MODELING THE OPERATION PROCESSES IN FOOD MANUFACTURING BY USING SIMULATION TECHNIQUE

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Thesis submitted in fulfillment of the requirements for the award of the Bachelor of Industrial Technology Management with Hons

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion this report is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Industrial Technology Management with Honor.

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STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for the quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted for award of the other degree.

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DEDICATION

This thesis is dedicated to my parents, project's supervisor, and friends who always support me for all these time during my research study till the end of the process.

First of all, I would like to dedicate this thesis to my parents who give me an encouragement and strength to finish my project.

Other than that, I also would like to dedicate this thesis to my project's supervisor, Prof Razman bin Mat Tahar who gave me a lot of advices and suggestions throughout my study.

Furthermore, I would like to dedicate this thesis to all my fellow friends who were willing to help and teach me whenever I needed help.

Finally, I want to dedicated this study to the owner HFI Enterprise who gave me permission to do my research and data collection in his company.

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My sincere thanks also go to HFI Maju Enterprise owner who give me permission and opportunity to collect all the data in their company to do my research study. Without their permission I would not be able to finish my research study.

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ABSTRACT

This study discusses about modeling the operation processes in food manufacturing by using simulation technique. The scope of this study is to focus on the production processes of chili sauce's company. The time frame covered is one year which is in year 2014. This study is conducted by using ARENA simulation software to simulate the modeled of chili sauce production processes in the simulation software. It is a quantitative study which the performance of the processes is measured by the average cycle time for the whole system of chili sauce processes. The results of the simulation model of the chili sauce processes has determined the bottleneck in the process and measured output of the process. The improvement has been made by using "What-if Analysis" and scenario planning approach.

Keywords: Simulation, ARENA Software, Cycle Time, Average Queue Waiting Time, Utilization, and Bottleneck.

ABSTRAK

Kajian ini membincangkan tentang model proses operasi di kilang makanan dengan menggunakan teknik simulasi. Skop kajian ini menekankan pada operasi pemprosesan di kilang sos cili. Tempoh masa untuk kajian tersebut diliputi adalah setahun iaitu pada tahun 2014. Kajian ini juga dilaksanakan dengan menggunakan perisian simulasi ARENA dengan menghasilkan model mengikut proses pemprosesan sos cili di dalam perisian simulasi. Jenis kajian ini merupakan kajian kuantitatif dimana prestasi pemprosesan sos cili diukur dengan purata masa kitaran untuk keseluruhan proses tersebut. Keputusan daripada perisian simulasi dapat mengesan kesesakan dalam proses berkenaan dan juga bilangan pengeluaran dapat diketahui. Peninkatan prestasi pada proses tersebut dapat dilaksanakan dengan mengunakan kaedah "Apa-jika" dan kaedah senario.

Kata Kunci: Simulasi, Perisian ARENA, Kitaran Masa, Purata Masa Menuggu, Penggunaan Sumber, dan Kesesakan.

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CHAPTER 1

INTRODUCTION

This research study is to evaluate and analyze the chili sauce production processes from the Chili Sauce Manufacturing in Padang Tembak, Pengkalan Chepa, Kelantan. The evaluation on the production processes is to determine the organizational performance. The purpose of analyzing the process system is to improve the quality of the process to become more efficient and increase the quantity of the product to support the market demand by using simulation technique which is practiced well in manufacturing and service sector. This chapter will cover the background of study, problem background, problem statement, research objective, research question, method of analysis, scope of study, significance of study, operational definitions, and conclusion of this chapter.

1.1 BACKGROUND OF STUDY

Chili Sauce Production Manufacturing was registered under the Small and Medium Enterprise (SMEs) in Malaysia. SMEs in Malaysia has contributed to Malaysia growth development per capital (GDP) in our country. The growing of SMEs in Malaysia's GDP is about 32% in 2013, considering its current growth momentum and the country's healthy economy. According to the (SMEs MASTERPLAN 2012 – 2020), service sector has contributed 87% to our country's economy, which is the highest while manufacture sector and agriculture sector has contributed 7% and 6% respectively. In term of size in SMEs Corporation, microenterprise with less than 5 employees is the higher or 67%.

Nowadays, our government also encourages all people to involve in business whether in service sector, manufacture sector or agriculture sector to keep ongoing contribution in order to increase the Malaysia's economy. According to the Tenth Malaysia Plan (10MP), the development of SMEs will be given more focus and it may become the vibrant engine of Malaysian economy growth. During the Tenth Malaysia Plan period, Malaysia government will conduct a lot of program and support to nurture SMEs in order to create "domestic, regional, and global champions". In order to increase the performance and reputation of SMEs, they may use the simulation techniques to evaluate, create a model, identify the problem, and etc. By using the simulation techniques, they can forecast the future demand of their business.

Operation management is very important in industrial and manufacturing sector because it will manage all the processes or stages in the production. Operation management can be explained as a set of activities or steps that create value in the form of goods and services by transforming the input into outputs. The examples of the inputs are raw materials such as labors, machine, equipment, and etc. The examples of output are finished goods, semi-finished goods, and also work-in-progress (WIP). An excellent of operation management in the production system will increase the organization's profitability and reputation. Process design in operation management is to combine all the aspects of an industry or organization with the needs and requirement from the customers.

Capacity planning is an activity or process that determines the production capacity of the product needed by the company to meet customers' needs and requirements or the changing of demands for its product. Capacity planning can be categorized into three time horizon of planning which are long-range planning, intermediate-range planning (Aggregate planning), and short-range planning (Scheduling). The time period for long-range planning is normally greater than 1 year. This stage of planning includes the adding of the facilities and equipments in the organization that need a long lead time. Besides, the time period for intermediate-range planning and short-range planning are 3 to 18 months and lower to 3 months respectively. Intermediate-range planning is to plan and make a decision either want to add the equipment, personnel, and shifts; subcontract the production of product to the

third party; and we can store and use the inventories in the warehouse when needed. For the short-range planning, scheduling the jobs and people, as well as allocating the machinery is enhanced. To change and modify capacity in the short-range planning is difficult to be implemented as it is constrained by existing capacity.

The role of bottleneck or constraints is a key concept that related to the capacity planning. Bottleneck problem in an operation process limits the production process flow. The bottleneck problems will decrease the efficiency of the production process and it will limit the output or finished good. The word bottleneck is referring to the neck of the bottle, which is water inside in the bottle can flow out based on the diameter of the literal neck of the bottle. There are three metrics to analyze production capacity system which is process time of a station, process time of a system, and process cycle time. Process time of a station is the time to produce the product in each process. Process time of a system is the longest process of bottleneck. Process cycle time is the time for overall production process with no waiting time.

1.2 PROBLEM BACKGROUND

There are many food manufacturing that produce chili sauce in Kelantan and high competition has been occurred. In this kind of situation, negative effect is given especially to small manufacture because small manufacture cannot supply the product in the high quantity to meet the customer demand. Small food manufacturing cannot provide the lower prize for customer because the quantity of the product is too low compared to the large manufacture.

The competitions in the market occur in the daily life especially for the food manufacturing because there are a lot of people involving in this field of business. Many people involving in food field of business because many people believe that human need food for their living and also human enjoy their life with the delicious food. Although there are high demand on food in the market, but still have some manufacturing cannot be survive in a strong competition especially for small manufacturing.

Based on this research, Chili Sauce Manufacturing in Padang Tembak, Pengkalan Chepa, Kelantan is hard to survive in the market because they cannot to provide a capacity of the product that meet the customer demand. The break even cost of the manufacturing is also higher than the other huge manufacturing. This challenge need to be reduced by increasing the efficiency of the production process and eliminate all the constraint such as bottleneck. Furthermore, some of the processes are operated manually which longer time is needed.

1.3 PROBLEM STATEMENT

Production process is a process that transforms the input or raw material into the output or finished goods. In production process system, there are a lot of problems and constraint such as machine failure, lack of raw material at peak season, and etc which cannot be avoided. Although these problems cannot be prevented, they can be reduced.

According to the chili sauce manufacturing, bottleneck is the constraint that occurred in the production process. Bottleneck in the production process will limit the production process system. This limit will cause the production capacity decreasing and the production process needs a long cycle time to produce the product.

Chili sauce demand in the market is flexible. The customer order will increase at the peak season and decrease otherwise. The capacity of the product will not be able to support the customer demand especially at the peak season. So, chili sauce manufacturing needs to reduce the constraint such as bottleneck in the process system because it will reduce the cycle time of the production. Automatically the capacity of the product will be increased.

Without the bottleneck constraint in the production process system, it will help the company reduce cost and increase the organization profit. The cycle time of the process also will be shorter than before and increase the capacity of the product.

1.4 RESEARCH OBJECTIVES

The objectives of this research are:

- ✓ To identify the bottleneck of chili sauce production.
- ✓ To measure a capacity of chili sauce production at the plant under study.
- ✓ To propose an improvement of chili sauce production process.

1.5 RESEARCH QUESTIONS

The questions of this research are:

- ✓ Where is the bottleneck constraint that occurred in chili sauce production process?
- ✓ How many capacity of chili sauce production can be produced?
- ✓ What is the improvement on the chili sauce production process?

1.6 METHOD OF ANALYSIS

Method, tool, or technique is the important elements to conduct a research study. According to this research study, the most appropriate method to evaluate and analyze this research is by using the simulation techniques and data collection method. Simulation techniques are a well known method and it was practiced in many countries to detect any constraint in the production system. Normally it will be used by manufacturing to solve the constraint in the production system such as bottleneck. Arena software will be used to apply simulation technique in this research. It can analyze the production system and detect the problem that occurred in the process. Moreover, simulation techniques no need to use very high cost and the result of the analysis is easier to get. Furthermore the risk of failure can be reduced by using simulation because there is no need to use the real situation to analyze the production system.

Data collection method is also important because it can support the simulation technique to analyze and evaluate the process. Real data is needed to create the production system model using Arena software to represent the real production system.

The data and information must be accurate. So, the better technique to collect the information and data is by using observation method which is called as primary data. Secondary data also needed to support the primary data such as historical data and interview method.

The improvement of the chili sauce production processes can be determined by using "What-if Analysis" approach and also scenario analysis. "What-if Analysis" approach is a changes on the processes in the simulation model and analyze the simulation model the get the better results. Meanwhile, scenario analysis is a technique that to analyze the possible future events by considering alternative possible outcomes from "What-if Analysis" approaches and also its management in the company.

1.7 SCOPE OF STUDY

This research will focus on evaluating the performance of the Small and Medium Enterprise (SMEs) food manufacturing, in Padang Tembak, Pengkalan Chepa, Kelantan. This organization produces the tomato and chili sauce. In this research, I will focus on the capacity planning and bottleneck on chili sauce production process. The good planning on the process will give a good result in term of profitability to the organization. From this research results, it may give a new idea and system to the organization to implement the new model of production system.

At the beginning of the research, I will create a model based on the actual production process of chili sauce manufacturing by using the Arena software. From the model, I will run the model to get the result. From the result, the evaluation of the chili sauce production can be determined. The evaluation of the performance based on the actual production process will be a benchmark to the other model that will develop it to increase the performance. The development of the model or redesign the production process will be implementing by using "What-if" analysis approach to get a better production process system compared to the original production process system. It will reduce a lot of cost by using this approach.

Producing chili sauce has several stages and steps of process which are including the machine and handmade or manually process without using the machines.

There are bottleneck problem on the some stage of production process in the organization to produce the chili sauce. After figuring out the bottleneck stage on the production process, we need to reduce the waiting time of the bottleneck problem in the related station or stage. This includes reducing the overall time of chili course production. So it may increase the capacity or quantity of the product and meet the customers demand in market.

As a conclusion, the best of new model in the production process to produce chili sauce will be proposed to the organization. The best model should be meet the objective of the research which is the model has a high performance compared to the current model and the waiting time in the bottleneck station has been reduced. So this model will allow the company to produce the chili sauce according to the customers' orders and will meet the customer needs in the market. This also will automatically increase the organization reputation and efficiency.

1.8 SIGNIFICANCE OF STUDY

The production process in the manufacturing is vital because without a good operation process management, the company performance and reputation will decrease. This research is to overcome the problem such as bottleneck in each station or stages in operation process. This automatically will reduce the overall processing time to produce the chili sauce. When the processing time reduces, the capacity and quantity per day will increase. Hence it will meet the customer demand in market.

This research can be a guideline to all manufacturing which has operation and production process to produce a product. This research result also can be used for any food industry sector as well as the agriculture and service sector. This will provide the strategy to the company on how to develop a better process design to overcome several problems such as high demands and low supply in the market, bottleneck problem in each station or stage, and lack of labors or workers. This finding is important to help the company to run the process going smoothly without any problems and errors.

This study also important to the owner's of the company, managers, workers, and also supplier. Managers need to plan everything that related to the operation process that may affect the operation process. Nowadays, there are a lot of machines and techniques are upgraded to be more efficient. So they need to study the new method or research to understand more about the current problem that the others company face and see how they solve the problem by using certain technique, method, and tools.

1.9 OPERATIONAL DEFINITION

Based on to the research, there are several key terms have been used in this research study. For examples of key terms are chili sauce, operation management, capacity planning, bottleneck, theory of constraint, and also simulation technique. The definitions of all the key terms are:

Chili sauce:

According to the (Darlene Schmidt), chili sauce is an extraordinary seasoning that adds spice and flavor to the all types of dishes. Chili sauce basically is an Asian recipe and now was spread to the western favorites. It also can be used as a wonderful dip for fingers for all types of food. Besides, it also can be used as a condiment to add more spice to your food. Moreover, chili sauce is a handy cooking ingredient. Using chili sauce as a food and dishes condiment is very famous in the Asian country as well as in Mexico and Central America. If there are no a bottle of chili sauce can considered the table setting is not complete.

Operation management:

The definition of operation procedure refers to the process of operating something or dealing with a particular situation, procedure, or processes. The term operational defines something such as a variable in term of precise process or set of validation experiments that are used to establish its present and quantity.

Capacity planning:

The definition of capacity planning is the process of finding the production capacity that needed by the company to meet the fluctuated demands for its product to meet the customer satisfaction. There are two categories in the context of capacity planning which is design capacity and effective capacity.

Bottleneck in Production Process:

Bottleneck in an operation management defined as a problem occurred when all the activity has a limit in a certain stages or station to ongoing the throughput. The word of bottleneck is based on the "assets are water" metaphor, which means when the water is poured out from the bottle, the rate outflow is limited by the width of the conduit exit.

Theory of Constraint:

According to the Sergio Rattner, the Theory of Constraint (TOC) is an organizational change method. It focused on the improvement of profitability in the organization. Based on the TOC, every organization must have at least one constraint. The constraint is any factor that limits the organization to achieve its goal and increase the profit. In manufacturing, the constraint is called bottleneck.

Simulation technique:

According to the investopedia (Monte Carlo Simulation), the definition of simulation is a problem solving technique that can be used to approximate the probability of certain output or results by using the multiple trial runs, or using random variables。

What-if Analysis approach:

The definition of "What-if Analysis" approach is the measure of the changes on the independent variables which can impact the dependent variables as the output and result with reference to a given simulation models.

Scenario planning:

Scenario planning also known as scenario analysis and scenario thinking which means the future event planning or long term planning process that was generate by using simulation methods.

1.10 CONCLUSION

The bottom line of this chapter is the production process system is a very crucial thing that needs to be planned by all the company's owner or managers. This is because the failure of planning in production process will affect the company productivity, profitability, and reputation. To support the production process is runs smoothly, the good planning on the capacity planning is needed because this also include in the operation process to produce the product. When the lack of input such as raw materials is occurred, the process also needs to stop. The bottleneck problem in any station also will disturb the production process because there are long waiting time. To overcome to these problems, simulation technique is the most suitable approach to be used because simulation technique can create a model of operational process. When model is created, we can see the results or performance of the model without using the real process. This may reduce the company cost and time to get the results before setup or redesign the real production process system. Simulations technique will be used in the Arena software.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The meaning of literature is writing and a body of literature is refers to all the published writings in a particular style on a particular subject. Literature review means a study on the literature that has been published by the scholars and researcher. Basically the types of literature review include journal, articles, book, authoritative database, and primary source. Newspaper, magazines, film, audio, video, and secondary data are included in the literature review but it is seldom used by the researcher. The primary source is original information or firsthand literature that used by the research to refer and support the research as the evidence. The literature review will be divided into several subtopics which include food processing in industry, operation management, simulation study, product capacity, bottleneck in each process, constraints in operation process, and theory of constraints.

2.2 FOOD PROCESSING IN INDUSTRY

Malaysia food processing manufacturing has become a crucial segment of the agro-based industry according to the government's focus on the agriculture sector. Based on the Industrial Malaysian Plan 2006-2020 (IMP3) period, the target for the food processing industry have been set at RM24.6 billion (Ministry of International Trade and Industry, 2012). In the area of the business environment, manufacturing from Small and Medium Enterprise (SMEs) was dominated the food industry in Malaysia. Functional food, health food, convenience food, food ingredients, and halal

food are the growth food in the year of 2002. Business growth can be explained as the growing in an organizational capital or expansion of its size and capability. Growth is a very important component to all organization especially in business because it will measure the organizational performance whether it is in good reputation or vice versa (Kartinah and Rabaah , 2013).

2.3 OPERATION MANAGEMENT

Operation management was practiced everywhere in the world whether in manufacturing, and service industry. Operation management is related to the production process. Production means the creation of goods and services in the firm. Production plays a high role in the operation management which is a set of activities to have a throughput and transform input into the output to create value in the form of goods and services in the organization. All the organization will do this activity to have a better planning, increase productivity, increase profit and others that give a benefit to the organization. Production in manufacturing industry is an activity to create tangible goods which customer can see and touch it such as food, car, motorcycle, and etc. Otherwise, the organization that does not produce tangible product is called activities services. The service is not obvious and hidden from the public and even from the customer. Operation management is crucial because it is a costly part of an organization (Jay and Barry, 2011).

2.4 CAPACITY PLANNING OF PRODUCT

Capacity requirement planning is one of the planning methods and it can calculate and measure the ability in the operation process. Capacity is the quantity of the product and it is related to the production demand. A good capacity planning can make sure there is enough production capacity to meet the production demands. Production demands basically will depend on the customer needs and orders. After that, it also can be used to analyze and check the feasibility of production plan outline, main production planning, and material requirement planning. Furthermore, it can change the production demand into relevant capacity requirement and estimate useable capacity. Besides, it can make relevant calculation to balance the production capacity and production load.

MRPII/ERP system can detect the bottleneck in the production process by the capacity requirement planning (Yang et al., 2007).

Capacity discrepancy between mid-term capacity planning and consistently delivering promised capacity can be eliminated by the efficient system of modeling. Conflicting objectives in capacity planning and production scheduling can be resolved. It will be resolved by the capacity constraints that derived from production rate, machine timeline, and machine allocating preference matrix. Otherwise, the configurable constraint are designed and implemented for special concerns in planning and scheduling functions. It also will facilitate the pursuing of optimized production plans and schedules. The collaboration between two or more company is very important. They also can share the data among collaboration companies to forecast, order, and production status for continual enhancement of the deliverability and gaining more market shares. Sharing information between mid-term and short-term production capacity among companies will improve customer service level, reduce cost through the synchronization of resources, analyze and adjust the capacity arrangement timely, and response swiftly to changes in market (Wang et al., 2005).

Nowadays, the key factor to maintain invincible in the high competition market of enterprises are quick response specific to market changes and needs along with the horizontal and vertical development of economic globalization trend and growing diversification of customer demands. To improve the efficiency of enterprise operation and utilize various internal and external resources held by the enterprise as far as possible, enterprise need to apply the modern computer and network techniques to transform traditional enterprise operating method. For example, realizing the enterprise information by making use of the ERP system. Moreover, to manage the enterprise operation, the information technology is adopted. (Tu et al., 2011).

Saving the investment cost by producing an optimal long-term facilities planning of the mould enterprise is a very crucial thing because the facilities is very expensive. To balance the manufacturing production capacity and demand is the key decision of the long term of capacity planning. There are different characters to the flow shop manufacturing. First of all, mould manufacturing is under the condition of single

unit job lot production. The buffer between the capacity of facilities and production demands because there is no mould inventory. The similar type facilities were put together and shared the process kinds of parts many mould orders in the same time to enhance the utilization ratio of facilities. There are replaceable multi-process routings to produce one type of mould part with the improvement of technology. The process time and manufacturing cost of these routings are different (Yu and Chen, 2011).

Thin Film Transistor Liquid Crystal Display (TFT-LCD) is a Taiwan company and the production networks of this company have three manufacturing stations. The manufacturing stations or stages are called as Array, Module, and Cell processes and each station has multiple production sites. Array and Cell processes are capacity-constraint and high- investment production environment. Utilization and planning for the production capacity effectively is a very important to the TFT-LCD company. The TFT-LCD has paid the attention to the capacity planning has become problem as a very crucial thing because of the several reasons. The first reason is the complex product hierarchy and product types caused by a wide range of product application (Karabuk and Wu, 2003). The second reason is a multi-stage, multi-generation and multi-site production network generated by coexistence of multiple generations of manufacturing technologies in each manufacturing stage and production site (Swaminathan, 2000). The last reason is the rapid growing and changing market demand due to the consumer requirements for the replacement of the traditional Cathode Ray Tube (Wang and Lin, 2002). TFT-LCD Company is facing the critical strategic capacity planning problem due to the rapid-changing product-mix. This problem is due to the imbalance demand and supply in multi-generation and multi-site productions chain (James*et al.*, 2009).

2.5 BOTTLENECK IN PRODUCTION PROCESS

Operation process for producing product is a crucial thing in manufacturing and minimizing the cost, having a competitive business, and managing the operation process efficiently in manufacturing are not an easy role for manager and top management to implement. There will be a new problem or old problem will reoccur in the period of time although the processes have been done with prevention and appraisal of the problem. All these problems that are constraints of business utilizing various resources

in different forms without adding any value in the system called bottleneck in manufacturing unit. Bottleneck also can be derived as an activity which delays the performance of the process and reduce the overall efficiency of the process. For example company has many process lines of production and each of them are connected to each other. The process cannot support the quantity of previous process if one of the machines is broken. Delay of production will occur and it will affect the output of the production.

The main reason of the production lines in a manufacturing unit slowing down is because of the bottleneck problem. Bottleneck in production lines need to be identified, analyzed, and to be resolved on the basis of facts. When bottleneck in production lines is identified correctly and efficiently, it can help to reduce the production cost and increase overall efficiency of the process. There can be a long term or short term constraints in the process in manufacturing. Fishbone diagram is one of the approaches that can identify the bottleneck in operation process. Fishbone diagram also can be called as Ishikawa diagram or cause effect diagram and it was created by Dr. Kaoru Ishikawa from Japan. Fishbone diagram is a quality control tool that provides a systematic and graphic way of identifying possible causes for a problem by using categories to focus and structure the thinking in order to work toward determining the root causes (John, 2012). According to this approach, different data related to the problem are collected and analyzed precisely in order to determine the root cause for the particular problem (Peter, 2010).

There is one research on finding a new method to determine the bottlenecks and rank the bottlenecks level in a manufacturing system. To analyze and determine bottlenecks in a production process is not an easy task to accomplish. Bottleneck problem in production line usually come from the Optimum Production Technology, or known as "Theory of Constraints". Besides, the main problem of the bottlenecks are caused by the manufacturing line are inherently variable. The cause of this variation might be due to random events or machine failure and long term changes in the system such as seasonal variation of demand, new product launch, and machine load changes. Bottleneck in the production line can be categorized into two which are dominant bottleneck and momentary bottleneck. Dominant bottleneck is a fixed or most occurred

in the production line but momentary bottleneck is a random event such as machine failure (Sankar et al., 2008).

There are several methods to determine the dominant bottleneck and momentary bottleneck. This method is including the following statements:

- ✓ Detect the shifting bottleneck according to the machine duration that being active without interruption.
- ✓ Detect the bottleneck based on the machine utilization. The machines with the highest utilization is considered bottleneck.
- ✓ The machine with the longest average up-stream queue length is considered bottleneck.
- ✓ Estimate the blockage and starvation probabilities of a machine by using analytical approach.
- ✓ Detect the bottleneck in order to optimize the scheduling in a shifting bottleneck procedure by using a graph theoretic approach.

Toyota Research Laboratory had proposed a method for finding on identification and ranking the bottleneck in a manufacturing system. This method is specifically applies to a discrete event system. All machines are assigned to any one of the predefined discrete state at the time given. At this state, it will be categorized into two groups which are active and inactive categories. The duration of the active machine without any interruption by an inactive state is measured. Series active states are considered as one active state. The longest duration of the machine throughput is known as bottleneck. The advantages of the method are no knowledge of the structure of the system or order of processing is needed, and it can calculate the level of confidence of the solution recommended (Roser et al., 2002).

2.6 THEORY OF CONSTRAINTS

The Theory of Constraints (TOC) is a methodology for determining the most crucial limiting factor or constraint that blocking to achieve a goal. The improvement of the productivity will occur when no longer constraint in the system. In manufacturing industry, the limiting factor or constraint is based on the bottleneck. Every process in

the manufacturing has a constraint or bottleneck. The fastest and most effective way to improved profitability is focusing on the improvement efforts on the constraint or bottleneck in the process. The TOC takes a scientific approach to improvement. The common organization goals are the same which is to increase the profitability in the short term and also in the long term period. There are a set of powerful tool for helping the organization to achieve its goal providing by Theory of Constraints (Sergio Rattner).

The tools for helping the organization to achieve goals are:

- ✓ The Five Focusing Steps means a methodology for identifying and eliminating constraints.
- ✓ The Thinking Processes means tools for analyzing and resolving problems.
- ✓ Throughput Accounting means a method for measuring performance and guiding management decisions.

According to Dr. Eliyahu Goldratt, the characteristic of Theory of Constraints is prioritizes for improvement activities. The top priority is always the current constraint. Theory of Constraints is highly focus on the methodology for creating rapid improvement in the environment where there is an urgent needs to be improve. There are several benefits if the Theory of Constraint can be implemented successfully (Tim, 1998). The benefits are including:

- ✓ Increase the profit (The primary objective for implemented the TOC in the organization).
- ✓ Rapid improvement (The results is only focus on one critical area in the system constraint).
- ✓ Improve the capacity (Eliminate bottleneck enables more product are produced).
- ✓ Reduced lead times (Eliminate bottleneck enhance the process run smoothly and faster product flow).
- ✓ Reduced inventory (Work-in-process will be reduced if bottleneck was eliminated).

2.6.1 Constrains in Operation Process

There are many different kind of bottleneck problem in manufacturing industry such as labor, time, material, and machine. The constraints that involve in manufacturing industry are people constraints, material constraints, equipment constraints, process constraints, management constraints, and environmental constraints.

People constraints are very difficult to manage in an effective way because everyone has their own behavior. There are different people working together in manufacturing unit with different experience, background, and educational qualification and they have their own way of motive towards work. So it will be different bottleneck problems in the same line of production. Material constraints is production capacity which is strongly affected by the poor production planning and management of inventory, inadequate forecast of material and finance, inefficient of supplier, changing product mixed, and etc. Improper flow of materials resulting reduction in overall production capacity and increasing lead time may occur (SMC Focus, 2012).

Equipment constraints are caused by inappropriate planning, breakdown of machine, unavailability of spare parts, improper maintenance, low level of infrastructure machines and equipments. Process constraints in manufacturing unit may due to poor plant layout, inflexible process, insufficient resources, and quality problems. The process constraints may occur anywhere in the process, supply chain, and also customer (Small business tool kit, 2012).

Management constraints means the management is not be able to meet the needs of the system and it will cause different problems such as employee motivation decrease, and ineffective flow of material and information. A policy constraint happens because management cannot illustrate all the problems in detail and specific way in manufacturing. It is a common form of constraint (Lean production, 2012).

2.7 SIMULATION TECHNIQUE

Simulation and modeling are interrelated to each other to solve any problem either in manufacturing or services industry. What is the different between simulation and modeling? The meaning of modeling is a process that creating or producing a model. A model is the representation of the real system and it is similar to the real system but simpler than the system it represents. The main objective of a model is allowing the analyst to forecast the effect of changes to the system. A model must be close approximation to the real system and incorporate most of its salient features. Besides, it is easier to understand and experiment with it. Balance tradeoff between realism and simplicity will give the model become high in quality. Model validity is very crucial because model validation techniques include simulating the model under known input conditions and comparing model output with system output. From the term of modeling, we can derive the simulation as the operation of a model of the system. The model that was created can be reconfigured and experiment with it. Simulation method is a tool to evaluate the performance of the existing system and can proposed an improvement system via the model. Simulation is used before an existing system is change or new system built because it can reduce the chances of failure to meet specifications, to eliminate unforeseen bottlenecks, to prevent under or over-utilization of resources, and to optimize system performance (Anu, 1997).

The purpose of simulate the factory layout using ARENA software is to solve industrial's problem. By using the ARENA software, we can create a model based on the real situation in the factory into computer software or it is called as simulation. A simulation study may determine the efficiencies of the machines in the factory. In the factory layout context, the crucial thing of simulation is to find out the most efficient arrangement of machines in the machine shop. By the simulation model, we can also see the individual movements from one machine to another machine. The main objective of using simulation in factory layout is to illustrate how the plant lay out cab be solved and it also can help us to think how the efficiency can be improved. It should start with the analyzing and evaluating the existing layout which the data can be collected by interviewing engineers and top managements. For the analysis using ARENA software, the data such as time of each machine need to be calculated and also

inter arrival time is also noted using these data the material flow is simulated and machines with largest queue is found and also efficiencies of different machines are found out. We may create another layout model by using the software to improve the efficiency. The efficiency are depends on how well the production facilities and amenities are located in the factory. The relationship among the output, floor area and manufacturing process must be optimum.

To develop aggregated simulation models with in System Modeling Language (SysML) based on simulation model aggregation framework with high accuracy need several steps to done it. The three majors of simulation model aggregation framework are system conceptual, simulation modeling, and additive regression model-based parameter estimation. The beginning stage is to construct the system conceptual model for a generic seedling propagation system in term of system structure and activities hierarchical manner such as low, medium, and high levels. The second step is using simulation or Arena software to construct the simulation model conforming to the conceptual model. The third step is an additive regression model-based approach is proposed to estimate parameters for the aggregated simulation model. One of the huge grafted seedling propagation systems in North America was demonstrated in the proposed framework. The output of this research show that the proposed framework permits us to construct accurate but computationally affordable simulation models for seedling propagation system and model aggregation improves the randomness of simulation results. The results are same accuracy as that of a detailed simulation model and achieving significant execution speed improvement (Pasupathy*et al.*, 2013).

The basic theories of the discipline of simulation science and technology are including the simulation theory together with the simulation modeling theory and the application of the simulation theory. The simulation model theory can be described as quantitatively or qualitatively the running characteristics of specific system such as models, and also the study. The specific system for the models and study are crucial in simulation theory and it required technologies for constructing domain simulation systems. To construct the simulation systems for simulation theory, there are three levels of theoretical hierarchy which is the general theory, the domain theory, and the supporting technologies. The first level is supporting technologies which including the

run-time supporting technologies, design-time supporting technologies, and standards and specifications. The second level is domain theory. The domain theory consists of the super-reality of simulation systems, the space-time consistency of simulation systems, and the real-time of simulation systems. For the third level or last level is the general theory and consist of the definition and classification of simulation systems, architecture theory of simulation systems, design theory of simulations systems, and life-cycle management theory of simulation systems (Xu et al., 2008).

The key that needed within the Modeling and Simulation (M&S) arena is the ability to compose simulations and simulation environments rapidly and efficiently. M&S is a component that represents and model simulation and interoperable simulation environments useful for testing, analysis, training, mission rehearsal, and the prototyping and acquisition of new systems. Base Object Models (BOMs) supported by Simulation Interoperability Standards Organization (SISO) provide a key of mechanism in facilitating interoperability, reuse, and comparability and support and promote the reuse of simulation components and agile, rapid, and efficient development and maintenance of models. (Paul and Tram, 2004)

CHAPTER 3

RESEARCH METHODOLOGY AND PROCESS DESCRIPTION

3.1 INTRODUCTION

Research methodology can be explained as a method and technique on how to conducting the research. It can answer the research question and solved research problem under the study. This chapter will explained how to conduct the research from the beginning steps until the end of the research in detailed. Furthermore, it will elaborate on the research framework or design, how to collect the data, and how the data will be analyzed to get the results. This chapter also will include the research design and, data collection method, simulation model and process using ARENA software, and process description.

3.2 RESEARCH DESIGN

Research design is a process to make a beginning plan and framework to conduct the research. This is the first step to make sure the planning of the research process and research flow is going smoothly as expected. Besides, research design can be figure out the overall of the research and to see what is the problem that may occur when we to conduct the research. Research design also can be able to answer the research question. It is also able to control the variance during the research.

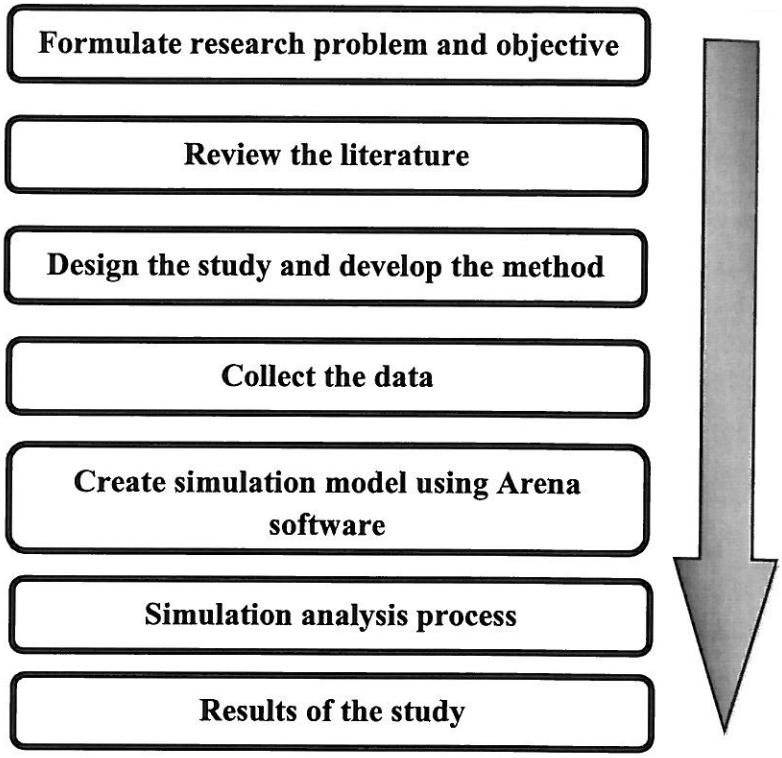

Figure 3.1: The flow of the research design

Step 1: Formulate the research problem and research objective

For the first step of the research on the chili sauce production process system is defining on what is the problem that the organization was faced which affects the productivity and product capacity of the organization was reduced. From problem that occurred in the organization, research objective can be developing in the research design. Research objective is a purpose of doing the research and to solve the organization problem.

Step2: Review the literature

Review the literature is a process of study the previous research which is related to research objective. This will help and guide us to do the research smoothly. The literature can be journal, articles, newspaper, book, and any other thing that will give information about the research. As we know that the technology changes are very fast, so we need to refer the latest literature because old literature cannot support the current

situation. For example, the simulation study for the last 10 years is a costly techniques compared to the current year which is not a costly technique. Otherwise, the simulation technique will save a lot of cost and time to do the evaluating and analyzing.

Step 3: Design the study and develop the method

After reviewing the literature, it will help us to conduct the research easier because understand all the problem and objective. When understand what we need to do on the research, we are able to design the study and decide on what method that appropriate to conduct the analysis. Choosing the suitable method is a very important in the research study. This is because choosing wrong method maybe cannot give the most accuracy answer to the research objective. The most suitable method for this research is simulation technique.

Step 4: Collect the data

Data collection is the most important for every research. Data is like a key of the research method for starting to evaluate and analyze the production process system. From this research study, data and information need to support the simulation technique. The type of data and information is referring method and how to run the method. For simulation method, the data and information that needs to be used is the cycle time of the production system and the process description of chili sauce production. Unsuitable information and data will not give an accurate answer and this study will not give any benefit to the organization.

Step 5: Create simulation model using Arena software

When the information and data of the production process system is recorded, we will be able to create a production model using Arena software. Choosing the correct item in the Arena software is needed to represent every single process to create the chili sauce production model. Production process model need to validate by using the data that has been collected.

Step 6: Simulation analysis

Simulation analysis is an analysis to evaluate and analyze the model to be more efficient and eliminating the constraint in the chili sauce production system. The usual constraint that occurred in the manufacturing process is bottleneck. So, the first model is created to measure the performance of the chili sauce production and analyze the model to determine the bottleneck in the chili sauce production model. It also can be conduct by using "What-if" analysis approach. What-if analysis approach is creating another model to improve the chili sauce production process and reduce the bottleneck problem.

Step 7: Results of the study

After the simulation analysis and what-if analysis approach, the result of all model that created using Arena software need to measure on its performance. From the result, the simulation production model that gives a high performance to the production process system will be chosen.

3.3 DATA COLLECTION METHOD

Data collection method is a very important process for doing a research because the research study will not achieve research objective without the relevant and accurate data. Data collection method is involved the gathering and measuring the information process. The information also can be known as data. Data collection is an establishment of the research to get the output or results and answering the research questions and hypothesis, and evaluating the results before implement it. Data can be divided into two categories which is quantitative and qualitative.

The importance of data collection is to capture the quality of evidence that can be translating into rich data analysis and allows the building of a convincing and credible answer to answer the research questions. The accuracy of the data collection plays high role to maintaining the integrity of the research regardless of the field of study or preference for defining the data. To minimize the error occurred is needed to

select the appropriate data collection instrument either existing, modified, or newly developed and delineated the instructions clearly.

The effect of selecting the data collection in improper way is:

- ✓ Research questions unable to answer correctly and accurately.
- ✓ The study unable to repeat and validate.
- ✓ Results and outcome can be distorted in wasted resources.
- ✓ Fruitless avenues of investigation will occurred by misleading the other researchers.
- ✓ Compromising decisions for public policy.
- ✓ Causing hazardous to human participants and also animal subjects.

The degree of impact from inappropriate data collection may different by the field of study, nature of investigation, and the branch of knowledge. Disproportionate harm may be occurred when these research results or outcomes are used to support the policy recommendations. So the collecting of inappropriate or not accuracy data collection needs to be avoided in doing a research to prevent any harm occurred.

Maintaining data integrity and accuracy can support the detection of errors in the data collection process, whether the errors is intentionally or not. Intentionally made an errors means deliberate falsifications, then not intentionally means systematic or random errors that occurred while collect the data. The two approaches that can maintain the data accuracy and ensure the scientific validity of study outcomes are 'quality assurance' and 'quality control' (Most, Craddick, Crawford, Redican, Rhodes, Rukenbrod, Laws, 2003). According to the Whitney, Lind, and Wahl (2003), these two approaches are implemented at different timeline of the research process. Quality assurance is an activities running before data collection begins and quality control is an activities running during and after data collection.

Since the quality assurance will take place before the data collection process begin, so this approach is focus on 'prevention'. Prevention is forestalling problems with data collection and the most cost-effective process to ensure the accuracy of data collection. This proactive measure is to develop in comprehensive and detailed

procedures manual for data collection and it is the best demonstrated by the standardization of protocol. The risk of failing to determine the problems and errors will increase if written manual is very poor or ineffective. In the context of research, quality assurance is related to the qualitative research strategies which is non-participant or participant observation, interview, archival, field of study, ethnography, context analysis, oral history, and unobtrusive research.

Hence, the activities of quality control are detection, monitoring, and action during and after collecting the data. The details of procedures manual needs to document carefully to make sure the process is going smoothly. Lax monitoring and limits opportunities for detecting errors occurred because of the poor developed communication structures.

The examples of data collection problems that require immediately action include:

- ✓ Errors in individual data items
- ✓ Systematic errors
- ✓ Violation of protocol
- ✓ Problems with individual staff or site performance
- ✓ Fraud or scientific misconduct

Based on this research study, the most suitable method to collect the data is observation and interview method for primary data. For secondary data, historical data is needed to support the primary data such as journal, articles, documents and books that can generate idea to continue and completing this research study. The operation process of producing chili sauce data is such as process flow and description from raw material to finished good, time taken of every single process, and others data that can support the research going smoothly.

3.3.1 Interview Method

Interview is an activity of the interviewer asking the questions to the interviewee. Interview data collection method also can be known as one-on-one data collection

method. There are structured interview and unstructured or open interview. The example of structured interview is using survey form to the respondents for answering the questions whereas open interview is directly talking with the respondents. The question that will be asking in interview session is prepared before the interview started and it will refer to the research questions and research objective or purpose of the study. It is very important to design the pilot test form as preparing the interview questions. Interviewees or respondents might not be able to answer the questions as we thought. So, interviewer must assure to collect the accurate data, and avoid wasting time and money by using small-scale test prior to the actual use data collection (Alessandro Iannuzzi, 2013).

There are two major functions of interview data collection method which is description and exploration. Description means respondents or interviewees have a tendency to give more explanation replies as the questions are made to be open-ended. The attitudes and beliefs of the interviewees is more understandable using the description method and the information receive is more personal. Besides, exploration means the respondents respond can help in understanding new areas under the research work and it also can be used to develop other methods such as questionnaires. From the interviews data collection method, the bond between the interviewer and respondents will become stronger.

In this research, the focus respondents or interviewee is the owner and employee of the company. The question that will ask to the owner is about the company problem, operation process, capacity of the product, and etc which related to the chili sauce production. All the questions needs to have a limit to avoid any issues or problems occurred. The limitation of questions is do not asking the sensitive question to the owner. Besides, the second group of interviewee is the employees.

3.3.2 Observation Method

Observation method will include in this research for collecting the data. Observers can make the direct collecting data by observe the operation process, human behavior, and etc. There are two categories of observation method which is direct

observation and indirect observation method. Direct observation means observer be able to use their senses such as sight, smell, taste, touch, and hearing to experience it. Besides, indirect observation means observer experience or observe something any event after it was happened. Basically indirect observation method is the opposite with direct observation method. The example of direct observation is observer seeing the burning fire in front of his own eyes. By this situation, observer is able to feel its warmth and smell the fumes. Furthermore, observer's eyes get watery because of the burning smoke. On the other hand, the example of indirect observation is observer going to the empty campsite to see the burnt logs and ashes.

From the two types or categories of observation method, the most suitable for this research is direct observation. To relate in this research, direct observation is a method that to collect the related data and information such as to see how the process is run from raw material or input until output process or finished good. Furthermore, observer will be able to take the duration of time for each process station and overall processes. From this data and information, it will help this research to analyzed and evaluate the operation process of chili sauce production. The main purpose of this research is to determine the bottleneck problem that happens in the operation process and define the capacity of the product. Furthermore, this direct observation will focus on the production process flow, capacity of the machine used, the cycle time of each stage of the operation process, and the machine effectiveness and efficiency. Data and information that has been collected will be used in the simulation process to solve the entire problem in the production process.

3.4 SIMULATION MODEL USING ARENA SOFTWARE

Simulation is a techniques to imitate or enactment the behavior of some situation or some process for the purpose of the study and the research. According to the research, the development of the model by using the Arena software would be able to describe all the production process step by step. Arena software can simulate the real chili sauce production into computerized modeling chili sauce production process system. This will prevent the try and errors method which is will give a high risk and company may lose a lot of cost to implement it.

The steps in developing a simulation model by using Arena software are listed below:

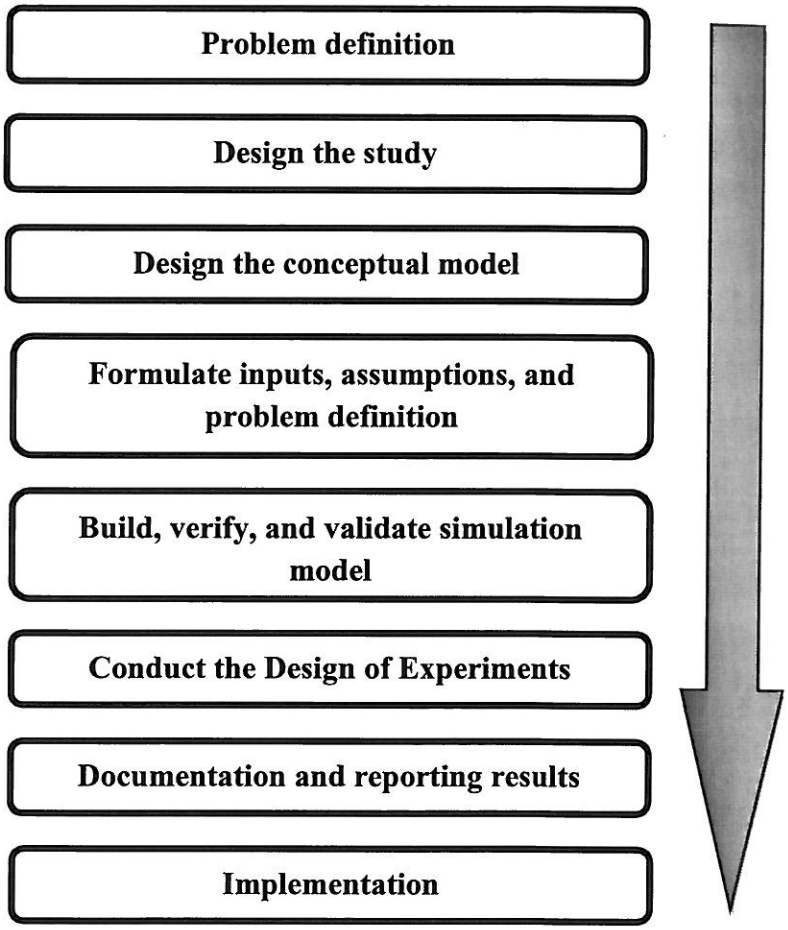

Figure 3.2: Simulation method process.

Step 1: Problem Definition

For the first step of the simulation is to determine the research objective by indentify the research problem in the chili sauce production process. Research objective and problems should be identifying in the beginning to give a direction to researcher running this research and avoiding from out of the topic study. When the research problem had been identified, it will make the data collection process to be easier and analysis for the steps of chili sauce production process model in detail.

Step 2: Design the study

Once the researcher have a clear research objective and purpose of study, the next steps in developing the simulation process is design the study. Designing the study will include the data collection method. The data collection method will conduct in both interview and observation method. This is because interview and observation method will give a clear and accurate data and information needed to support the simulation process. After that, the researcher also needs to finalize the model and the duration of the simulation exercise.

Step 3: Design the conceptual model

At this stage, the first level of chili sauce production process model is done to understand the dependencies that exist in the process. Furthermore, this stage also will validate the data collected via interview and observation method. To validate the production process is crucial to make sure the process model is representing the real production process model of producing chili sauce.

Step 4: Formulate inputs, assumptions, and process definition

For this step, the researcher will key in the data that was collected into the chili sauce production process model to generate or run the simulation process. The most important in this step is to make an assumption while the simulation process in generating. This step is to identify the predictability and accuracy of the simulation model. The prediction is one of the ideas on how to do the research.

Step 5: Build, Verify, and validate the simulation model

The result from the generating simulation model by using the real data that had been collected is used to validate the accuracy of the chili sauce production process model. The simulation model must be able to imitate the real scenario of the process as closely as possible. The final validity of the chili sauce production process model is

based on the assumption that had been made and also according to the research objective of the simulation from the previous steps.

Step 6: Conduct the Design of Experiments (DOE)

Once the simulation model is confirm with it accuracy, then it can be used to leveraged by generating several of the "what-if "analyses. What-if analysis need to be done in a structured Design of Experiment (DoE) way to ensure that all "to be" scenarios are simulated. The most suitable "to-be" model will be chosen but the most suitable "to-be" model may not represent the optimized scenario. This is because of the fact that some process constraints that cannot be excluded in the real time.

Step 7: Document and Reporting

Documentation is another crucial step which it will ensures that the researcher is able to leverage the learning from the simulation model in the long run. The simulation outputs will be interpreted and analyzed in this phase. After that, the finalized results will be analyses by the researcher into the report and documentation.

Step 8: Implementation

The results or output of the simulation will solve the research problem or eliminating the bottleneck in the chili sauce production process system. The capacity of product also will increasing and meets the customer demand in the market. So, the organization able to implement the best chosen model to increase their performance, profitability, and reputation.

3.5 WHAT-IF ANALYSIS

What-if analysis is a process of changing the simulation model to see how those changing will affect the outcomes and results on the performance of the model. The changing in simulation might be a small changing such as adding some process at the bottleneck station. What-if analysis is an approach to see how the changing can give a

benefit to the company. This approach might not give an optimize solution to the problem. Besides, the simulation models are often subjects to errors caused by the estimated parameter of underlying input distribution function. What-if analysis is needed to establish confidence with respect to small changes in parameter of the input distribution. There four different methods for estimating performance function for several scenarios using extrapolation/interpolation are presented. A comparative experimental study on the efficiency of these methods is provided by using the simulation technique which is simulating simple reliability model.

3.6 PROCESS DESCRIPTION

The purpose of process description is to explain and describe the process flow for producing a product from stages to stages. In this study will describe on the chili sauce production flow from the raw material until finished goods. Besides, this study also will covers on the machine utilization, material flow from input transform to output, and chili sauce production. Furthermore, the description on chili sauce production will provide a clearer production process and it will help to make this study going easier to be implemented and did not run out of the research objective. The way and technique to produce chili sauce is similar for all the manufacturing. The different that makes the taste differ is on the ingredient and its quantity. The types and freshness of chili also will affect the taste of the chili sauce. Nowadays, there are many type of machine to process the chili sauce. Each machine has different capacity and the time taken to produce it also differ.

There is several processes flow to produce chili sauce. The processes is included the raw materials from the supplier until the packaging of the product.

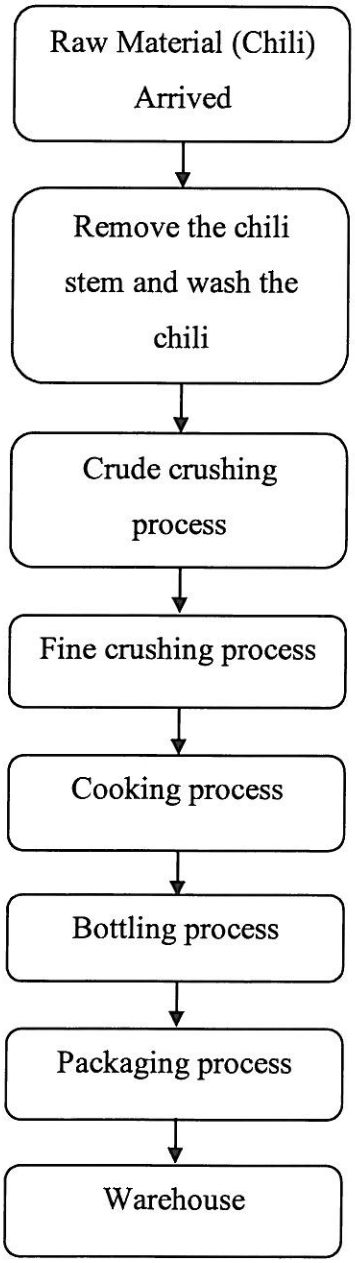

Figure 3.3: Chili sauce production process

Stage 1: Raw material arrived

The first stage to produce the chili sauce is waiting the chili arrived. When the supplier delivered the chili to the storage, stage 2 can begin. Chili sauce need to be ordered based on the capability of the manufacturing to produce chili in a day because chili inventory cannot keep it too long of time. If the company wants the chili sauce to be fresh and delicious, they might be applying the Just-in-time (JIT) approach. It also can reduce the holding cost of the inventories.

Stage 2: Remove the chili stem and wash the chili

For the next stage is plugging the chili stem and leaf. After that, wash the chili to be clean for avoiding from any mud or dirty thing stuck at the chili. The hygiene of the product is the main policy of this company. So hygiene is a crucial steps and this stage are using workers to run it because machine will not be able to clean up the chili as clean as possible.

Stage 3: Crude crushing process

After the chili was washed as clean as possible and no any dirt at the chili, the process will continue by crushing process. There are two steps of crushing process and the first stage is crude crushing process which means crush the chili crudely using the machine.

Stage 4: Fine crushing process

The second stage of chili crushing process is fine crushing process. In this process take a longer time period compared to crude crushing process. The purpose of fine crushing process to crush the chili to become liquid states before move it to the cooking process.

Stage 5: Cooking process

For the cooking process, we need to move the fine crushing chili into the cooking machine along with the ingredient to cook it. Cooking with the added ingredient is wan the sauce to become more taste such as sugar, salt, and etc. Every single ingredient has its own measuring. The cooking process is done when the temperature is achieved 82 degree Celsius.

Stage 6: Bottling process

Bottling process is a process that to fill the product into the bottle. This process is taken 3 second per bottle. Bottling process need to be doing directly after the cooking process because the chili sauce will grow fungi if did not close it properly.

Stage 7: Packaging process

After the bottling process had been done, the packaging process will continue the chili sauce production process. Packaging process is the last process in the chili sauce production process.

Stage 8: Warehouse

After the packaging process, all the chili sauce will move to the warehouse for counting the production before send it to the customers.

CHAPTER 4

MODEL DEVELOPMENT AND DATA ANALYSIS

4.1 INTRODUCTION

The purpose in this chapter is to evaluate the performance of the chili sauce production processes. There will be described in more detailed about the model development which is creating by using the ARENA Software to imitate the real process of chili sauce production processes. Furthermore, this chapter also will discuss and explain about the results that getting by the simulation analysis and compare it with the original process. The most crucial thing to get the imitating process is similar with original process is to get the accurate data of the real processes. So the data analysis is very important to get the real processes to imitate in the ARENA Software as describe in the previous chapter. For this study, the data was collected at the HFI Maju Enterprise in Pengkalan Chepa, Kelantan.

In this chapter, the model will be developed in the ARENA Software and make an evaluation on the processes. From this analysis, the bottleneck constraint and cycle time of the chili sauce production processes will determine. The production performance will be increased by modifying some process flow by adding some of the process to improve the production performance.

4.2 MODEL DEVELOPMENT AND DATA ANALYSIS

4.2.1 Model Development

The model of the processes was developed by imitating the real process from the HFI Enterprise which producing the chili sauce as a main production. The process was constructed by using basic process template, advanced transfer template, and flow process template in the ARENA Software. There are several modules was choosing to develop the process which is one for CREATE, six for PROCESS, three for STATION, three for ROUTE, one for ASSIGN, one for TANK, two SEIZE REGULATOR, two FLOW, two RELEASE REGULATOR, one SEPARATE, one BATCH, and one for DISPOSE.

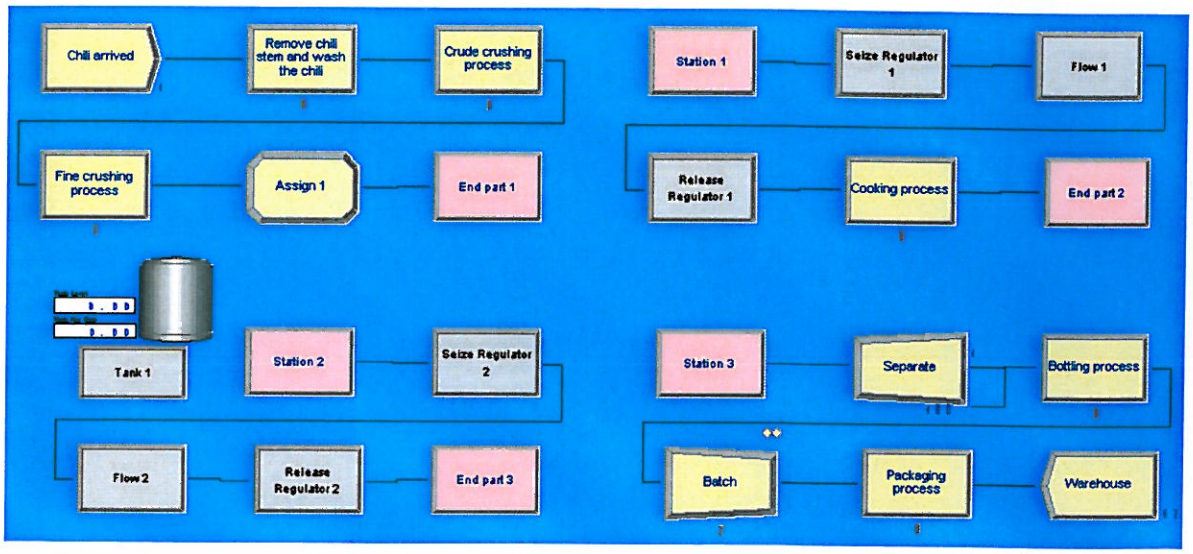

Figure 4.1: Simulation Model of Original Processes

The beginning of the steps of the simulation model is CREATE Module. The understanding and interpreting of this module is very important because it may cause the process cannot run or did not get the output same as the real process in the manufacturing. Based on the chili sauce production processes, the raw material or chili is arrived once per day in the morning. The chili is order by weight which is 60kg per day. In this module, the arrival of the chili is constant and the entity per arrival is one.

The maximum arrival also is one. Although the entity per arrival is only one unit, but it is represent 60kg of chili per arrival.

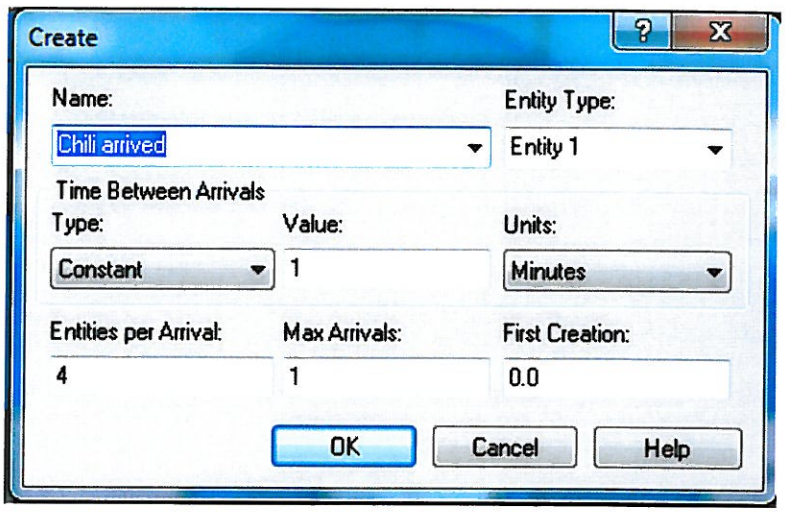

Figure 4.2: Create Module

PROCESS Module is the main processing method for all the process in the simulation model. There are several options such as seizing and releasing resource **constraints in this module. Furthermore, there is an option to use 'submodel' and** specify hierarchical user-defined logic. According to the chili sauce production processes, there are many processes involved to produce the chili sauce completely. First of all, the data that was taken from the company must be analyze it before put it the process. All of the action of overall model is queue-seize-delay-release of resources, or any part of this.

There are six modules are involved in this model which is removing chili stem and washing the chili process, crude crushing process, fine crushing process, cooking process, bottling process, and also packaging process. Removing chili stem and washing the chili process is operate manually by three workers because there are no suitable machines that can run this process. Furthermore, Malaysia is a Muslim country, so the hygiene of the food is very important. Crude crushing process, fine crushing process, and cooking process are taking a long time to complete the process. The time taken of these processes is in minutes.

One entities of the bottling process is represent 12 bottle of chili sauce and it take 3 second per bottle to fill the chili sauce. There are two flow which is bottling process can fill the chili sauce 2 bottles in 3 second. So the time of bottling process is set as 18 second per entity. Lastly, packaging process is 24 bottles. So in this process only batch two entities which are represent the 24 bottles of chili sauce. One dozen of the chili sauce needs 1 minute to complete it. After the packaging process is done, the finish product is transfer to the warehouse of the company.

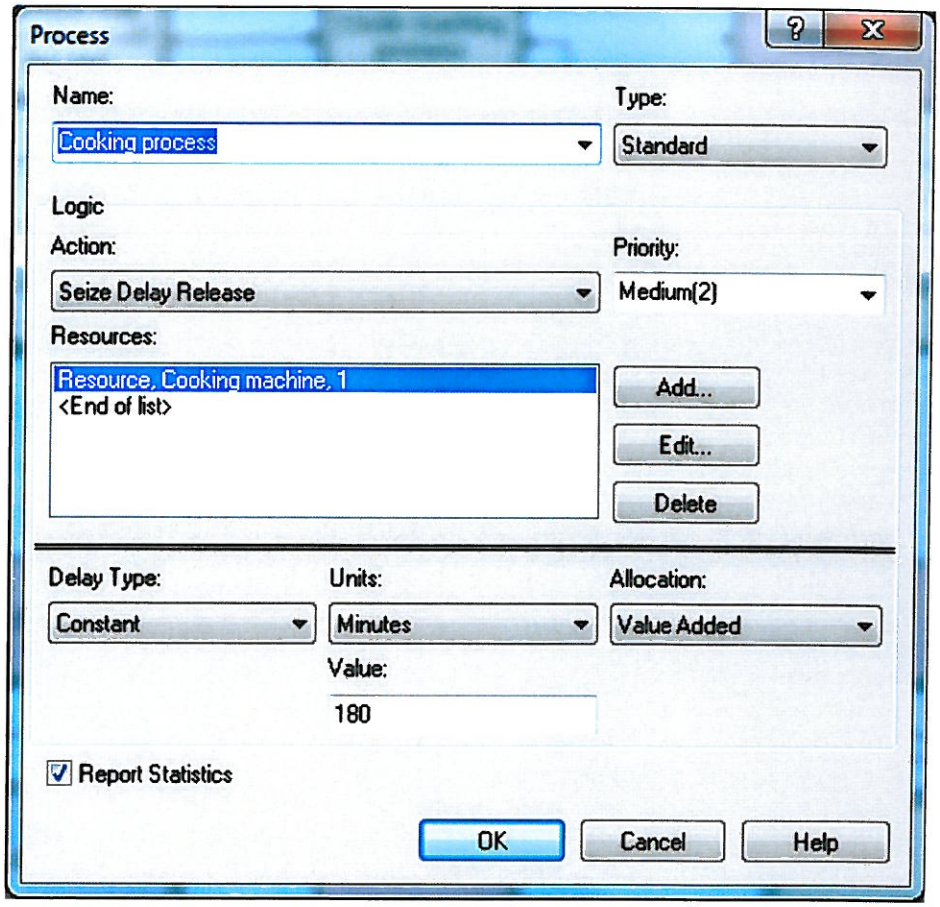

Figure 4.3: Process Module

ASSIGN Module is a module that used for assigning new values to variables, entity attributes, entity types, entity pictures, or other system variables. Based on this study, the ASSIGN Module is used to differentiate the product or chili.

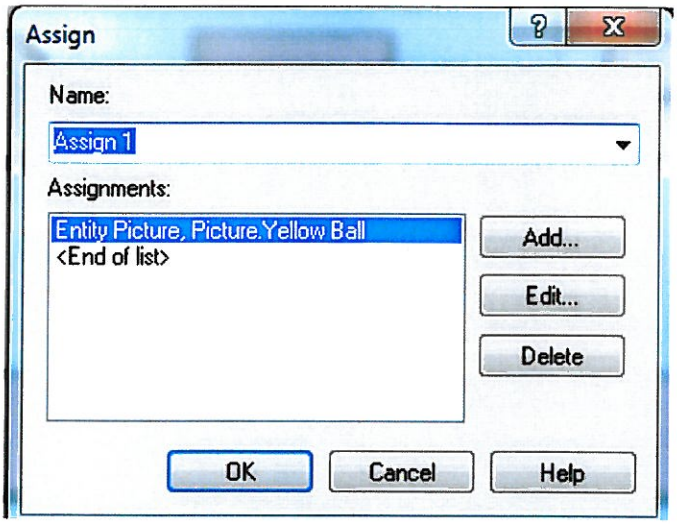

Figure 4.4: Assign Module

ROUTE Module is a transfer module which is transfer the entities from one station to the another station. The time of transferring the entities are depend on the layout of the company. According to the research, the time of transferring the entities is not much affect the overall processes because the layout of this is small only.

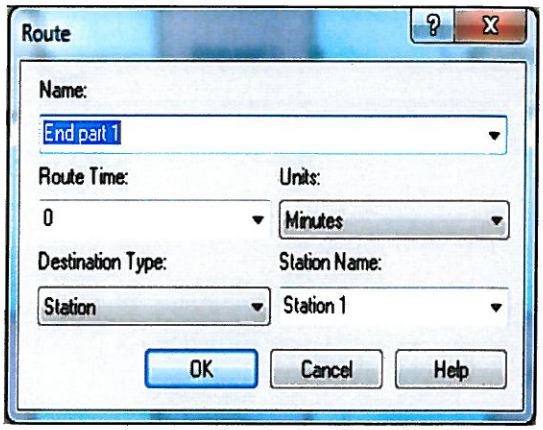

Figure 4.5: Route Module

STATION Module is a module that defines a station corresponding to a physical or logical location where processing occurs.

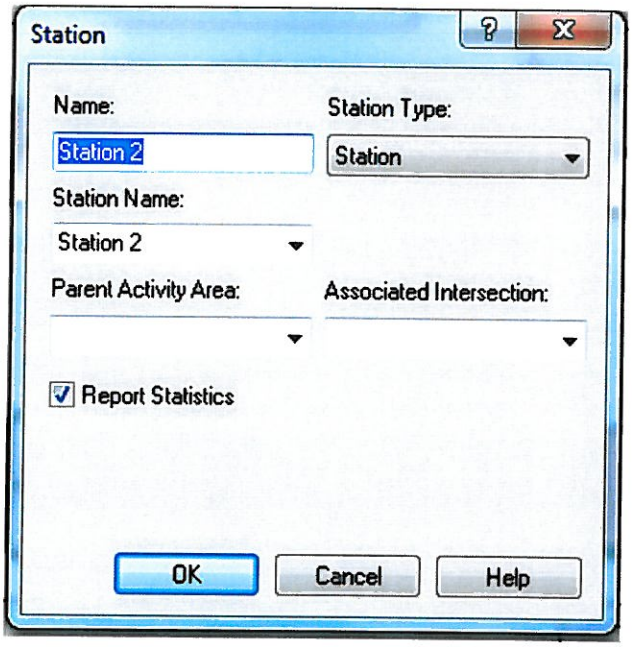

Figure 4.6: Station Module

SEIZE REGULATOR Module, Flow Module, and Release Module are related to the flow process which is a tank regulator may be used for only flow operation at any given time. In this study, there are two set of flow process which is flow into the tank 1 and flow out from the tank 1.

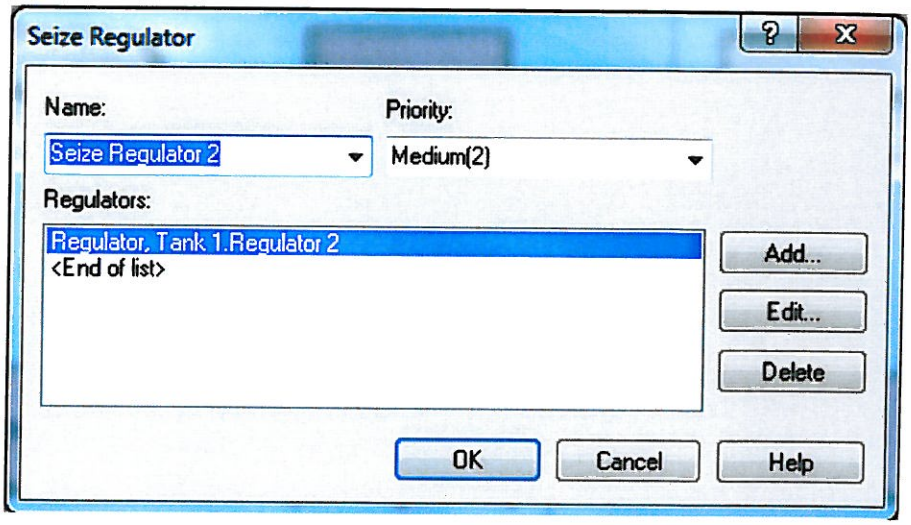

Figure 4.7: Seize Regulator Module

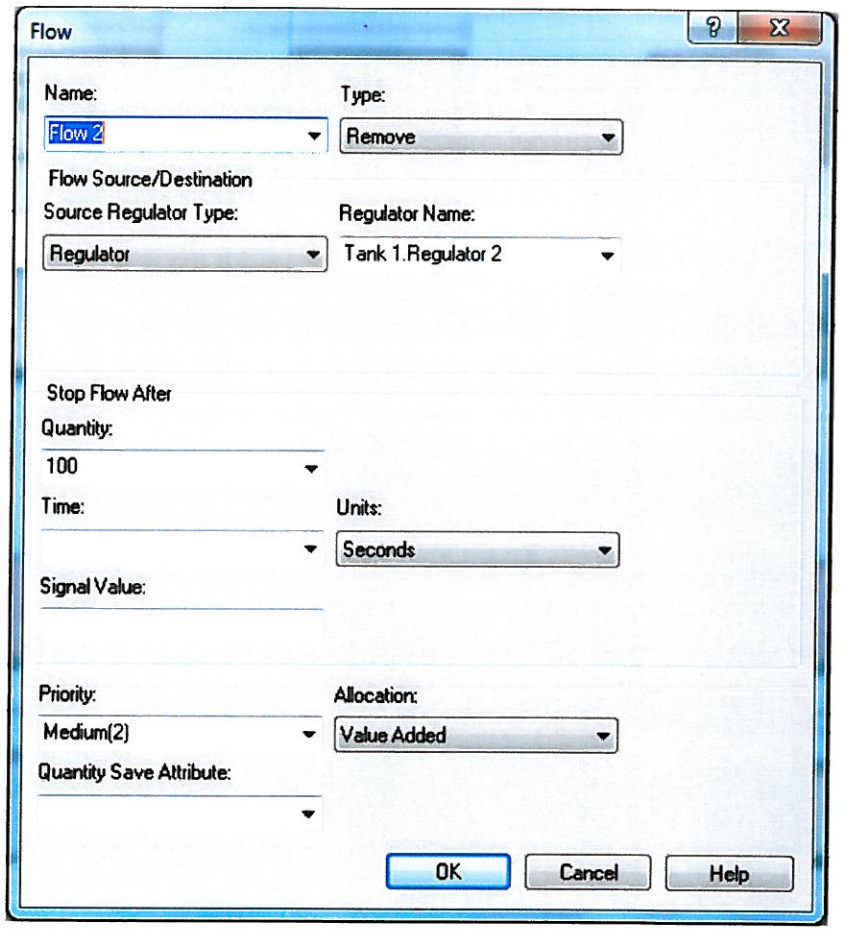

Figure 4.8: Flow Module

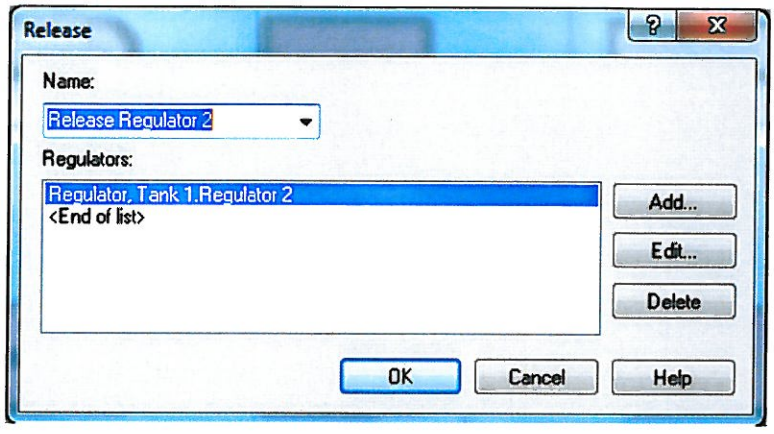

Figure 4.9: Release Module

SEPARATE Module also was applied in this process model. The function of this module is to duplicate the entity become more. This is because the total weight of chili will divided into small amount of the chili sauce for bottling process.

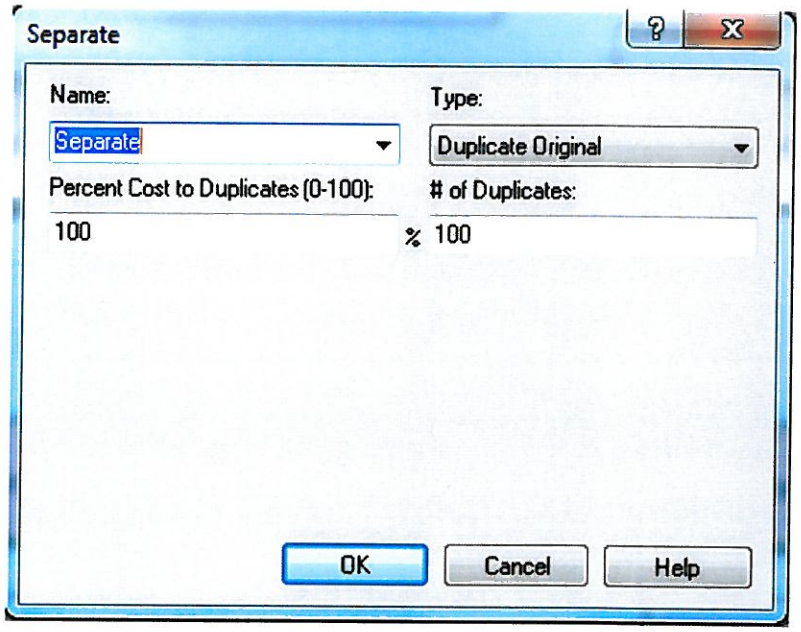

Figure 4.10: Separate Module

BATCH Module is a combining the entities to become one entity. This module is normally applied for the packaging process which is we need to arrange all the chili sauce in total of 24 bottles. The batch size is 6 because one of the batch sizes represents 4 bottles of chili sauce.

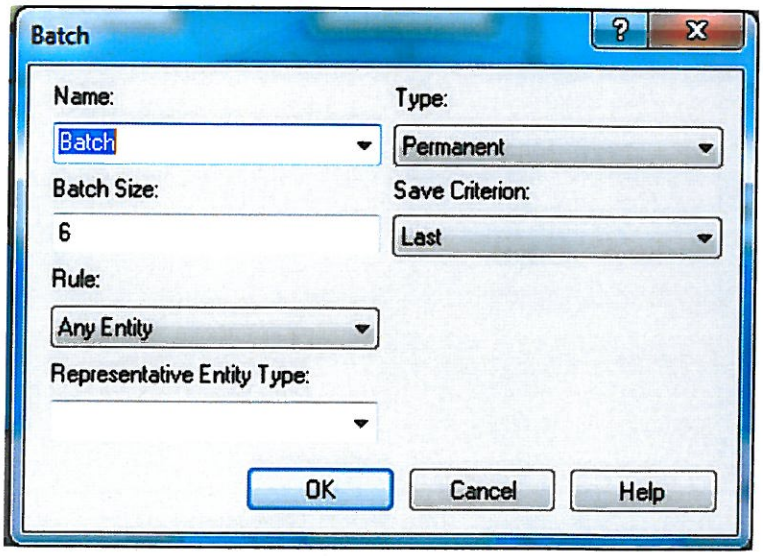

Figure 4.11: Batch Module

DISPOSE Module is the last module in the process flow of the model. The entities flow will stop at this module and the result will be recorded.

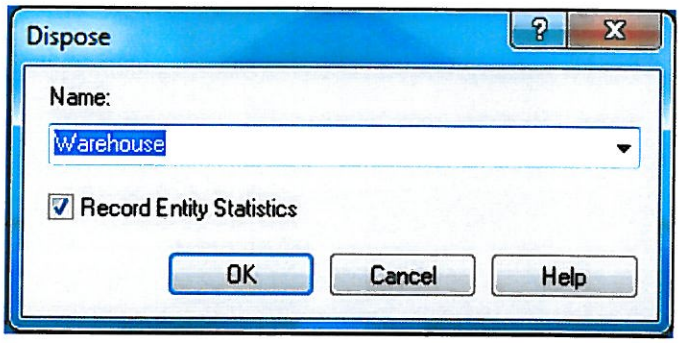

Figure 4.12: Dispose Module

TANK Module is a location where is held or stored the capacity of the entities. According to this research, the tank is to fill in the fine crushing chilies to be stored and then cook it. The cooking process is normally taken nearly 1 hour or the temperature is arrived at 82 degree Celsius.

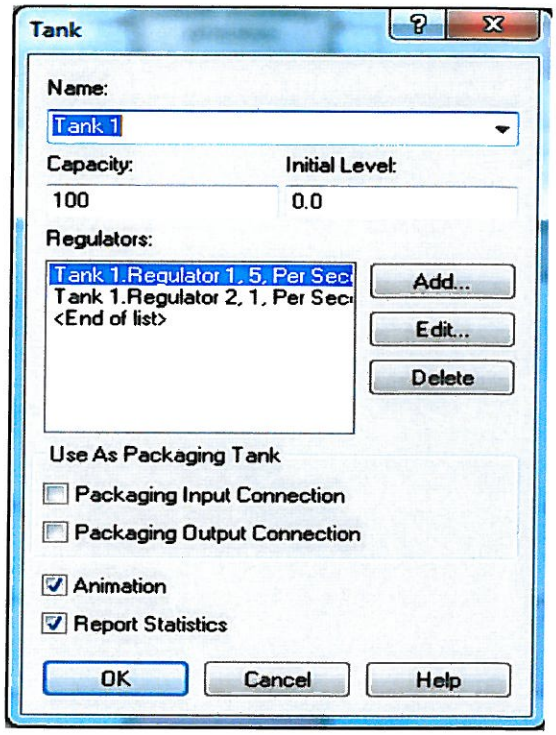

Figure 4.13: Tank Module

4.2.2 Input Analysis

The data and information was taken from the chili sauce production company in Pengkalan Chepa, Kelantan. Observation technique is used to get the data from the company. The observation method is the best method which is we can directly seeing the production run. The time taken of each process also will record as primary data to key in the simulation model process. The data was observed for six days and all the data will be analyze by using Input Analyzer in the ARENA Software. The function of Input Analyzer is to get the average number of the data such as triangular, normal distribution, mean, exponential, and so on. From the observation in the company, the data was recorded as the table below:

Table 4.1: Time taken of processes by using observation method

Day	Remove chili stem and wash the chili (Minutes)	Crude crushing process (Minutes)	Fine crushing process (Minutes)	Cooking process (Minutes)	Bottling process (Minutes)	Packaging process (Minutes)
1	14	16	31	42	0.05	1
2	15	16	33	43	0.05	1
3	18	19	36	45	0.05	1
4	16	18	35	45	0.05	1
5	15	17	34	44	0.05	1
6	18	20	37	46	0.05	1

According to the observation data that was observed, the data were formulated in the Input Analyzer to get the average number before key it in into the simulation model. Observation method data is normally known as the primary data and it will support by secondary data such as interview method and also historical data.

The results from the Input Analyzer can be present in the form of graph and the statistics. All the time taken processes will be analyzed by using Input Analyzer such as Remove chili stem and wash the chili process, Crude crushing process, Fine crushing

process, and also Cooking process. The Bottling process and Packaging process will be excluded from this analyzing because the time taken of these two process are constant which is 0.05 minutes and 1 minutes respectively.

Below are the results from the Input Analyzer for Day 1 until Day 6 of the chili sauce production processes:

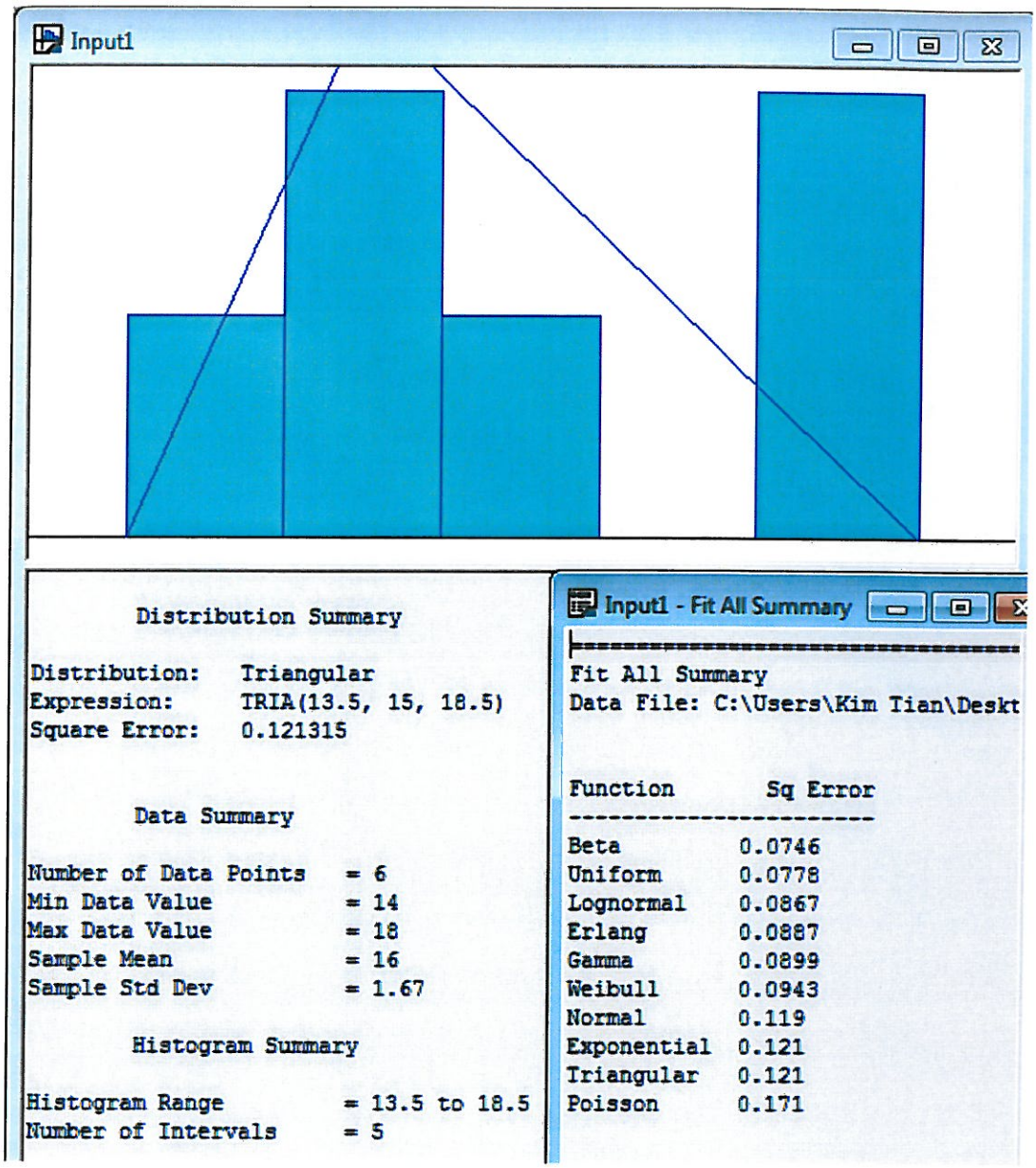

Figure 4.14: Bar chart and statistical data of remove chili stem and wash the chili process

This figure has shown the average of the removing chili stem and washes the chili process data for Day 1 until Day 6. From the statistical output from the Input Analyzer above, the minimum and maximum time are 13.5 minutes and 18.5 minutes respectively. The most likely value is 15 minutes with the errors of triangular function is 0.1210.

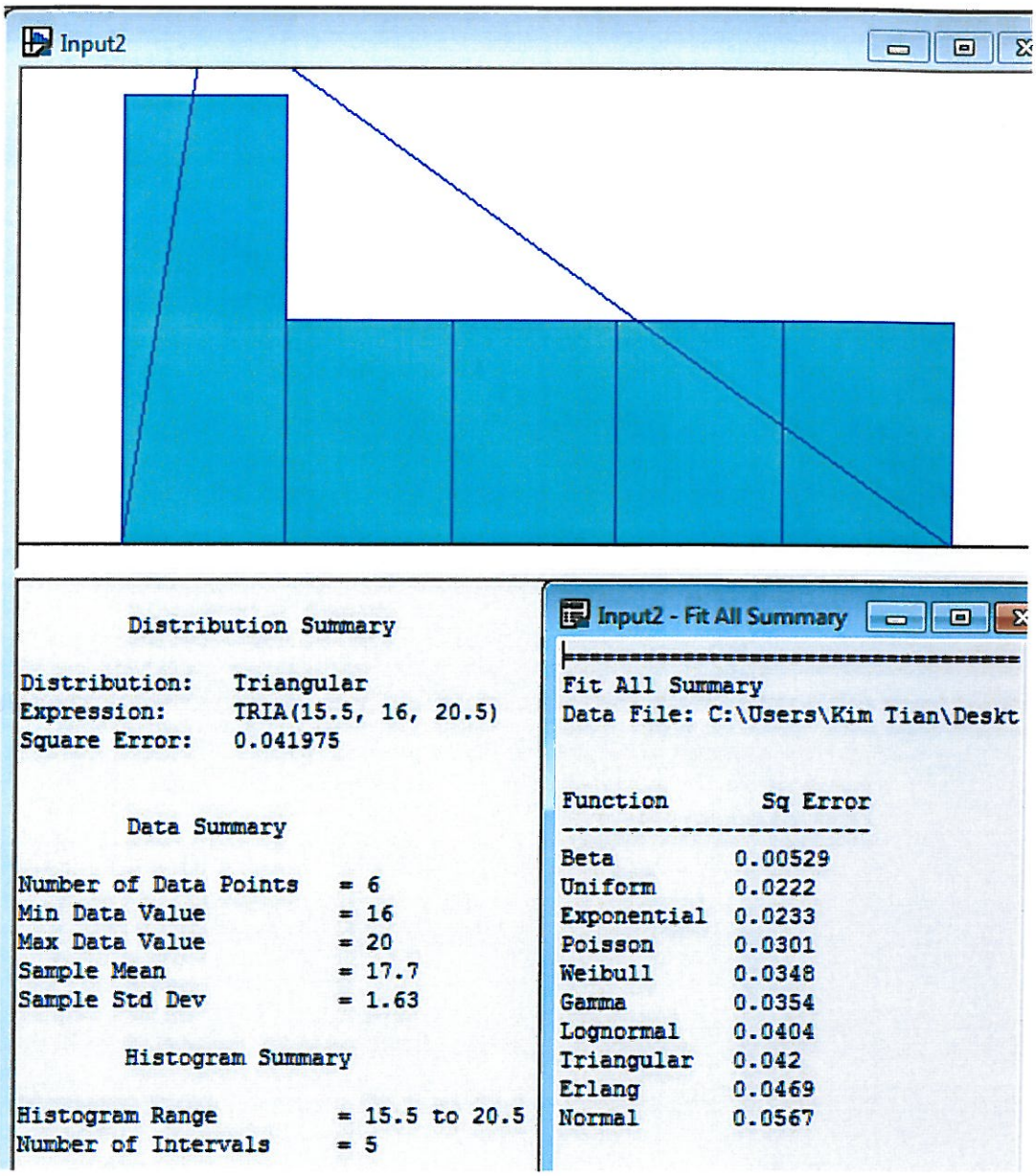

Figure 4.15: Bar chart and statistical data of crude crushing process

This figure has shown the average of the crude crushing process data for Day 1 until Day 6. From the statistical output from the Input Analyzer above, the minimum

and maximum time are 15.5 minutes and 20.5 minutes respectively. The most likely value is 16 minutes with the errors of triangular function is 0.0420.

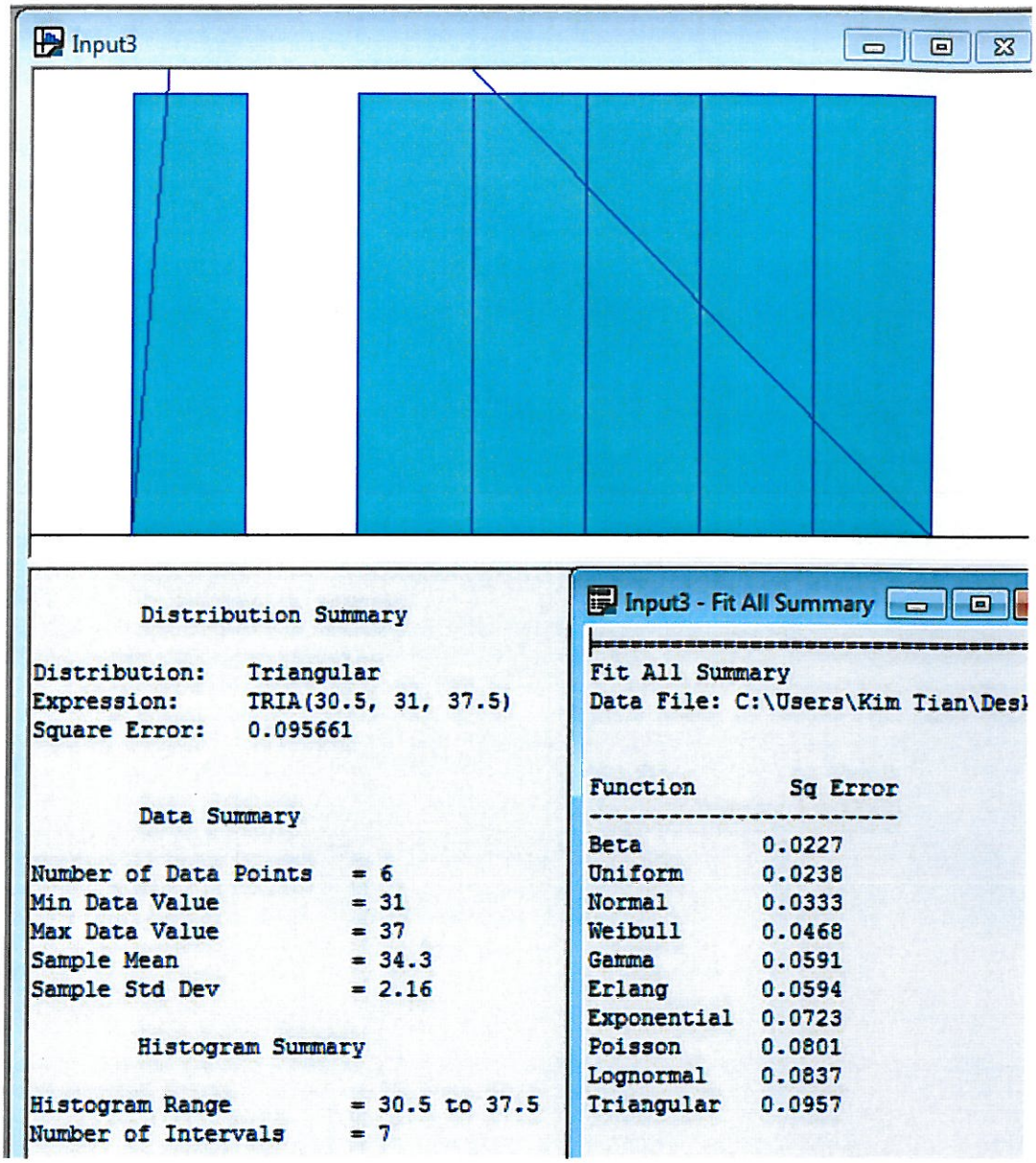

Figure 4.16: Bar chart and statistical data of Fine Crushing Process

This figure has shown the average of the fine crushing process data for Day 1 until Day 6. From the statistical output from the Input Analyzer above, the minimum and maximum time is 30.5 minutes and 37.5 minutes respectively. The most likely value is 31 minutes with the errors of triangular function is 0.0957.

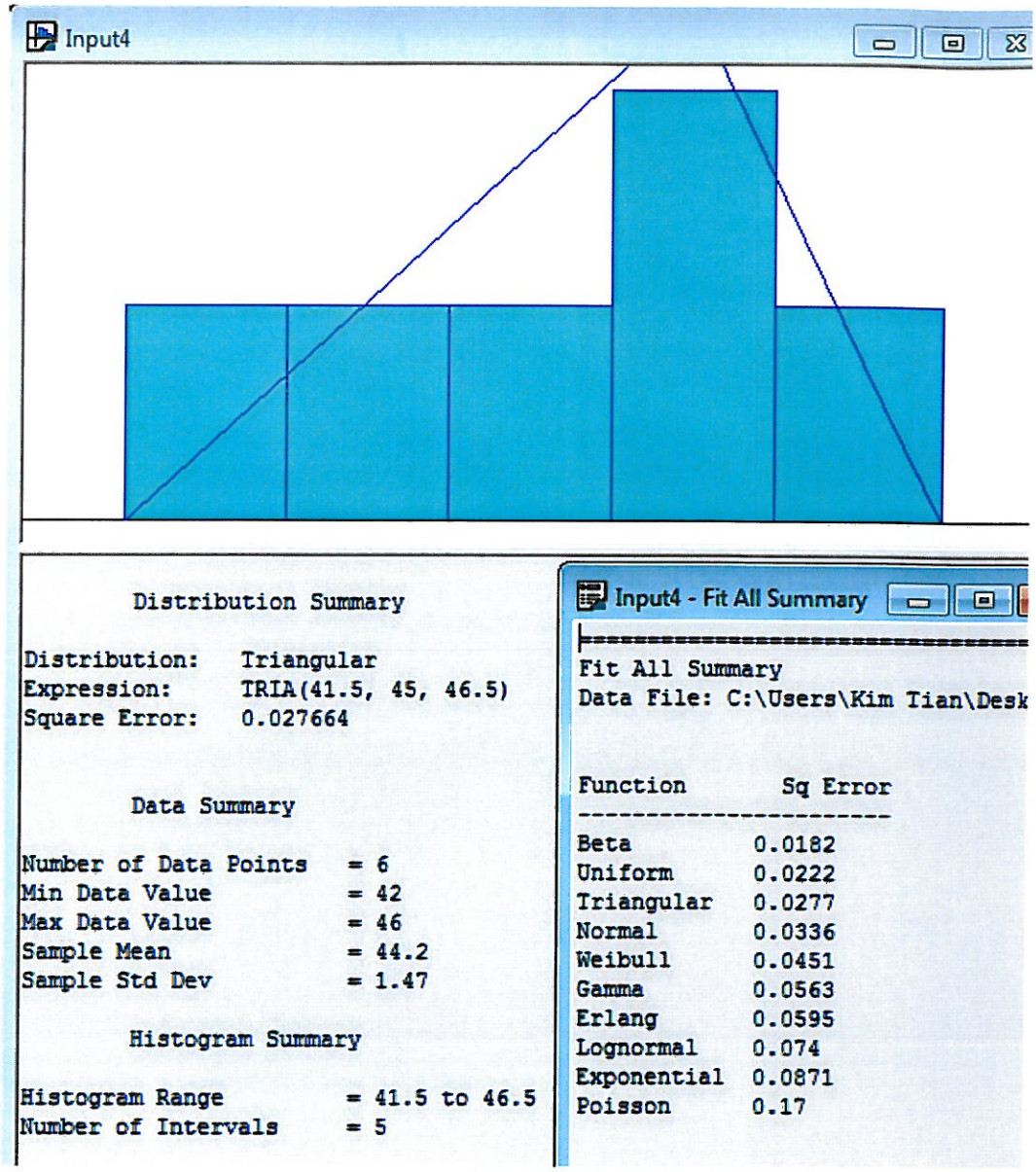

Figure 4.17: Bar chart and statistical data of cooking process

This figure has shown the average of the cooking process data for Day 1 until Day 6. From the statistical output from the Input Analyzer above, the minimum and maximum time are 41.5 minutes and 46.5 minutes respectively. The most likely value is 45 minutes with the errors of triangular function is 0.0277.

4.3 DATA VERIFICATION AND VALIDATION

Data verification and validation process are very important process to get the simulation model running similar with the real process. The simulation model can be proceeding with the research when the simulation model output is similar with the output of the real process.

Verification of the model can be grouped into two aspects which is design of the model and implementation. Fully understanding about the specification of the ARENA Software module is very crucial to build the simulation model according to the chili sauce production processes under study. The flow and arrangement of the simulation model must approximately same with the real process for every single process that was applied in the company. Furthermore, the time taken for each process and also number of resources that using in the chili sauce company also must be the same as the real situation. The implementation of the simulation model will represent the real situation when all of the desired information and data was key it in the software module.

Besides, the validation process also can be divided into two categories which are conceptual validation and result validation. Conceptual validation is occurred when the anticipated fidelity of the model or simulation conceptual is assessed. Other than that, result validation is occurred when the result from the simulation model is compared with an appropriate referent to demonstrate that the simulation model can fact support intended used. For this simulation study, 10 time of replication was setting up in the replication parameters in Run Setup of ARENA Software. Then the averages output will calculated and recorded in the software. The results from the software which is average output were compared with the real output.

The difference of range between simulation model process and real process of chili sauce production must be in between 10%. The calculation of the difference range between these two models can be used by using the equation below:

$$\text{Differences} = \frac{Simulation\ process\ ouput - Real\ process\ output}{Real\ process\ output} \text{ x } 100\%$$

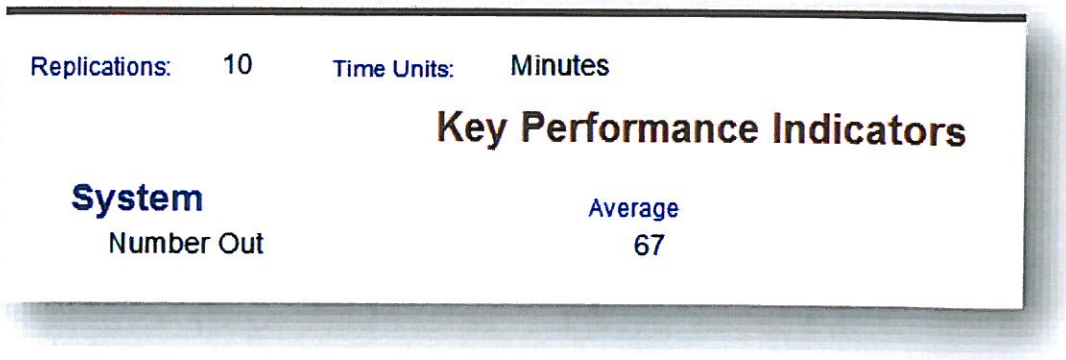

Figure 4.18: Simulation model average output

According to the research study, the simulation process output is 67 units and the actual process output is 63 units. By using the differences equation, the range between these two outputs is 6.35%. So, the validation of the process is very strong and it can be representing the real process of chili sauce production processes. Therefore, the simulation model process can be accepted valid.

Figure 4.19: Check model in ARENA Software

From the figure above, it is shown that the simulation model by using ARENA Software able to run completely to get the statistic output. This is an evidence to prove that the simulation model has no any errors. So, the validation of the simulation model is strong because this simulation model can be run completely with the differences of the average simulation output and real process output is about 6.35%. It can conclude that this simulation is valid and able to continue the next step which is data analysis.

4.4 DATA ANALYSIS

Data analysis is analyzing and interpreting process from the statistic results of the ARENA Software. The statistic results that was collected is average waiting time, average queue waiting time, cycle time, and resource utilization to observed the bottleneck constraint from the animation developed in the simulation model.

4.4.1 Measuring the Average Waiting Time

Table 4.2: Measuring the average waiting time

Workstation	**Average Process Wait Time per Entity (minutes)**	**Average queue Waiting Time (Minutes)**	**Average Number in Queue (Units)**
Remove chili stem and wash the chili	3.7017	3.7017	0.0274
Crude crushing process	21.3861	21.3861	0.1584
Fine crushing process	24.0076	24.0076	0.1778
Cooking process	0.0000	0.0000	0.0000
Bottling process	10.0000	10.0000	7.4815
Packaging process	0.0000	0.0000	0.0000

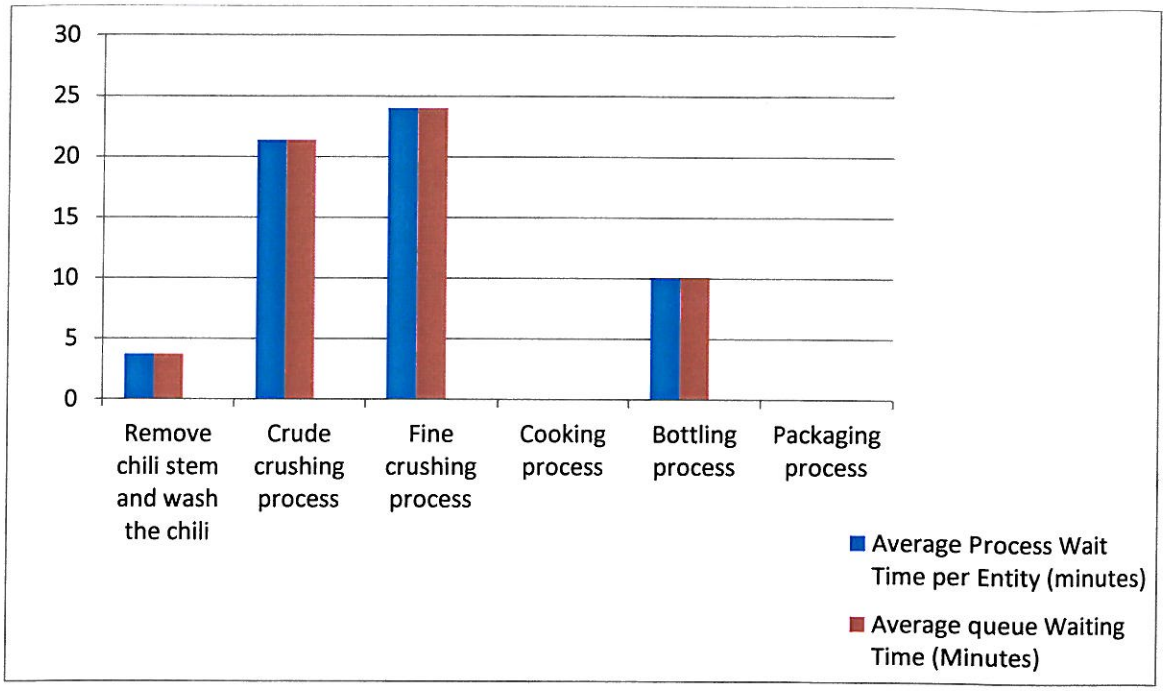

Figure 4.20: Bar chart of Average Waiting Time

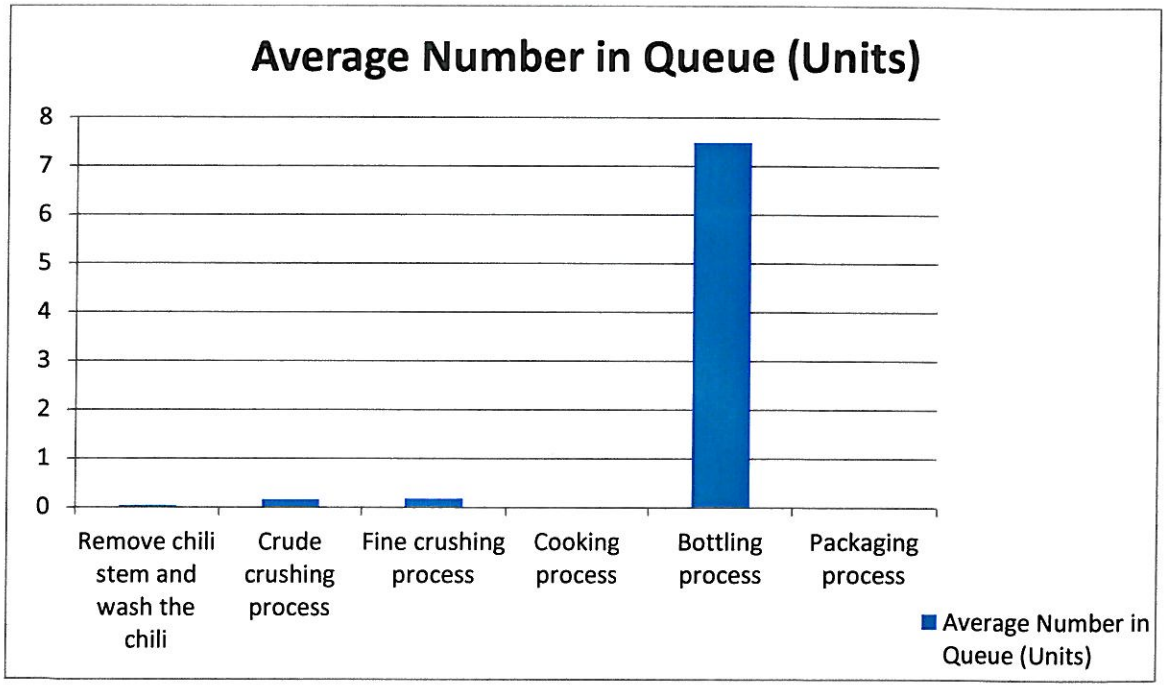

Figure 4.21: Bar chart of Average Number in Queue (Units)

The bottleneck constraint in the process can be identified from the measuring of the average waiting time. The machine that has the highest average waiting time will be considered as the bottleneck of the process.

This simulation model was implemented by using ARENA Software in 9 hours and 10 replications to get the output or statistic results. From the table and bar chart above, the highest average waiting time is fine crushing process which is 24 minutes and the average number queue waiting is 0.1778 units. Meanwhile, the highest average number of queue waiting is 7.2 units and its average waiting time is 12 minutes. So the bottleneck is occurred at the fine crushing process of the chili and also bottling process.

4.4.2 Utilization of Machine

Table 4.3: Average Utilization and Number of Busy

Workstation	**Resource**	**Average of Instantaneous Utilization (Minutes)**	**Average of Number of Busy (Minutes)**
Remove chili stem and wash the chili	Workers	0.0390	0.1169
Crude crushing process	Crude crushing machine	0.1285	0.1285
Fine crushing process	Fine crushing machine	0.2469	0.2469
Cooking process	Cooking machine	0.3298	0.3298
Bottling process	Bottling machine	0.1496	0.1496
Packaging process	Packaging machine	0.1241	0.1241

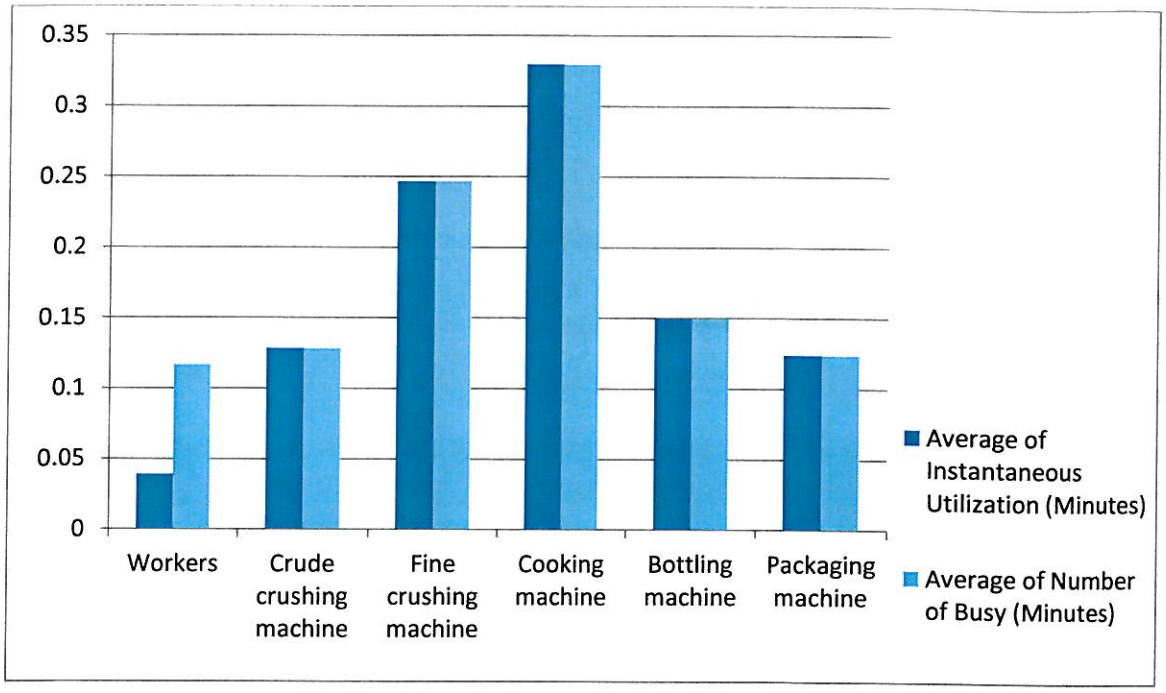

Figure 4.22: Bar chart of Average Utilization and Number of Busy.

According to the figure above, the highest of average instantaneous utilization and average number of busy is cooking machine which is 0.3298 minutes. So, the bottleneck is occurred in the cooking process.

4.4.3 Cycle Time

Table 4.4: Cycle time result

Workstation	Average Value Added Per Entity (Minutes)	Average Wait Time Per Entity (Minutes)	Average Total Time Per Entity (Minutes)
Remove chili stem and wash the chili	15.7819	3.7017	19.4836
Crude crushing process	17.3485	21.3861	38.7346
Fine crushing process	33.3336	24.0076	57.3412
Cooking process	44.5191	0.0000	44.5191
Bottling process	0.2000	10.0000	10.2000
Packaging process	1.0000	0.0000	1.0000
Total	**112.1831**	**59.0954**	**171.2785**

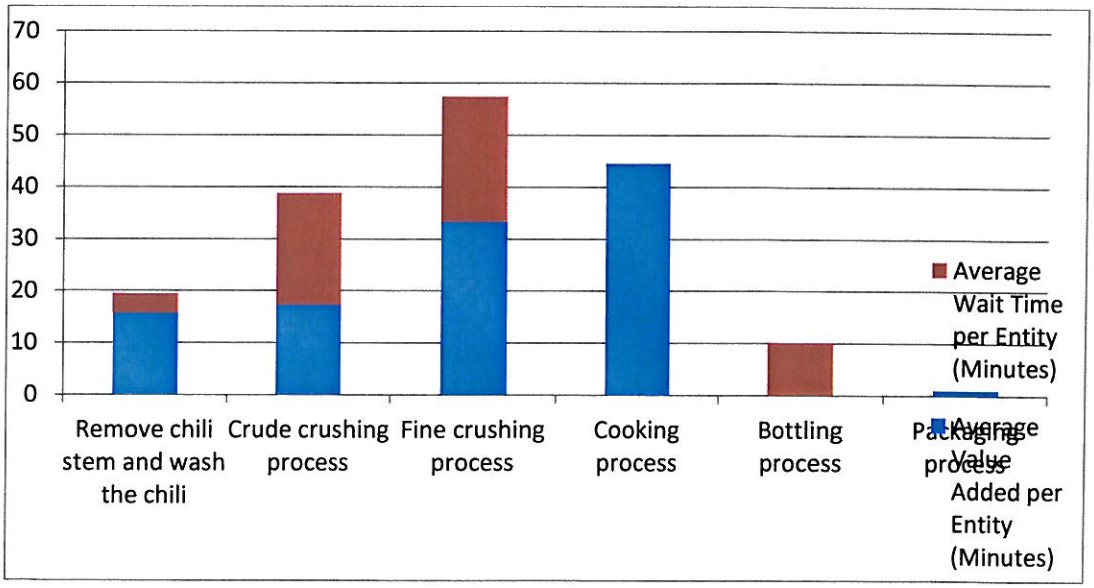

Figure 4.23: Bar chart of the cycle time

Cycle time is an overall processing time for producing a product or services to the customers. Cycle time was included in the total of average value added time per entity and also average waiting time per entity.

CHAPTER 5

MODEL EXPERIMENTATION AND CONCLUSION

5.1 INTRODUCTION

In this chapter, there will be a series of discussion on the model experimentation. In this study, "what-if analysis" approach is used to make the improvement on the chili sauce production process. According to the simulation model from the previous chapter, the output of the simulation will change to be a better process. "What-if Analysis" approach is similar to the try and error method by using the ARENA Software. The changes of the model must be improved the processes by reducing the bottleneck process, and increase the capacity of the product. From the new output results, it will compare with the original simulation process and give a recommendation to improve the company. The recommendation is based on the Scenario Analysis. Scenario analysis also can be called as "Alternative Worlds" is the process of estimating and planning for the future in term of management, process, and etc.

5.2 RESULT DISCUSSION

The analyzing of the simulation model was carried out in the previous chapter by finding the bottleneck and capacity in the simulation model. The result of the original simulation process model was discussed in the Chapter 4, but in this chapter I will explained more detailed in for the results and give some recommendations to improve the chili sauce production process.

From the analyzing on the previous chapter, the measuring of average waiting time for all processes involved in producing chili sauce was determined. From the results, the bottleneck in the chili sauce production process is Fine crushing process.

Fine crushing process was detected as the bottleneck in this process because it has the longest time of average queue waiting time which is 24.0076 minutes per entity.

Resource of the process also will included in the analyzing the effectiveness of the chili sauce production process. Utilization of the resource which is machine is used for the specific process will be analyzed. Process that is used machine to operate the process is Crude crushing process, Fine crushing process, Cooking process, Bottling process, and also Packaging process. Removing chili stem and wash the chili process is conducted by the three workers, so this process will be excluded from analyze the average of the utilization of machine because this process is doing manually without machine. From this analysis, cooking machine has the highest utilization compared to the other machine.

Bottleneck in the cycle time was detected in the process are cooking process, crude crushing process, and fine crushing process. Cooking process was detected as the bottleneck because the output results shown it average value added per entity of cycle time is the highest among the processes which are 44.5191 minutes and the second highest is fine crushing process which is 33.3336 minutes. These two processes have the highest and huge differ from other processes. Besides, the fine crushing process was detected as the bottleneck because it has the highest number of average waits time per entity of cycle time is 24.0076 minutes followed by Crude crushing process which is 21.3861 minutes. From the total average cycle time, we can conclude that fine crushing process, cooking process, and crude crushing process are bottlenecks in this process.

Table 5.1: Bottlenecks detected in workstation of the process

Bottleneck Detection Method	**Average Waiting Time in Queue**	**Average Utilization of the Machine**	**Average Cycle Time**
Detected Bottleneck in Workstation	Fine crushing process, and crude crushing process	Cooking process	Fine crushing process, Cooking process, and Crude crushing process

From the table above, we can summarize that all of bottleneck detection method showed fine crushing process is the most bottleneck problem in the process except average utilization of the machine. Cooking process is the highest utilization of the machine because it has the longest process time needed to complete this process per entity.

5.3 MODEL EXPERIMENTATION

Model experimentation of the ARENA Software is the changing or modification of the process model to get the better results and give a solution to solve the problem in the research study. Before starting the model experimentation, the verification and validation of the process must be conducted to prove that the simulation process model is running similarly with the real process in the chili sauce factory. Simulation model that imitating the real process from manufacturing has the same or approximately output, the simulation is verify and valid to continue the model experimentation. Based on the previous chapter, the verification and validation has been proving that the simulation model is able to proceed with the model experimentations.

"What-if Analysis" approach is one of the methods to modify the simulation model and improve the model by several scenarios. All the scenarios must create by referring to the result discussion above and answered the research questions. According to the chili sauce production process, the bottleneck of this process is at fine crushing process workstation. To reduce it waiting time and queuing time, we can add another fine crushing process workstation. This approach is an investigating to find the best solution that can increase the performance of the process.

5.3.1 What-if Analysis 1: Adding one workstation of Crude Crushing Process in simulation model with the same workers in charge of the workstation.

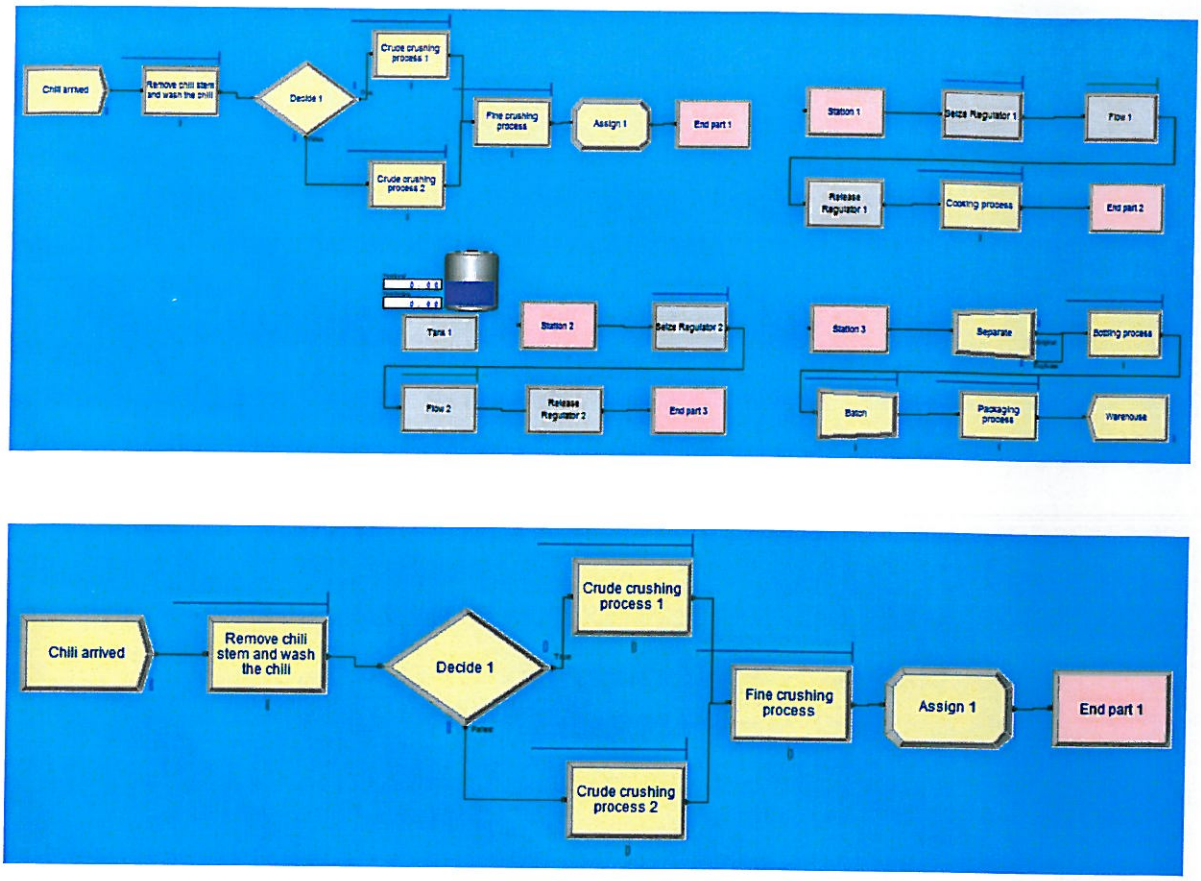

Figure 5.1: What-if Analysis 1 of modify simulation model

From the figure 5.1 above, what-if analysis 1 is modify in the simulation model by adding one more workstation in the processes. The modification in this simulation is by adding second Crude Crushing Machine to make the process become faster. By adding this new machine, the average queue waiting time and also cycle time can be reduced.

"What-if Analysis" approach was implemented in this modification by adding second machine in the crude crushing process. In the previous chapter, bottleneck was detected in the simulation process. The modify simulation model also will be run for 10 replications to get the accuracy results.

Table 5.2: Comparison of the average queue waiting time and average number waiting

Workstations	**Average Queue Waiting Time (Minutes)**		**Average Queue of Number waiting**	
	Current simulation model	New simulation model	Current simulation model	New simulation model
Crude crushing process 1	21.3861	4.8194	0.1584	0.0198
Crude crushing process 2	-	6.0387	-	0.0317

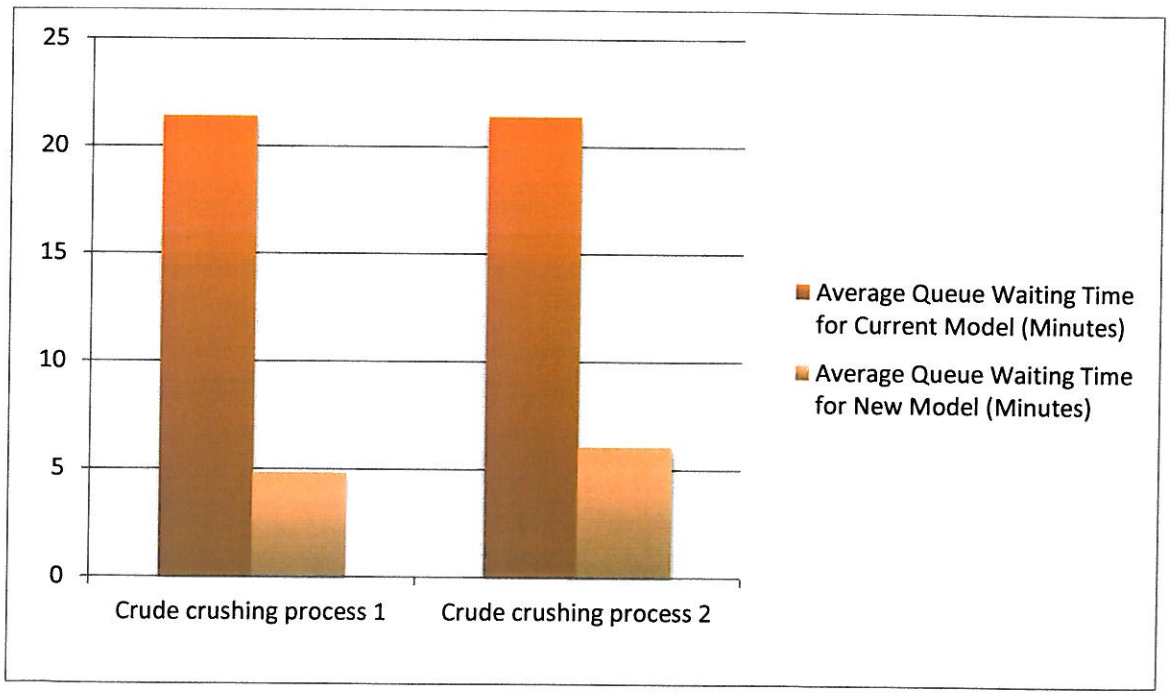

Figure 5.2: Comparison of the average queue waiting time

According to the table 5.1 and figure 5.1 above, the results was determined and it's shown the improvement after the modification of current simulation model by

adding one new machine in the crude crushing process. From the results above, we can conclude that the average queue waiting time was reduced from 21.2861 minute for current simulation model to 4.8194 minute for crude crushing process 1 and 6.0387 minute for new crude crushing process. The reducing of the average queue waiting time is about 77.36% and 71.63% respectively.

5.3.2 What-if Analysis 2: Adding one workstation of Fine Crushing Process in simulation model with the same workers in charge of the workstation.

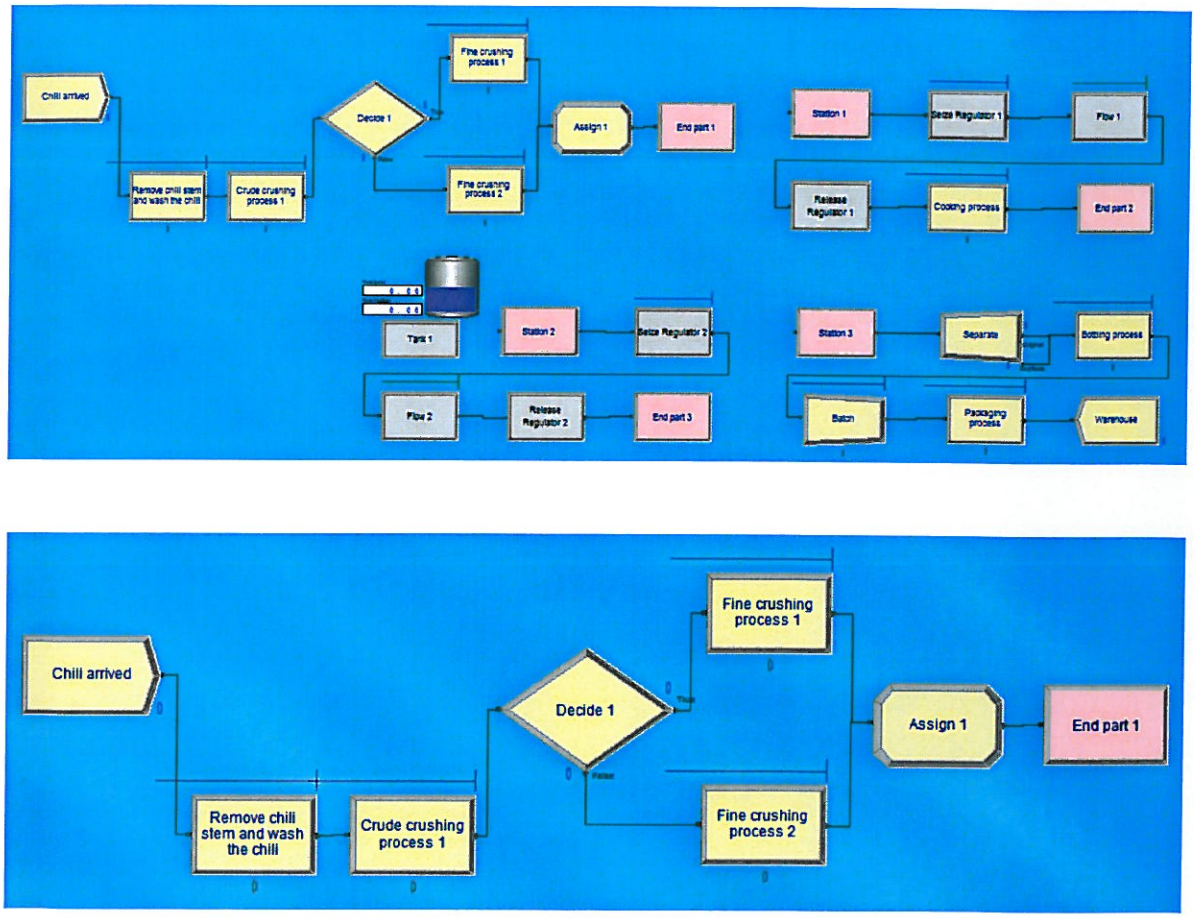

Figure 5.3: What-if Analysis 2 of modify simulation model

From the previous chapter, the longest average queue waiting time and average cycle time was occurred in the fine crushing process. Bottleneck was detected in this process because the production line cannot go smoothly because it takes the long time to finish in this process. By using "What-if Analysis" approach, the new machine for

fine crushing machine was added in the simulation process to modify it to become smoothly and shorten the average queue waiting time and also average cycle time in the process.

Table 5.3: The comparison of the average queue waiting time and average number waiting

Workstations	**Average Queue Waiting Time (Minutes)**		**Average Queue of Number waiting**	
	Current simulation model	New simulation model	Current simulation model	New simulation model
Fine crushing process 1	24.0076	4.0635	0.1778	0.0182
Fine crushing process 2	-	4.8175	-	0.0255

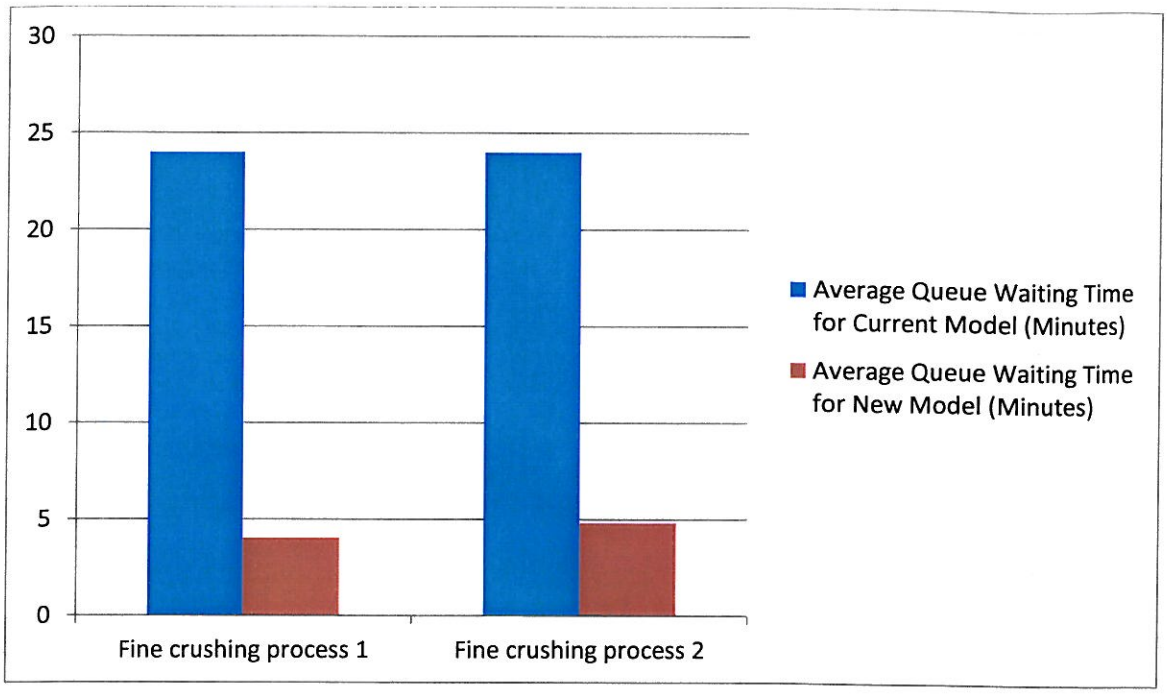

Figure 5.4: Bar chart of the comparison of average queue waiting time

According to the results in the table 5.2 and figure 5.2, we can see that the results shown a huge reducing from the current simulation model which is fine crushing process take 24.0076 minute to 4.0635 minute for fine crushing process 1 and 4.8175 minute for fine crushing process 2. The reducing is about 83.07% for fine crushing process 1 and 79.93% for fine crushing process 2 by adding new fine crushing machine in the modify simulation model.

5.3.3 What-if Analysis 3: Adding one workstation of Crude Crushing Process and one workstation of Fine Crushing Process in simulation model with the same workers in charge of the workstation.

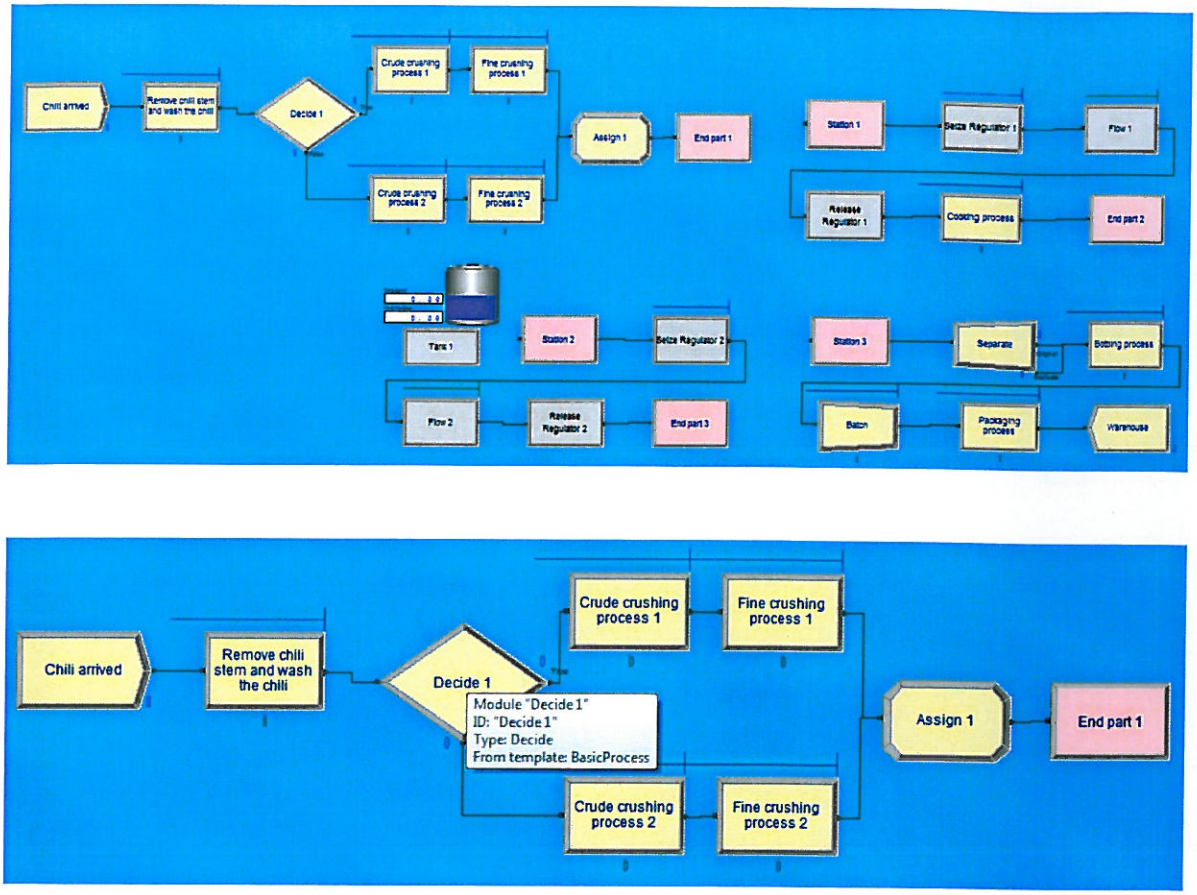

Figure 5.5: What-if Analysis 3 of Modify Simulation Model

From the data analysis in the chapter 4, the results output of the simulation model of chili sauce production process shown that the bottleneck was occurred at the fine crushing process workstation. The bottleneck was happened in this workstation because of the longer average waiting or queuing time and average cycle time in the workstation. The longer waiting or queuing time is happened maybe because of the longest average value added time of the crude crushing process and fine crushing process.

Based on the figure 5.1 above, "What-if Analysis" approach was implemented by adds one workstation of crude crushing process and one workstation of fine crushing process workstation in the simulation model to reduce the longest queue waiting time in crude crushing process and fine crushing process workstation.

Modify model in what-if analysis 1 also has been for 10 replications to get new result output in the ARENA Software. 10 replications of the process are the most appropriate and accurate for the new analysis and comparing the result output with the original simulation model.

Table 5.4: Comparison of average queue waiting time

Workstation	**Average Queue Waiting Time for Original Model (Minutes)**	**Average Queue Waiting Time for New Model (Minutes)**
Crude crushing process	21.3861	4.8194
Crude crushing process 2	-	6.0722
Fine crushing process	24.0076	7.5440
Fine crushing process 2	-	9.2291

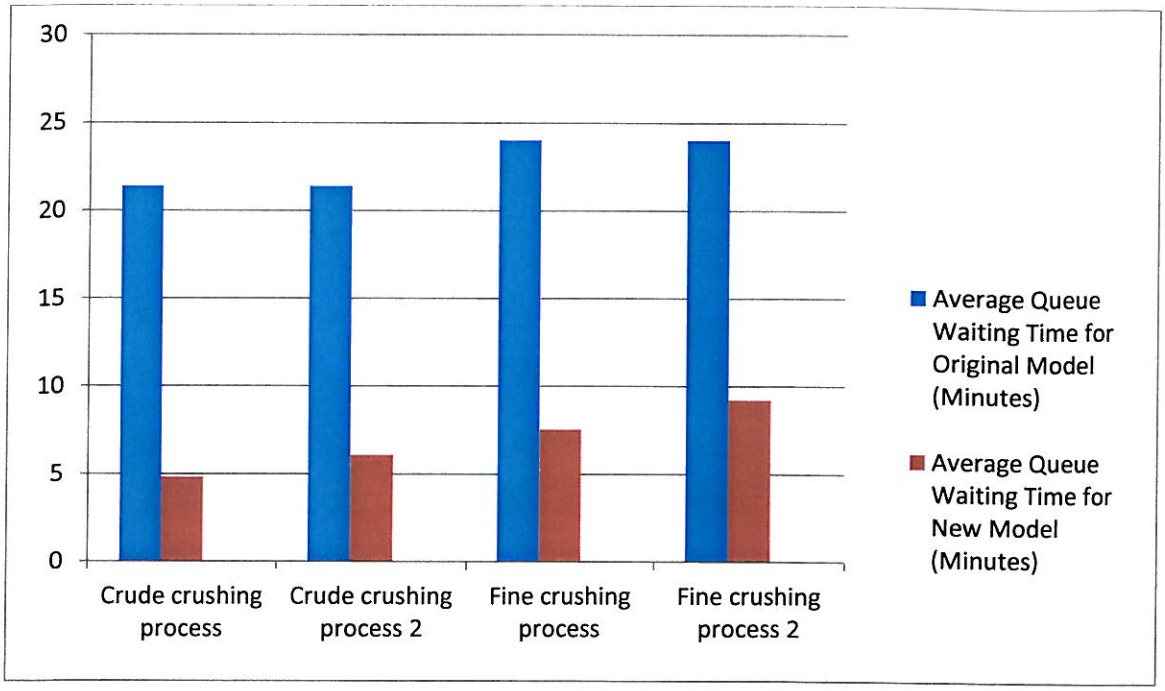

Figure 5.6: Bar chart of comparison average queue waiting time

From the results above, the average queue waiting time was reduced from 21.3861 minute to 4.8194 minute (Current Model) and 6.0722 minute (New Model) respectively for Crude Crushing Process. For Fine Crushing Process workstation, the average queue waiting time was decreased from 24.0076 minutes to 7.5440 minutes (Current Model) and 9.2291 minute (New Model) respectively. By adding another workstation for both Crude Crushing Process and Fine Crushing Process, the cycle time and added value time also will be reduced.

5.3.4 What-if Analysis 4: Adding one more entity per arrival from 4 entities to 5 entities in What-if Analysis 5 modification simulation model.

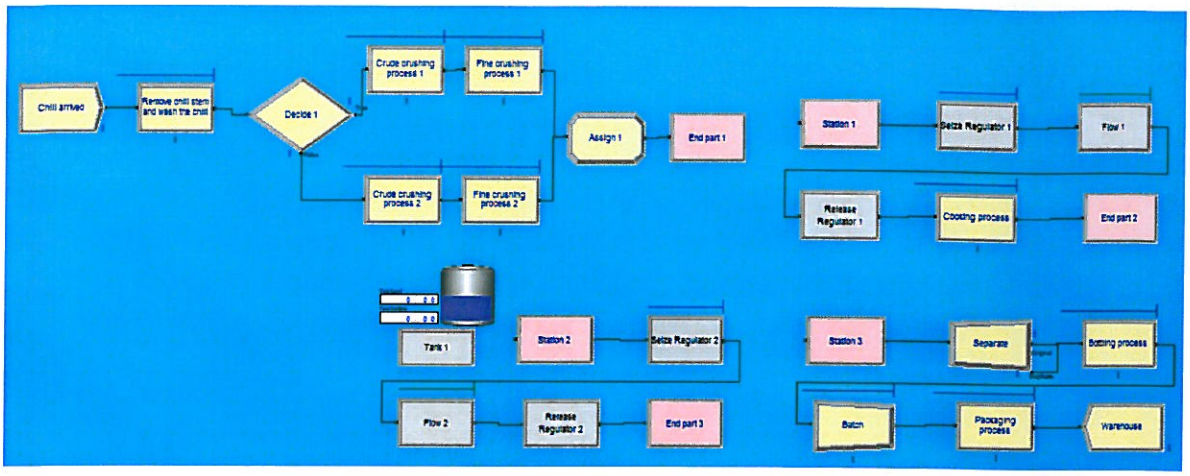

Figure 5.7: What-if Analysis 4 of Modify Simulation Model

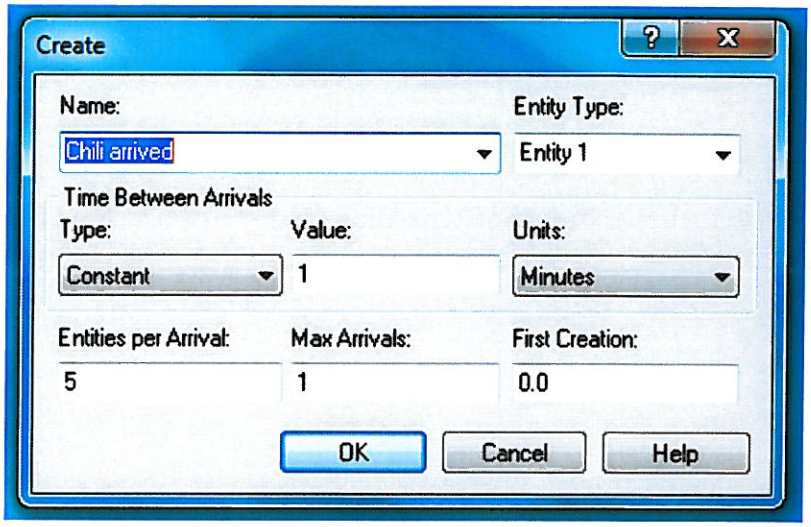

Figure 5.8: What-if Analysis 4 of entities per arrival

Based on the What-if Analysis 3, the average queue waiting time and average cycle time has reduced by adding one crude crushing machine and one fine crushing machine at each workstation. To increase the capacity of the product in the one day production, it can be adding the one more entity per arrival from four entities to become five entities. One entity is represents 15kg of the raw chili.

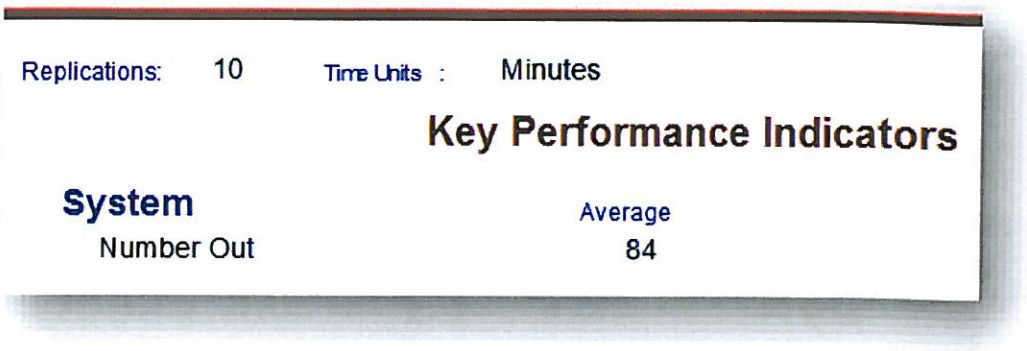

Figure 5.9: New chili sauce production per day

Table 5.5: Comparison of the Outputs

Process Model	Real process (4 Entities)	Simulation model (4 Entities)	Simulation model (5 Entities)
Output	63	67	84
Percentage (%)	29.44	31.31	39.25

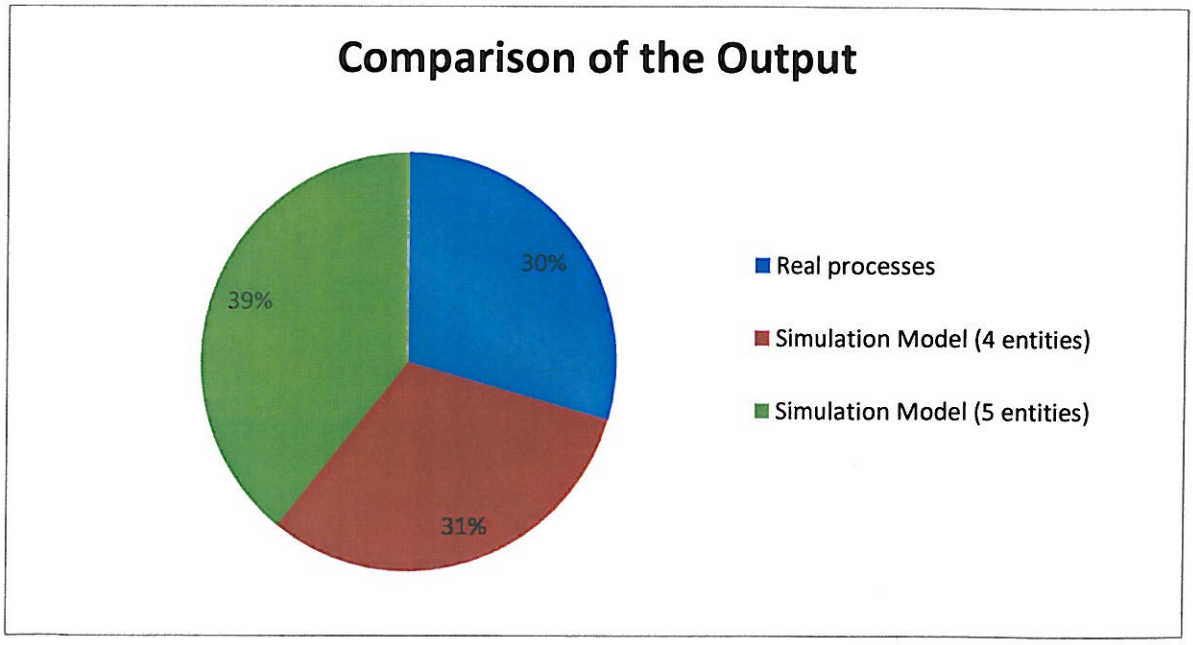

Figure 5.10: Pie chart of outputs comparison

"What-if Analysis" approach has implemented in this simulation model to improve the performance of the company production. From the real chili sauce processes, it can be produce for 63 boxes per day. One box of chili sauce consists 24 bottles of chili sauce. Otherwise, the simulation processes model has the same output which is 67 boxes of the chili per day. The entity per arrival of the raw chili for both real processes and simulation processes model are 4 entities or 60kg of raw chili.

According to the results above, the output of the What-if Analysis 4 is 84 boxes per day that can be produced by the company if they add one more entity per arrival of the raw chili. The increasing of 21 boxes of chili sauce will increase the supply to the market. The company performance also will be improved.

5.3.5 Comparison and Analyze of all What-if Analysis Approach.

From the analyzing of What-if Analysis 1, What-if Analysis 2, and What-if Analysis 3, the results shown that the average queue waiting time and average cycle time was reduced. What-if analysis approach was used to add another workstation that was detected as the bottleneck in the chili sauce production process. If the bottleneck workstation in the process was added the new resource, the workloads of the machine in the process will divided and work simultaneously which can reduced the average cycle time and also average queue waiting time in the process. Comparison of average queue waiting time:

Table 5.6: Comparison of average queue waiting time among what-if analysis

Workstation	Current Model (Minute)	What-if Analysis 1 (Minute)	What-if Analysis 2 (Minute)	What-if Analysis 3 (Minute)
Remove chili stem and wash the chili	3.7017	3.7017	3.7017	3.7017
Crude crushing process	21.3861	4.8194 6.0387	21.5643	4.8194 6.0722
Fine crushing process	24.0076	38.2066	4.0635 4.8175	7.5044 9.2291
Cooking process	0.0000	0.0000	0.0000	0.0000
Bottling process	12.0000	12.0000	12.0000	12.0000
Packaging process	7.9012	7.9012	7.9012	7.9012

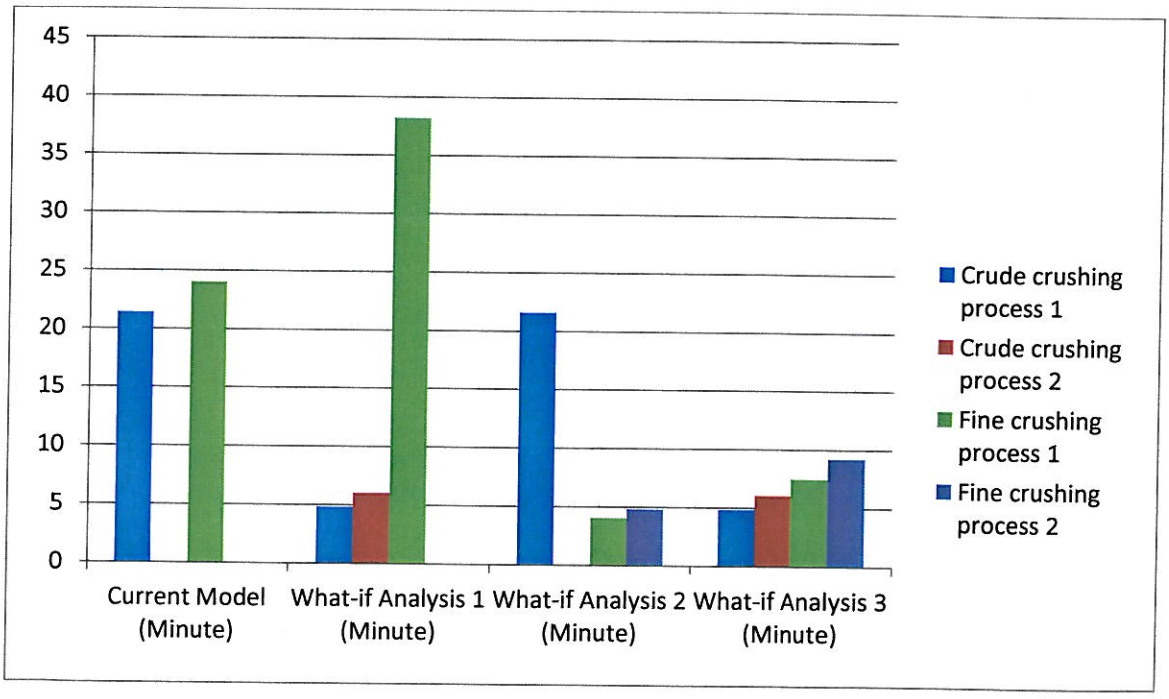

Figure 5.11: Bar chart of comparison on the average queue waiting time

From the comparison above, what-if analysis 1 has changes on the average queue waiting time for crude crushing process meanwhile what-if analysis 2 has a

changes on the average queue waiting time for fine crushing process. What-if analysis 4 is the changes on the entity per arrival of the raw chili. So what-if analysis 4 is not included in the comparison above because the purpose of the changes in the in the entity per arrival from 4 entities to 5 entities is to increase the production output per day.

All the what-if analysis 1, 2, and 3 have a huge different compared to the Current Model. The Crude crushing process and Fine crushing process of the average queue waiting time was decreased dramatically. According to the what-if analysis 3, the crude crushing process and fine crushing process was added for each workstation. This is the combination of the what-if analysis 1 and what-if analysis 2.

As a conclusion of the results above, what-if analysis 3 has been chosen to improve the chili sauce production process. This is because it will have huge changes for both processes which are crude and fine crushing process. The bottleneck problem in the chili sauce production processes also can be removed. Besides, the entity per arrival of raw chili also can be added to increase the production output of chili sauce from 67 boxes to 84 boxes.

5.4 SCENARIO ANALYSIS

5.4.1 Scenario Analysis 1

According to all what-if analysis approach which has been applied in the simulation model, the improvement of the chili sauce production processes was improved and bottleneck in the process was eliminated. Besides, the management of the company must be able to change from time to time. Problem and constraint in the process will be occurred from time to time such as machine broke down. The backup machine should be applied in the company to prevent the production is stop for whole day when production is stop. From what-if analysis 3, there are two new machines will be added in the chili sauce production processes to eliminate bottleneck problem. In the same time, this second machine also can be known as back up machine. When one of the machines was broke down, but the production process still can be preceding without delay the process while waiting the maintenance of the machine. Furthermore, layout of

the manufacturing also needs to be strategic to reduce the time taken of the overall production process.

5.4.2 Scenario Analysis 2

Long term planning is needed for the future problem and constraint that might be occurred. In Malaysia, there are a lot of celebration for all culture and races. The management team or the owner must plan for the seasoning demand which is the demand on the chili sauce is higher than normal day. Seasoning demand is not a daily amount that needed, it just need in one or two time per year. So, the company can be using the same permanent workers by doing overtime (OT). Besides, they also can be employing the part time workers for this season without adding any new machine. Purposely adding new machine for seasoning demand is costly because the demand is high for a short term period only. Furthermore, the working time must plan carefully because human needs to have enough time to rest and giving some reward to motivate the workers.

5.5 RECOMMENDATION

From this research, we can figure out the performance of the chili sauce production process by using simulation technique. Chili sauce production process was producing by using several machines to operate or produce the product. However, there some steps that need to do manually and needs some workers to run the machine in production process. So, this company was hired 2 workers to produce the products. Three female workers are in charged on the removing chili stem and wash the chili process. Other than that, they are in charged on labeling process and cleaning process. Another 2 male workers is in charged on the running the machine.

My suggestion for this Chili Sauce Company is maintain the number of workers and adding some machine in desired workstation. The bottleneck was detected in the crude crushing process and also fine crushing process. I suggest that adding one more crude crushing process and one fine crushing process for each workstation. By add this two machines, the chili sauce production process can reduce the queue waiting time can

be reduced. Reducing bottleneck in the process may help the process will going smoothly without waiting for continue another process.

Furthermore, adds these two machines will help the process reducing it average cycle time in the process. When the overall process time per day was reduced, this company may add the raw material or chili to increase the capacity of the production process. The daily output of the process will increase.

Simulation technique is a professional method that eases people to determine the real problem in the real situation by using Arena Software. This software can be use in the various type of company. All the process can be imitate in the software to get the better results of the process. Then it also can get the solution to solve the problem.

5.6 CONCLUSION

The objective of this study is to evaluate the performance of the chili sauce production process at the HFI Enterprise in Pengkalan Chepa, Kelantan. In order to achieve the objective of this study, there are many information was studied to get the current information about the simulation study. Simulation is used by worldwide because it can make the bigger problem to solve in the software.

Chili sauce production process under this study have six processes to produce the product which is remove the chili stem and wash the chili process, crude crushing process, fine crushing process, cooking process, bottling process, and packaging process. From these workstation process, there are five processes is using machine to operate and one process is using manually by workers. Removing chili stem and wash the chili process is use manually because there hygiene quality is better if doing by human.

The information and data of the every single process must be accurate with the real process before imitating in the Arena Software. The verification and validation of the information and data can be made after creating the processes in the software. The validation of the process if the different between the real process output and simulation model output is under 10%. If the output different is under 10%, the simulation model is

valid and the analyzing the process can be made. After that, it does also can continue the modification of the model by using "What-if Analysis" approach.

In this study, the bottlenecks were identified and the improvement of the process was implemented. Bottleneck was detected at the crude crushing process and fine crushing process which is has longer average queue waiting time and longer average total cycle time. The average queue waiting and the average total cycle time was decreased by adding new machine for both workstations.

As a conclusion, simulation technique can help the company whether manufacturing or service company to solve the problem by imitate the real process or create the real process into the Arena Software. Simulation technique will reduce the cost because it is try and errors by using the computer software. It no needs to run it the real situation which is costly to do so.

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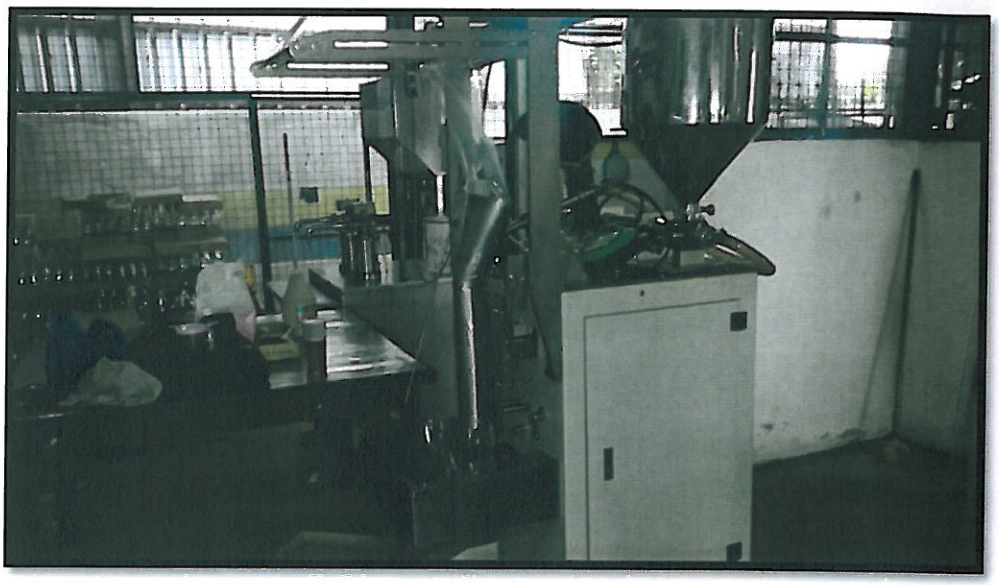
APPENDICES

HFI Maju Enterprise manufacturing

Chili sauce after packaging process

Packaging machine

Crude crushing machine



Bottling process machine