MODELING AND SIMULATION OF PALM OIL MILL TOWARDS EFFECTIVE SUPPLY CHAIN MANAGEMENT

Fazeeda binti Mohamad, Razman bin Mat Tahar
adeezaf@gmail.com, razman779@yahoo.com

Faculty of Technology Management
Universiti Malaysia Pahang

ABSTRACT

This paper evaluated the current capacity of the palm oil mill. The underutilized of capacity effect the cost of production of the mill. Data were collected from a palm oil mill as the case study. Modeling and simulation were used in designing and accessing the mill operation using Arena simulation. The result will help the management to do better capacity planning towards effective supply chain management.

Keywords: *simulation, capacity, supply chain management*

1.0 INTRODUCTION

Palm oil or scientifically known as *Elaeis guineensis* has become the major global agriculture commodities in the world. In Malaysia, the palm oil industry is a rapidly growing industry. Export volume and value of palm oil has increased tremendously showing that palm oil has become one of the important foods and fats being used worldwide. The chain of palm oil process begins with the supply of fresh fruit bunch (FFB) to the mill to process the Crude Palm Oil (CPO) and Palm Kernel (PK). The CPO and PK were then sent to crushers and refineries before continues the chain to the manufacturers and finally to the end users.

In palm oil mill, production line has become the most important subject to study as it relates to the efficient and effective in producing the CPO and PK. Millers will continue to control supplies to ensure they are able to maximize the production of good quality oil to meet the market demand. At plantation level, the manager or owner needs to comply with the request despite the millers were facing issues such as labor shortages, replanting and seasonal constraint.

1.1 Problem Statement

Theoretically, the production capacity for the mill is currently 30 mt/hr. It is however, the mill is now working below the actual capacity because of shortage of fresh fruit bunches being supplied by the plantation to them. It is as reflects to the two main important reasons which are replanting and seasonal factors. This will then affect the capacity utilization for the machine involved during the process.

1.2 Objectives of Study

1.2.1 To model the current configuration of palm oil mill operation system.
1.2.2 To evaluate the capacity and machine utilization in the palm oil mill using simulation towards better chain
1.2.3 To propose the potential improvement to maximize the use of the machine utilization for the palm oil mill operation system.

2.0 RELATED STUDY

2.1 Capacity

Capacity can be defined as the ability of any organization to produce or do that which the customer requires. In capacity management, there are usually two potential constraints which are time and capacity. In measuring the capacity, it must be measured in the unit of work.

In an organization, the capacity of the company can be measured by how they combine and use the capacity that has been purchased to do the job. In management, the capacity is determined by the standard operation time, and operating standard and the operation was conducted. Capacity can be divided into five entities of space, labor, equipment, information technology and materials (Yu Lee, 2002). As for this study, factor of equipment is one of the things or factors that are most important to measure the capacity of the plant. Capacity can then be measured by using simulation to see the organization or operation of manufacturing systems.

2.2 Underutilized of capacity

Firms need to hold the quantity of sufficient feedstock to maximize the use of production capacity of a plant or organization. If capacity is not fully utilized due to lack of raw materials, it will result in increased production costs as it involves some elements of costs for production. Use of part of the capacity does not help in reducing the costs involved. Therefore, to protect firms from losses, holding sufficient inventory is something that should be emphasized

There are several problems that may arise from the use of low capacity. Fixed cost per unit of goods will increase and means the profit will be reduced. Apart from cost, it can also reflect a negative image and affect the performance of staff. The staff can become bored and give up if they do not have much to do and continue to do the cleaning and maintenance only.

2.3 Modelling And Simulation

Simulation can be defined as a method for creating a model with features of real systems on a computer with appropriate software (Kelton et al, 2003). It is powerful problem solving tools associated with statistical sampling theory and complex systems analysis and physical probability. Simulation studies have been conducted in many business sectors including manufacturing and service industries and public sector (Robinson, 1994).

Simulation methods have also been used in production systems such as the handling, process planning, inventory control systems, production lines and job shop scheduling. Computer simulation was also used to solve engineering problems by experiments on a computer-based model (Robinson, 1994). Its use has led to an increase in efficiency, reduce costs and profits for businesses, including in the manufacturing and service industries.

Discrete event simulation allows the evaluation of operating performance before the implementation of the system. It allows companies to perform any operation using what-if analysis which may lead to better planning. Simulation again may allow comparison of various operational alternatives without interrupting the real system. It also allows the compression of time that the policy decision can be made in a timely manner.

From the practical point of view, simulation is the process of designing and constructing a computerized model to represent the actual or proposed model for the purpose of carrying out numerical experiments to give us a better understanding of the behavior of the system for a given set of conditions (Kelton et al, 2003). Song et al (2006) considers that the simulation model can represent the real world system in almost every level of detail to match the actual system. Moreover, Pidd (1992) shows that the model that produces the best results would be implemented in real systems.

Scheduling simulation is modeled to provide users with the ability to perform what-if analysis of scheduling problems. Pidd (1992) through his work support the idea, saying that the computer simulation involves experimentation on a computer-based model system. This model is used as a vehicle to try, often by trial and error to show the possible impact of various policies.

In the last three decades, simulations have been reported consistently, used as a research tool, the most popular operations. This is based on the model and its ability to handle a very complex system (Kelton et al, 2003). In addition, factors significant increase in performance / price ratio of computer hardware, making it more cost-efficient (Kelton et al, 2003). This makes the reputation and computer simulation is becoming more efficient and bigger than ever before due to the progress and advancements in computer hardware and software.

Y. Chang (2001) stated few benefits of SCM by using simulation. Simulation may help to better understand the whole and entire supply chain process and also the features and graphic. Through simulation, it may also able to capture master dynamic system by using the probability distribution. User may also model the unexpected events in specific areas and understand the impact of these events on particular chain. Other than that, simulation is dramatically reduced the risk of changes in the planning process, therefore, using what-if simulation, the user can test various alternatives before changing plans.

2.4 Supply Chain Management (SCM)

SCM is defined as the process of integrating or using suppliers, manufacturers, warehouses and retailers to deliver products and delivered in the right quantity and at the right time while minimizing costs to meet and satisfy customer requirements.

SCM has many advantages to all parties involved, especially to consumers. Good SCM can improve the capacity and coordination in terms of materials and to prevent loss of time and cost. Cycle times can be reduced and this will help reduce the cost of the cycle. Inventory costs can be reduced by looking at the demand and supply and to lowering the inventory level of uncertainty needs. Parties can also find out when and the suitable conditions for the purchase of materials on demand, logistics, capacity and other materials needed. Transport and vehicles can also be used optimally in order to reduce time and cost.

Analysis of supply chain management can also help to predict the spread of disturbance in response to downstream. In addition, SCM was able to understand the ability to deliver based on the availability of materials, capacity and logistics.

SCM efficiency can be achieved through consideration of capacity, materials and other important information. All companies today want to reduce inefficiencies in their business processes and redesigning business processes to achieve world-class business. Some of the inefficiencies can be obtained from the company, some of them are caused by their suppliers and some of them are caused by both reasons. Simulation can help companies to open their eyes about the dynamics and efficiency of their supply chain.

3.0 INDUSTRIAL CASE STUDY

The case study is located at the east side of peninsular Malaysia in Pekan, Pahang. With the ability to process up to 30 matrix tones per hour, the plant received only few tones which is less than their estimation from three palm oil plantation belonging to the same company where located in Pahang and Terengganu.

3.1 PALM OIL MILLING SYSTEM OVERVIEW

The process at the mill can be divided into several phases. The first phase begins the harvested ripe FFB being transported from plantation to mill. The FFB then will be graded before loading it into the ramp and transferred and undergoes a steam-sterilization process, which also facilitates the separation of the fruitlets from the bunch body.

The second phase will continue up to the move of the fruitlets on to a pressing station where the palm oil is extracted. The next phase is where it will pass through a clarification process to remove moisture, solids and impurities.

The result of the products will be the CPO and PK .The diagram of the palm oil milling process is shown in figure 1.

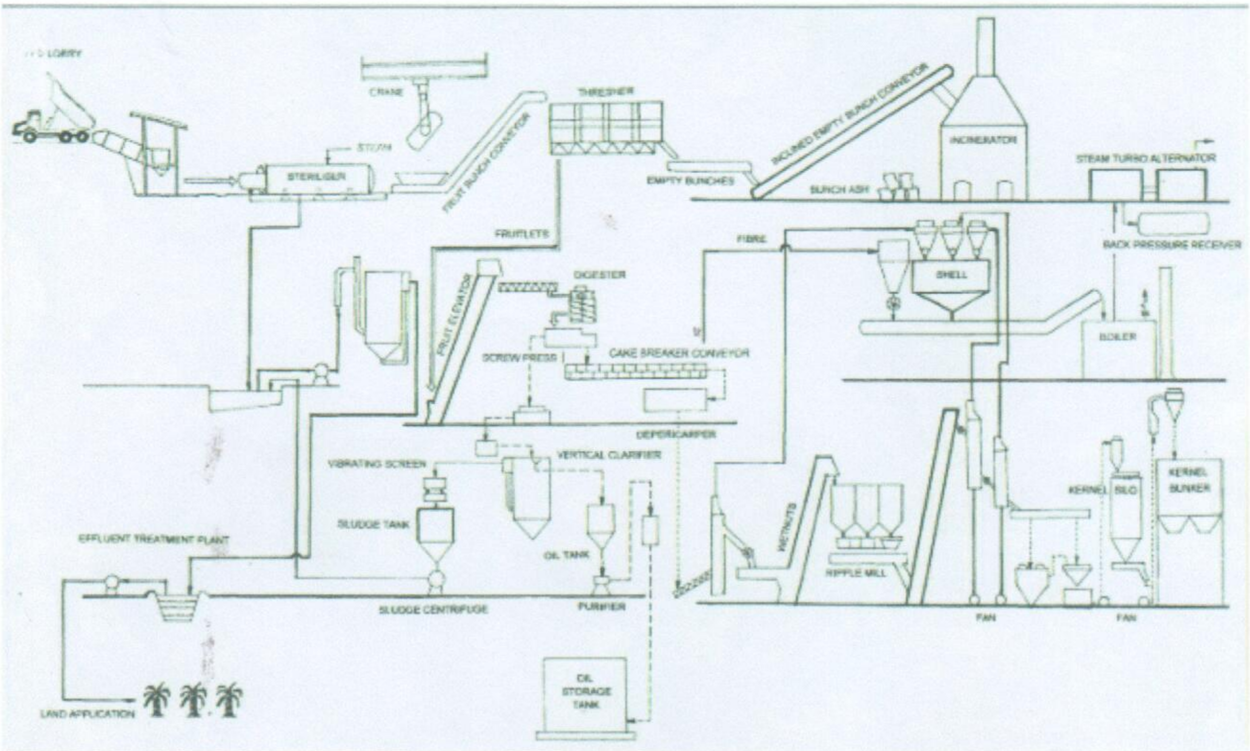


Figure 1: Crude Palm Oil Milling Process Diagram
Source : Ladang Sg Jernih

4.0 METHODOLOGY

We used the framework as proposed by Centino and Carillo (2001) to design the simulation model. Modeling and simulation were used to analyze the mill flow process. It consists of seven steps involving the problem identification, establish objectives, collect data, formulate model, verify and validate model, experiment and analysis and recommendations. Arena software was used in building the model in order to run the data and generate experiments related to the stated problems.

In building the model, the steps involved the designing a simulation experiment and performing simulation analysis. The steps and decisions for a simulation study are incorporated into a flowchart as shown in Figure 2.

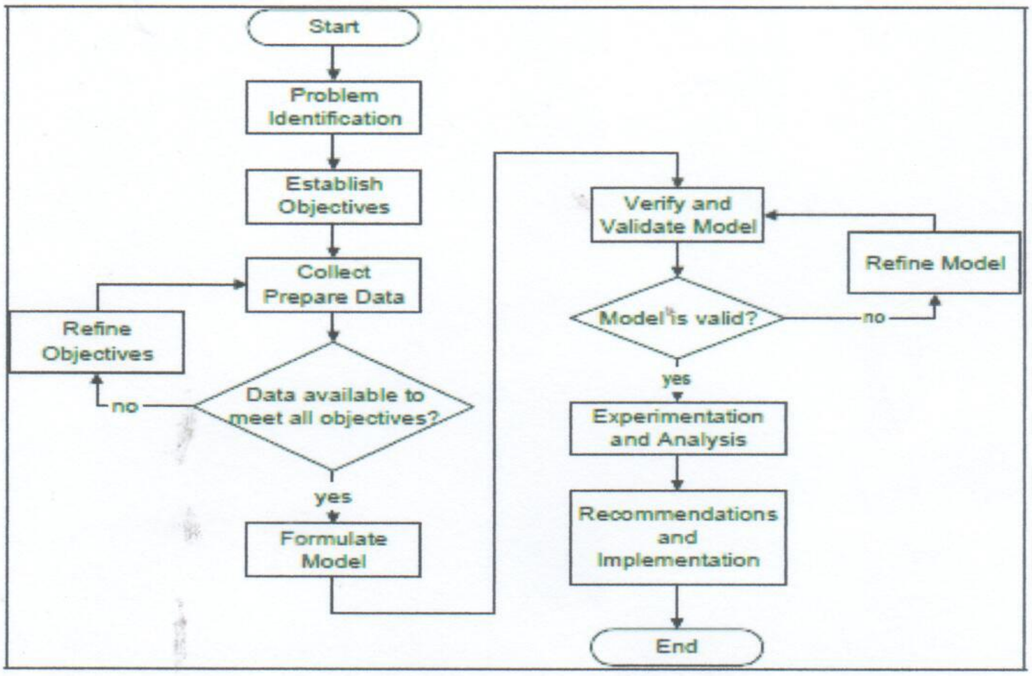


Figure 2: Steps and Decisions for Simulation Modelling Process
Source: Centeno and Carrillo, 2001

In developing the model, the first aspects need to be considered is the introduction of the problem and establish objectives. Next, data and other relevant information related to the study need to be collected. In the simulation, data such as the time is the most important thing that really plays a role. All data, mainly operating system of the process flow should be in accordance with the actual operating system. After that, then the model will be formulated.

As the simulation is the imitation of the real process, accurate representation is required. The model developed must be validated and verified. Once the model is considered as valid, then the experiment or simulation can begin. It must be based on the purpose or objective of the study.

Operating system does not end after each simulation, but it will be reviewed from time to time to check the system and respond to the diversity experienced by the system. It is important to find the best and suitable solutions for different problems that occur and to give suggestions for improvements before the actual implementation.

5.0 DATA COLLECTION AND ANALYSIS

5.1 Input Data Collection

In collecting data, we use several approaches such as interviews and obtain data directly from the field and the company database. The data have been taken from the interview session was to strengthen and understand the concept and process flow in developing the model. The data taken directly from the field and company database were including the time for each system operated and transfer from one station to the other in running the model developed using Arena simulation.

5.2 Input Data Analysis

In order to understand and define the machine process time, the actual process time were taken and collected using time study. Even most of the machine involved were set at specific time, variability may occurs due to any align times within the process. We conducted the motion studies as the result of any variation that may occur during the operation or process. The result obtained will be use in evaluating the current capacity of the palm oil mill and proposed the better configuration of the operation system.

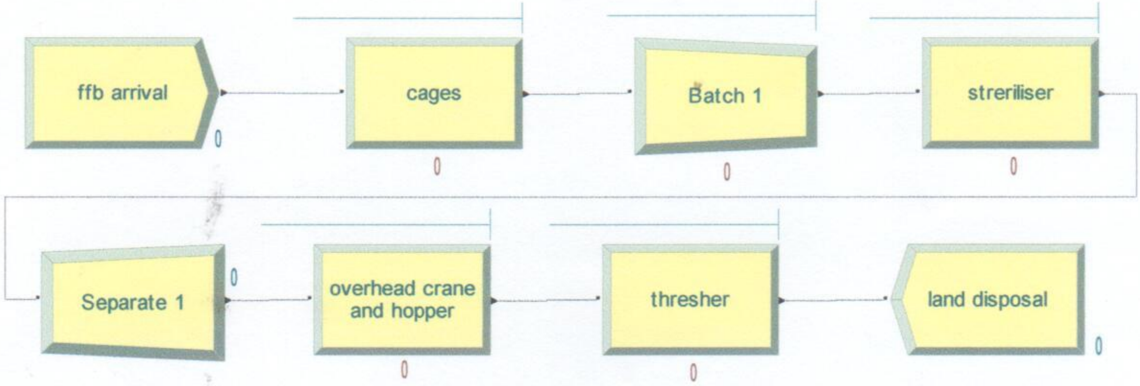
6.0 MODELLING – VALIDATION AND VERIFICATION

Having completed a simulation model designed, one of the aspects that need to be addressed is to ensure that the models perform as designed. Pidd (1992) stated that an important aspect in the simulation model is a model to be tested or certified before use. Accuracy is very important in a model for carrying out the purpose of the project. Verification and validation is important for the quality assurance procedures used in the simulation study. An initial goal of verification is to verify the accurate performance of each element in the model (Robinson, 1994). It is important to repeat the performance verification to ensure that it is really equal to the actual system.

Apart from the verification, validation is done for the purpose to ensure the accuracy of a model to examine the overall behavior of the model represents the actual system (Robinson, 1994). Model validation is concerned with accuracy and purpose of the simulation project used. In addition, confirmation is not only to verify the correct level of accuracy by confirming it, but the overall performance of the model is representative of the actual system. In conclusion, validation and verification are different elements. Simulation requires both elements to ensure the accuracy and relevance of simulation activities and solutions. Although verification and validation are described as two separate tasks, but actually there are a large number of overlapping elements between them (Robinson, 1994).

6.1 Simulation Model

Table 1 : Model of palm oil mill operation system using Arena software



7.0 RESULT AND RECOMMENDATION

By simulate the process, it is shown that the machines are all under utilization. The capacity is lower within the 16 hours working days. The simulation model was built using Arena software package and the simulation output exported Microsoft Excel Spreadsheet.

The simulation output is used to determine the production capacity of the machine utilization. Table 2.1 and 2.2 shows the utilization of each process and is used for the improvement in the utilization of machines/process.

Table 2.1 : Machine utilization of each process step in palm oil milling operation system

Machine/process step	**16 working hours (%)**	**12 working hours (%)**	**10 working hours (%)**	**9 working hours (%)**
Cages	6.18	8.24	9.89	10.99
Crane and Hopper	29.95	39.93	47.91	49.27
Steriliser	60.58	80.77	96.93	99.91
Thresher	33.65	44.87	53.84	55.28

Table 2.2 : Adjusted number of cages being processed using simulation

machine	Utilisation (56)	Utilisation (72)	Utilisation (80)	Utilisation (85)
Cage	7%	9%	9%	10%
Crane and hopper	33%	40%	43%	46%
Steriliser	63%	80%	90%	88%
Thresher	35%	45%	50%	50%

The best working hours to be practice by the mill is at 10/day. If they process less than that, the output might not be produced efficiently .Other than that, the best suggested number of cage for the mill to process the FFB is 80 cages per day as currently they processed it less than that due to replanting and few other factors.

The smaller number being process will give an impact to the utilization of machines throughout the system. This simulation is needed to cater the future supply of FFB to the mill as the palm oil tree will be mature within next three years.

In reducing costs and thus for better planning result, it is suggested that the effective working hours to increase utilization of the machine is to be at 10-12/day instead of 16 hours per day. It may lowering per unit cost and other cost involved as the time being used efficiently.

This is proven through simulation that the percentage of increment for the machine utilization is increased by 60%, thus create the efficient working environment and effective supply chain process. Even the utilization for each of the machine may increase better when the working hours is at 9, it is however the processed/output of FFB will be much lower. (1092/month instead of 1184/month).

8.0 CONCLUSION

Analytical modeling tools can help the planner get answers to "What if" scenarios so that a range of possibilities can be explored. The capacity planner is especially receptive to products that are seen to be scalable and also stable and predictable in terms of support and upgrades over the life of the product. As new technologies emerge and business strategies and forecasts change, capacity planners must revisit their plans.

ACKNOWLEDGMENT

The authors would like to thank to Universiti Malaysia Pahang for the grant provided during the study and to palm oil mill management for allowing us to conduct the study at their mill.

REFERENCES

Centeno, M. A. & Carrillo, M. (2001). "Challenges of introducing simulation as a decision making tool". *Proceedings of the 2001 Winter Simulation Conference*.

Kelton, W.D., Sadowski, R.P. and Sturrock, D.T. (2003) Simulation with Arena. 3rd edition, Singapore; McGraw-Hill

Pidd, M. (1992) Computer simulation in management science. 3rd edition, West Sussex, England; John Wiley & Sons

Robinson, S. (1994) Successful simulation – A practical approach to simulation projects. McGraw-Hill Book Company, London, England

Song, L., Wang, P. and AbouRizk, S. (2006) A virtual shop modeling system for industrial fabrication shops. Simulation modeling practice and theory, 14, pp 649-662

Y. Chang. and Makatsoris H. (2001). Supply chain modeling using simulation. Journal of Simulation, Vol. 2, No. 1.

Yu-Lee R.T,.(2002). *Essentials of Capacity Management*. John Wiley & Sons, Inc., New York, NY.