MEASURING PALM OIL MILL CAPACITY USING MODELLING AND SIMULATION

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ABSTRACT

This paper measured the capacity utilization of the palm oil mill operation system. The underutilized of capacity effect the production of the mill may disrupt the entire chain in the industry. Data were collected from a palm oil mill as the case study. Modelling 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

INTRODUCTION

Supply chain in the palm oil industry is an integrated and interdependent, especially in the upstream segment. Efficient supply chain must meet the structure of right quantities at the right time and at the right place. Therefore to ensure the efficient supply chain, business activities in this industry should be emphasized. In palm oil industry, supply chain can be divided into two segments which refer to upstream and downstream. The upstream refers to the nursery, plantation and milling process while the downstream refers to the crusher, refineries and other final products (Hai, 2002).

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 Crude Palm Oil (CPO) and Palm Kernel (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 aging palm oil, labor shortages, replanting and seasonal constraint.

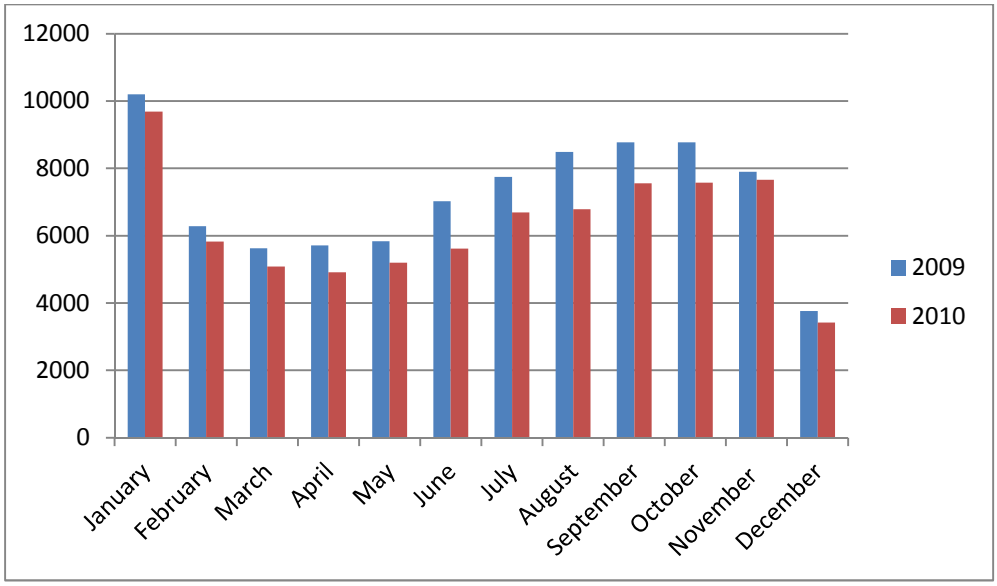
Problem Statement

Producing CPO and PK in order to fulfill the demand from the refiners and manufacturers is very important. The mill however cannot meet their target of meeting this demand as they are now is 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 few main important reasons which due to low acreage expansion, replanting, labor shortage and seasonal factors.

Low utilization of resources and capacity may create losses to the company as they need to bear cost for the unused ones. Low performance occurs in the mill is cause to main factor which is lack of fresh fruit bunch supplied from plantation. Factors such as labor shortage, low acreage expansion, aging palm oil, replanting, seasonal and few others were contributed to the low production in palm oil thus affect the entire chain in the industry (Economic Report, 2009/2010).

The focus of this study is towards the improvements of performance in the palm oil mill as the production in the mill currently is lower with the capacity is below the actual capability and low utilization of resources as FFB received was getting smaller as compared to previous years. Figure 1.1 showing the reducing number of original estimation FFB received by the processing mill.

Figure 1.1: FFB received from plantations for the year of 2009-2010.



Objectives of Study

- To model the current configuration of palm oil mill operation system.
- To evaluate the capacity and machine utilization in the palm oil mill using simulation.
- To propose the potential improvement to maximize the use of the machine utilization for the palm oil mill operation system.

RELATED STUDY

Supply Chain Management

Study in importance of the supply chain operations and management has shown an increasing number over the years. It is important as it plays a major role in steps of products life cycle. Supply Chain Management (SCM) currently focusing on the competitiveness of firms of the complex network of business relationship as its integrates to each other within the chain. It is gaining popularity and the interest is getting increased too (Naslund and Williamson, 2010). Firm'sperformance also depends on its upstream and downstream partners in the supply chain, as the performance of a supply chain will be determined by the joint success of supply chain members in a particular industry.

Performance in supply chain were also being measured at identifying improvement opportunities, coordinate efforts of different parties, and make contracting and risk sharing justifiable in a supply chain. Finally, time and resource consuming becomes the detailed activity analysis in the supply chain processes (Homburg, 2001). It has been claimed that in today business operation, competition is now between the supply chains instead of single companies (Trkman et al, 2007 and Li et al 2005 in Groznik and Trkman (2009). Thus, managing it successfully is to be forced.

Capacity

Capacity refers to an upper limit or ceiling on the load that an operating unit can handle.Capacity can be referred as the rate of a facility can produce according to their capability. It is usually expressed as volume of output per period of time. In any organization, the capacity of the company can be measured by looking at how it combines and utilizes the capacity it has purchased to perform work. In

management, the capacity of an operation was determined by its time standards, and operational standards, and the time that the operation was available.

Capacity entities can be divided into five which are space, labor, equipment, information technology and materials (Yu Lee, 2002). As in our study, the company experienced shortage of FFB which then effects the processing hours and their performance. Capacity then can be measured by using simulation and looking at the operation of the organization or manufacturing system. 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.

Capacity is closely related to efficiency and resource utilization. Efficiency is well known as how the organization uses their resources in producing outputs successfully. The definition is therefore can be stated as the ability of resources to produce outputs of a given quality meets the optimal use of resourcesto produce outputs of a given quality. Efficiency relates to benefits realized and resources used (Charnes et al., 2007).

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.

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. In an organization system, capacity plays a vital role in determining the production and the performance. As in this study, capacity can be evaluated using simulation. Simulation modelling not only affordable but relatively easy for managers to initiate simulation studies of a variety of situations including operations and processes, feasibility studies, business processes, human resource development, call centre staffing, capacity planning and others.

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.

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

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.

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.

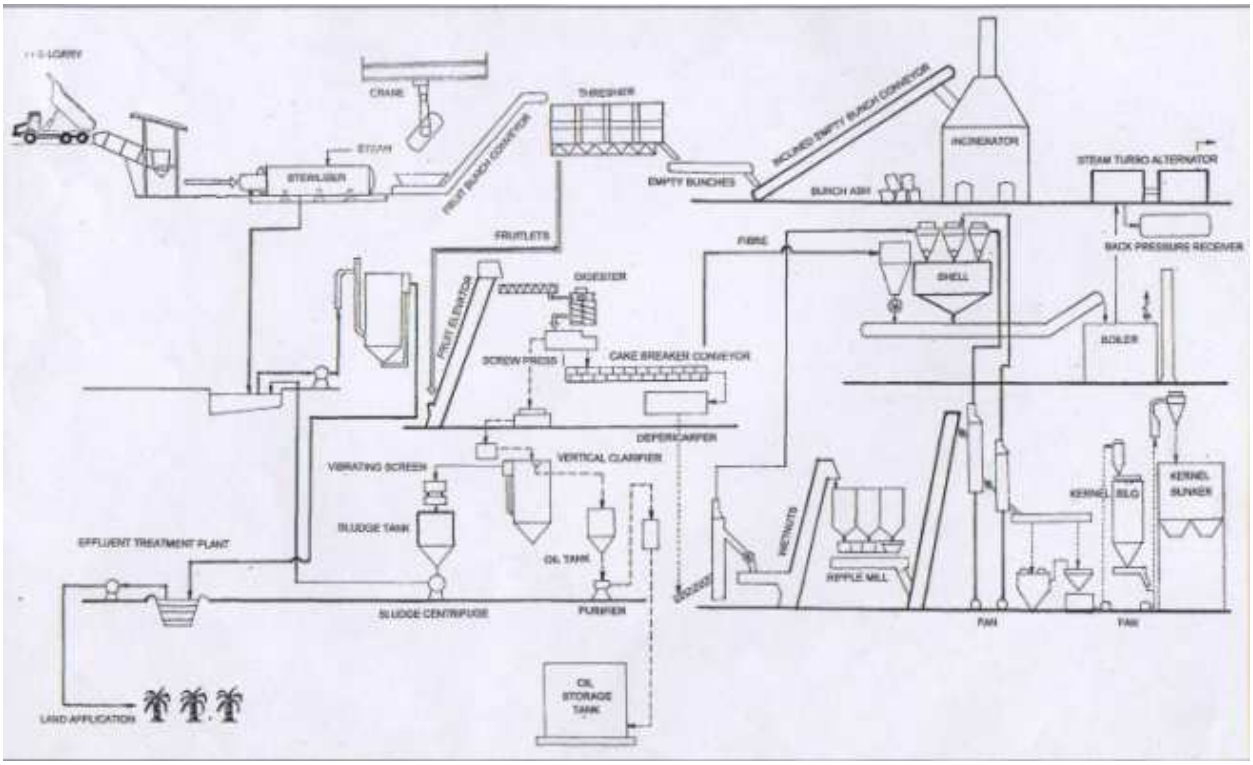


Figure 1: Crude Palm Oil Milling Process Diagram
Source : Ladang Sg Jernih

METHODOLOGY

We used the framework as proposed by Centino and Carillo (2001) to design the simulation model. Modelling 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.

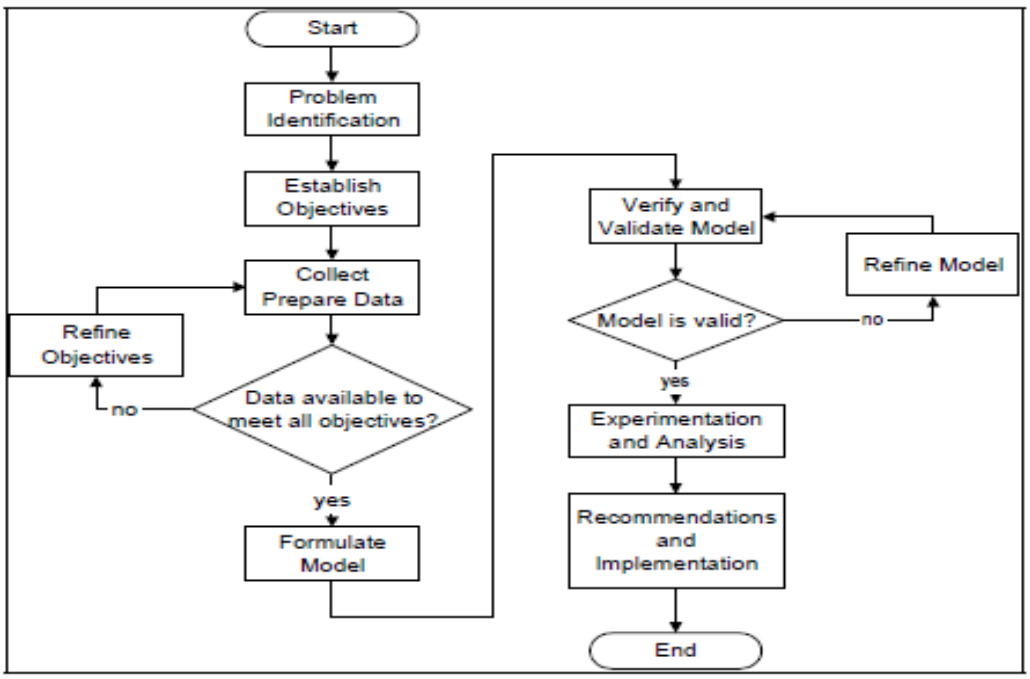


Figure 2: Steps and Decisions for Simulation Modelling Process
Source: Centeno and Carrillo, 2001

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.

DATA COLLECTION AND ANALYSIS

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.

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.

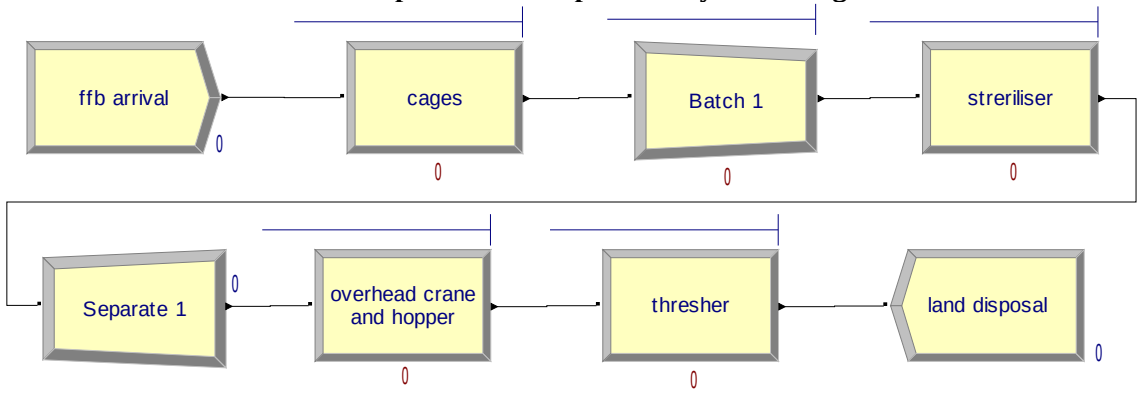
MODELLING – VALIDATION AND VERIFICATION

Once a simulation model has been designed, one of the important aspects need to be justified is how to ensure that the models perform as designed. A model need to be tested or certified before use or been simulated (Pidd, 1992). In carrying out a project according to the purpose, element of accuracy in a model must be addressed. As for this, elements of verification and validation are important to ensure the quality assurance procedures used in the simulation study. The goal of verification in a simulation study is to verify the accurate performance of each element in the model (Robinson, 1994). It is important in any kind of simulation study to repeat and verify the model accordingly to ensure that is it similar to the real system operated.

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).

Simulation Model

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



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 machine/ 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 /process step	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 suggested at least at 10h/day. If they work 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. The lower number of cages being processed may reflect their daily operation capacity.
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).

CONCLUSION

Analytical modelling 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.

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