is crucial to obtain the required data to ensure the models developed resemble the actual production systems. A simulation model of the current production system is then developed using the Arena Simulation Software. This model must be verified and validated by comparing the simulation result against the current actual output. Upon confirming the models validity, the simulation model is further analyzed to track the production problem. The simulation software provides a clear view as a guideline and improves the production line productivity and efficiency. Furthermore, a new model was developed to improve the actual production line as a guideline for management to increase its production output. The findings are then summarized in the result and discussion part before finalizing the conclusion for this project.

2.1 Data Collection

Data collection is a method of gathering and measuring in a systematically specified way of information on variables of interest that allow answering specified research questions, test hypotheses, and evaluate results[10]. There are many methods of collecting data, but in this project, the techniques that have been used were interview, observation, and direct time study.

Interviews contain questions and responses from study participants. The interviewing has various types of styles, including individual interviews and group interviews. The telephone or other electronic devices may be used to ask or respond to the questions. The interview method has been done with the owner of the company, Mr. Hanif. The data collected in the interview were the company's flow process, detail of workstation, working hour, input, and expected output of production.

Observation is a basic way to discover the world around us. In this study, the observation method was also used to get the data from the production line. The data that have been collected are the number of workers and process layout. The company uses more manual process than automatic process. The manual process requires worker in executing the task. The total number of workers on the production line are 3 workers. The number of workers allocated to workstations is different from one another. The heavier work and more time-consuming need to have more than one worker in the process. This is because to ensure a smooth flow in the production line.

Direct time study is a technique by which several subsequent observations of one worker, machinery, or process is carried out over a period of time. Each observation records the events at that moment, with estimation, if required. This method involves a very time-consuming activity to get the time taken for every process. Process cycle time is the total time from the beginning to the end of the process, as observed at the machinery or worker. Cycle time includes process time during which a unit is acted upon to bring it closer to output. During the data collection process, a datasheet was prepared for the tabulation of data. All the data collected for every process was conducted for 10 times by using a mobile stopwatch. The average, minimum and maximum value of the data series was measured for the purpose of model simulation and analysis.

2.2 Simulation Development

This project is conducted using Arena 16.0 student version by Rockwell Automation Technologies, Inc. to develop the production line process model. Arena simulation software is a discrete-event simulation that can be used in various area of situation. The arena has the potential to provide the user with the capability to develop a model quickly and easily. To develop the model related to the actual process, all the parameters and other variables such as resource quantity and operation cycle time have been collected. By entering the data into logical modules, the model could execute the desired process or production. Figure 1 and 2 illustrate the flowchart module for pizza dough and pizza topping production generated with the Arena simulation software.

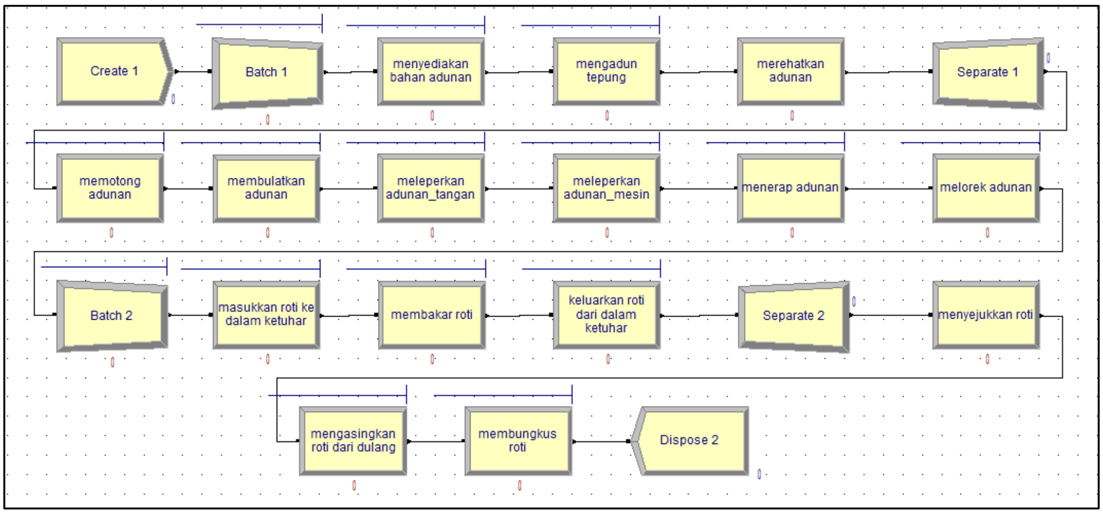

Figure 1: Flow Chart Module for Pizza Dough Production

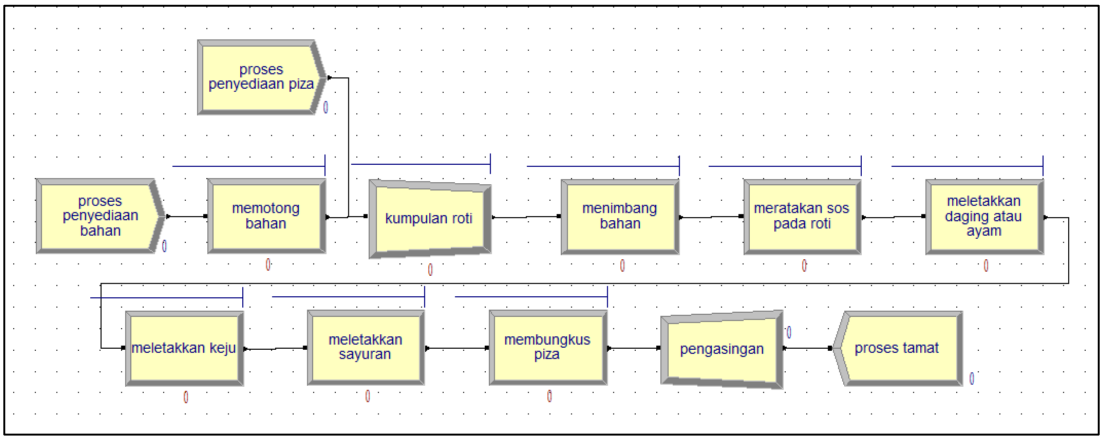

Figure 2: Flow Chart Module for Pizza Topping Production

Model verification and model validation are used to ensure that the simulation model can represent the actual production system. Verification is the static testing that ensures the model is free of function and logical errors. The logic system can be discovered between both compared models to get expected system behavior. It also makes sure the model is developed following the actual production line.

Validation models are defined as ensuring the simulation model's accuracy and animation, using the correct data, and representing the actual production system. The difference between the output of simulation and the real data is calculated using the following equation (1):

$$Difference\ (\%) = \frac{|simulation\ output\ - actual\ data|}{|actual\ data|} \qquad \text{Eq. (1)}$$

The simulation output is referred to obtain data from the simulation model, while actual data is collected from the real production line. By using equation (1), the difference must lower than 10% to achieve the level of similarity and accuracy. Once the system validates and verified, further analysis of the production system can be done. It is conducted to find the issue that occurs in the line process.

2.3 Equipment

Direct time study is one of the techniques for collecting data. Thus, there are several types of equipment used to implement the technique. Equipment selection type shall be precise and accurate to achieve data accuracy. For this project, time must be taken for data collection purposes. The equipment used is a stopwatch and it is used to measure the time taken for each process.

Distance between processes in this project should also be measured. A measuring tape which is a flexible tool with its length and scale is used to measure distance or size. The purpose of this equipment used is to measure the distance from one machine to another. The data was recorded as a reference for developing a model in arena simulation software.

3. Results and Discussion

Since there are two production line types, which are pizza dough and pizza topping production, two models have been developed differently based on their actual production line considered in this project report. It was based on the collection of data and information obtained from the previous section. All the models of simulation have different configurations. Each configuration was created based on the previous result and intended to improve the production line model. All the simulation is executed for 10 replications to achieve accuracy in the result [11].

The dough production line model was tested with standard operating settings to validate simulation productivity. The production line model has been modified, and the validation is repeated if the outcome is not valid. If the validating is close to actual production, the analysis is done based on their output production and resource utilization. After that, an improvement was made to the simulation model based on the identifed weaknesses to increase the production capacity. The step was repeated for the pizza topping production to increase the production.

3.1 Model of Pizza Dough Production

The first simulation set was made to validate the production line model with the real production line. In this simulation set, the production line model configurations are similar to the actual one to test whether the simulated line productivity is valid. For the second set of simulations, the production line was simulated with new working hours setting while the other remains unchanged. For the third set of simulations, the production line model was simulated with a new improvement from set 1. A new worker has been added to the line. However, the rest of the settings remain unchanged. Table 1 shows the result of the simulation for the pizza dough production model.

Table 1: The result of simulation for pizza dough production model

Set	General Setting	Output Number	Resource Utilization	Average
1	Working hours = 6.5 hours per day	326	Mesin ketuhar	0.4044
	Workers = 3		Mesin pengadun	0.4103
			Worker A	0.8320
			Worker B	0.7646
			Worker C	0.7620
2	Working hours = 7.5 hours per day	396	Mesin ketuhar	0.4000
	Workers = 3		Mesin pengadun	0.4000
			Worker A	0.8511
			Worker B	0.7579
			Worker C	0.7530
3	Working hours = 6.5 hours per day	377	Mesin ketuhar	0.4616
	Workers = 4		Mesin pengadun	0.5128
			Worker A	0.6804
			Worker B	0.8194
			Worker C	0.8194
			Worker D	0.6657

The pizza dough's production output from the simulation run set 1 is 326 pieces for 6.5 hours of operation. The simulated results were submitted for verification to the owner of the company. According to the company owner, the current production output is 300 units per 6.5 hours. This indicated that the simulation output is 8.67 percent different from the actual data. Since, the difference between the simulated model and the actual production line is below 10 percent, thus, it is said that the production line model is valid [12]. Based on the result from set 1, two processes which are below 0.5 utilization are considered as under-utilized, which are *mesin ketuhar* and *mesin pengadun*. As for worker A, B, and C, the average utilization on set 1 is 0.8320, 0.7646, and 0.7620. In other words, the workers are always occupied by workload within the range of 76% to 83%. Since, the utilization for all workers can be condidered as high, therefore, it is very difficult to handle the increasing of material flow and a bottleneck could occurred during the production process.

The capacity output increases dramatically for the production line set 2 compared to set 1. The output percentage improved by 21.47 percent from 326 units per day to 396 units per day. The improvement in the working hour per day would increase their productivity in terms of total output per day. As a result, more products can be produced during the period. The resource usage for worker A slightly increased from 0.8320 to 0.8511 due to the increasing the working hours. Other than that, the resource usage decreased marginally. However, resource usage is still the same because the difference between set 1 and set 2 is too small.

The production output for set 3 is more than set 1. Compared to the previous setting for set 1, the capacity of set 3 is significantly improved due to the extra one additional worker. Production grew by 15.64 percent from 326 units per day to 377 units per day. All resources rose on their average usage between set 1 and set 3 except worker A. This is because half of worker A's workload has been taken by worker D. Next, the utilization for worker B and worker C achieved over 80 percent due to their working time is almost entirely occupied, and less space remains for usage. The workers are getting busier with the new settings. Moreover, *Mesin ketuhar* still under-utilized because the average resource is below 50 percent, with the average utilization of 46.16 percent. Overall, the total output generated by set 3 is about 5 percent lower than set 2.

3.2 Model of Pizza Topping Production

The simulation model set 1 for pizza topping production must be tested before any tests and improvements are carried out. The simulation model of the pizza topping production must also be validated with from real production. For the development of the simulation model, all parameters and modifications from the actual production line were applied. Since the target is to improve capacity production, set 2 of the simulation was added with one hour overtime while the rest of the setting remains unchanged. Next, set 3 was merely a testing set, this section aims to determine the capacity and resource usage that can be maximized by improving the worker at set 1. Table 2 shows the result of simulation for the pizza topping production model.

Table 2: The result of simulation for pizza topping production model

Set	General Setting	Output Number	Resource Utilization	Average
1	Working hours = 5.75 hours per day Workers = 3	313	Worker A Worker B1 Worker B2	0.8966 0.9877 0.9877
2	Working hours = 6.75 hours per day Workers = 3	367	Worker A Worker B1 Worker B2	0.9356 0.9987 0.9987
3	Working hours = 5.75 hours per day Workers = 4	329	Worker A Worker B1 Worker B2 Worker B3	0.9660 0.6943 0.6943 0.6943

The performance for pizza topping production from the simulation run set 1 is 313 pieces per 5.75 hours of operation. The simulated outcomes have been presented to the owner of the company and it is confirmed that the current production output is 300 units over 5.75 hours, which is 4.33 percent different from the simulated model output. The difference between actual production and the simulation model is below 10 percent. Thus, the production line model is said to be valid [12]. Next, there are three workers for the line production work alternately between each process. Worker A involved one staff, and worker B involved two staffs on the process. The average set 1 utilizations for workers A and B are 0.8966 and 0.9877 respectively. This is considered as extremely high as they are very close to the maximum utilization of 100 percent. In other words, the workers are always fully occupied by the workload. Based on the result, it is noticed that the current production line does not have a problem of under-utilization. Overall, all workers are fully utilized and hence, it is impossible to handle the increasing of material flow.

The output number for set 2 increased due to the additional of extra one more working hours in a day. As a result, the total output increased. The output capacity for set 2 is more than set 1, which is

367 units per day. In short, the output percentage rose by 17.25 percent. The resource usage for worker A and worker B showing a small improvement between set 1 and set 2 as a result of the increment of the working hours. Worker A increased by 3.9 percent from 89.66 percent to 93.56 percent, but worker B does not significantly differ in resource utilization.

The production line's output number between set 1 and set 3 increased from 313 units per hour to 329 units per hour, which is 5.11 percent increment. Moreover, resource usage for worker A showing improvement due to increasing of the material flow. Worker A increased by 6.94 percent from 89.66 percent to 96.60 percent, but worker B utilization dropped compared to set 1. While worker A is fully utilized, worker B has more available time because of the additional one worker, contributing to a reduction in usage. The major difference in the result occurs for worker B after the addition of one new worker to the production line. The overall result for set 3 is unsatisfying because the capacity increases only by 5.11 percent between set 1 and set 3. There was a remarkable decline in resource utilization for worker B due to the additional one worker. This utilization can be improved if some rearrangement of the task from worker A is further delegated to one of the worker B. These results can be used by companies as a guide in making any decisions in the future.

4. Conclusion

Fast Kitchen Sdn. Bhd. Parit Raja is one of the small and medium enterprises that is currently having problem to achieve consistent target output. So, this project was carried out with two main objectives which is to build and simulate the Arena Simulation model for the production process of a food processing company and to analyse the capacity of the production process using Arena Simulation Software. It can be concluded that this study has been achieved overall of its objective.

Output number and resource utilization were successfully determined with the simulation in the Arena simulation software. The simulation was developed to determine the maximum production capacity in a day. In order to achieve optimum capacity, the production line should have a high output production and high resource utilization. The target production line's output number and resource utilization were successfully determined from the Arena Software simulation. From the simulation result, the real target production of the Small Medium Enterprise was simulated and successfully verified by the owner. The result of the simulation was studied and analyzed to determine the improvement of the production line. This simulation finding could be a guideline for the owner to decide for any improvement in their production.

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