MODELING OF MILK PRODUCTION PROCESS USING SIMULATION

NG ZHI XIN

Report submitted in partial fulfilment of the requirements
for the award of the degree of
Bachelor of Industrial Technology Management with Honours

Faculty of Technology
UNIVERSITY MALAYSIA PAHANG

2015

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project report 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 Honours.

Signature :

Name of Supervisor :

Position :

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STUDENT DECLARATION

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

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Name :

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DEDICATION

I dedicated this thesis to my parents, especially my mum, who support me all along.

I also would like to dedicate this thesis to my supervisor, Professor Razman bin Mat Tahar who gives me a lot of advices and suggestions throughout my work.

ACKNOWLEDGEMENTS

I am grateful and would like to express my sincere gratitude to my supervisor Professor Razman bin Mat Tahar for his germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. He has always impressed me with his outstanding professional conduct, his strong conviction for science, and his belief that a Degree program is only a start of a life-long learning experience. I appreciate his consistent support from the first day I applied to graduate program to these concluding moments. I am truly grateful for his tolerance of my naïve mistakes, and his commitment to my future career. I also sincerely thanks for the time spent proofreading and correcting my many mistakes.

My sincere thanks go to all my friends and members of the staff of UMP, who helped me in many ways and made my stay at UMP pleasant and unforgettable.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals. Special thanks should be given to my friends. I would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this study.

ABSTRACT

The purpose of the paper is to propose the idea of using simulation modeling to establish a model of milk pasteurizing processes. The scope of this study is the milk production process. This study is conducted by using ARENA simulation software to simulate the model. This study measured the utilization; value added time and productivity of the milk production process. Then, an enhanced model is recommended. The milk production process is improved by adding one more machine at filling process. After modification, the result recorded shows that the recourse utilization and output had increase.

Keywords: Milk processing, Productivity, Arena Software, Simulation modeling

ABSTRAK

Tujuan kajian ini adalah untuk mencadangkan idea menggunakan pemodelan simulasi untuk menghasilkan satu model tentang proses pempasteuran susu. Skop kajian ini adalah tentang proses penghasilan susu. Kajian ini dijalankan dengan mengguna satu perisian dengan nama ARENA untuk membentukan model. Penyelidikan ini mengaji utilisi, masa tambah nilai dan produktiviti proses penghasilan susu. Kemudiannya, satu model yang lebih baik akan dihasilkan. Proses penghasilan susu telah meningkat hasil dengan menambah satu lagi mesin pada proses pengisian. Selepas pengubahsuaian, keputusan menunjukkan utiliti pekerja dan hasil produk telah miningkat.

Kata kunci: Produktiviti, Utilisi, Perisian ARENA, Simulasi, Proses penghasilan susu

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Dairy product refers to food produces from the milk of mammals. Since eras, milk is used to make different products as well as for direct consumption. Human often consume dairy products to get sufficient nutrients in daily life. It is an important source of calcium, protein, vitamins A and D and other nutrients. Dairy foods are delicious and also offer a wide ranging set of health benefits.

Milk is a valuable healthy food; however, it has a short shelf-life and needs to be handled with much care. Milk is a first-rate medium for the growth of microorganism – specifically bacterial pathogens, which can cause spoilage and diseases in consumers. Milk processing enables longer preservation time for milk (days, weeks or month) and helps in reduce food poisoning. By using techniques such as cooling or fermentation, the consumable life of milk can be extended for several days. The heat treatment process that lengthens the usable life of milk is called pasteurization. This process lessens the amounts of potential pathogenic bacteria to the stages at which they do not signify a major health threat. Some examples of great value, concentrated and convenient dairy products with long shelf-lives are butter, cheese and ghee. These can be made by further processing the milk.

Furthermore, milk production creates employment opportunities for the society by its value adding activities such as the processing, marketing and delivery of milk. Milk processing contributes higher cash incomes to dairy producer than selling raw milk and provides better chances to reach regional and town markets. Milk processing can also help to deal with seasonal fluctuations in milk supply. The transformation of raw milk into processed milk and products can benefit societies by creating off-farm works in milk collection, shipping, processing and marketing.

According to Professor Dr. Aminah Abdullah, a food technologist at Universiti Kebangsaan Malaysia's Faculty of Science and Technology, a customer research conducted on last year revealed that 72% of 1000 Malaysians surveyed assumed that dairy was an essential part of a healthy diet (The Star Online, 2013). The significance of milk in Malaysians' live inspires me to conduct a study in milk production plant. Hence, I have chosen a milk production plant in Johor, Malaysia as my study target. The particular milk production plant is urging to enhance its production process so it can be on a par with or better than others plant. However, the plant unable to directly modify its current production processes as this could involves significant economic risks. The Arena software which has ability to simulate milk processing operation is highly desired as it lets computers to benchmark their present processes.

Simulation is abstract concepts of reality. It is an impressive instrument use to explore complex system in variety of fields such as supply chain, healthcare, marine and economic. By using simulation modelling, the result of an altered system can be predicted without influencing the existing system, which also cost and time saving. In the twenty-first century, various real-life problems have successful solved with the applications of simulation. Thus, modelling and simulation becomes the vital technologies to assist manufacturing industry. So, I offer to evaluate the performance measure of the milk processing plant and then enhance its process using simulation.

1.2 PROBLEM STATEMENT

According to statement of an employee, the packaging machine has problems frequently. This situation happens because of the increase in customer demand recently. In order to meet customer needs, the machine might have been overworking. The malfunction of machine has influence the whole operation of milk production and might cause delay. When the machine broke down, engineer or mechanic will be called. While waiting for the engineer to repair the machine, time has been wasted. An appropriate solution which will not have a negative effect on the current operation is needed to overcome this issue. So, I propose to use simulation modelling method since it is known as an effective tool for resolve problems related to manufacturing system design and operation.

This is an era where manufacturing companies are having excessive pressure due to global competition and higher customer expectation. The rising price of raw milk force milk production company looking for solution to increase their present throughput. This issue facing by the milk production plant can be resolved by evaluate the performance measures of present production processes using simulation, which include potential downtime, manufacturing lead time, throughput, blocking probabilities at process bottleneck and average inventory levels in buffers. Bottleneck workstation which creates obstacles must to be recognized in order to increase production rate and satisfy customer needs.

1.3 OBJECTIVES OF THE STUDY

The objectives of this study are:

i. To evaluate the different performance measures of milk production plant
ii. To recommend an improved production process that will increase profit
iii. To establish a model of milk pasteurizing processes by using simulation

1.4 RESEARCH QUESTIONS

i. What are the problems in the milk processing plant?
ii. How does simulation develop the process and solve the problems?
iii. What are the options to improve the milk production processes?

1.5 METHOD OF ANALYSIS

A simulation study is a refined systems-analysis activity that needs an analyst to require, at a minimum, understanding of simulation methodology, probability theory, statistics, project management and the detailed processes of the system being studied. During the application of simulation, there are some particular steps in order for the simulation to be successful. The process performed by simulation remains constant, no matter the variety of problem and the objective of the study.

Following are the steps for conducting a simulation study:

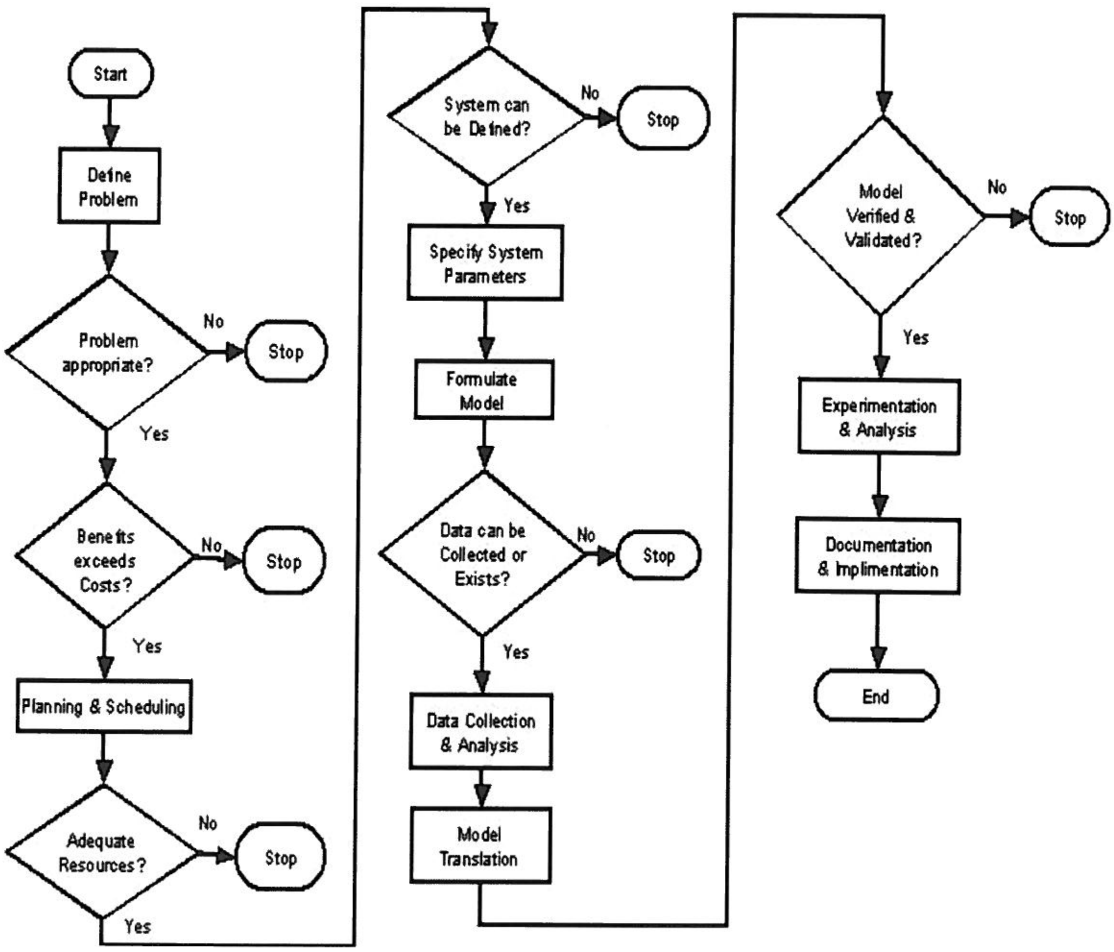

Figure 1.1: Steps of Simulation Study

1. Problem Analysis

   All study should initiate with a statement of the problem. The first step in building a simulation model is explores and understands the problems itself.

2. Setting of Objectives and Project Planning

   Then, defines the aims of the study and decides what the specific question that the study will need to answer. During this point, analyst should decide whether simulation is the appropriate methodology for the problem under study. The scope and requirement for the entire study should be decided upon this phase. A project plan should include the proposal for the study in terms of the time and resources required, such as personnel, software, hardware and costing to complete the simulation as a reference to refer to throughout the project cycle.

3. Data Collection

   Data is collected from various sources to estimate model input parameter. Data collection and model building is correlated. The required data elements may change, when the model changes. Date need to be revised after model building.

4. Model Conceptualization

   Recognizing how the real system acts and identifying the basic requirements of the model are necessary to build on the right model. Analyst may constructs a simple model first, then enhance and elaborate the model.

5. Model Translation

   The conceptual model is translated into a computer-recognizable format, either a general purpose programming language (e.g., C or C++) or a commercial simulation-software product (e.g., ARENA).

6. Verified?

   The model needs to be verified that it is free from logical faults and does what it is proposed to do. Verification helps to ensure that the model's assumptions are correct and complete.

7. Validated?

   Validation ensures the model could represent the actual system or problem and there is no significance divergence exists between the model and the real system. Expert could help to validate the models.

8. Experimental Design

   After validation of model, analyst must decide the suitable experimental design by setting up the system configuration. For example, simulation runs length, length of preparation period and number of runs need to be considered.

9. Production Runs and Analysis

   The simulation runs, then the result is analyzed and compared with the actual system to estimate the system performance. Every single scenario is repeated to raise the trustworthiness of scenario-related performance measures and the result is averaged to lower statistically inconsistency.

10. Documentation and Reporting

    The detailed of model is documented for several reasons. The same model could be used again for another analysis. Similar process can refer the report for some inspiration. All the analysis is reported clearly for the company to review. Manager can choose to implement or not for the strategy suggested.

1.6 SIGNIFICANCE OF THE STUDY

The purpose of this study is to evaluate the different performance measures of existing process and then recommend an improve process of a milk production plant in Johor, Malaysia. The milk production process is important and need to be maintaining its value in order to produce quality and bacteria free milk.

After doing some searching in internet, I found that there are only several articles or thesis write about modelling milk production processes using simulation. Thus, this study will be added in to be one of the guideline for others to do new exploration in this field.

The things a manufacturer care the most are how to improve their capacity, efficiency and output quality. The improvement in these area means that there will be an increase in the profit earn. Manufacturer also hopes to fully use the facilities in his plant. Whenever any machine failure happens, manufacturer suffers lost as it will affect the productivity on that day. The rising raw milk price also pushes the manufacturer to use its technology and machinery in order to maximize productivity. Higher productivity for sure will lead to greater capital gain.

Computer based simulation and modelling is a perfect tool in helping a manufacturing plant to improve their capacity, efficiency and quality. Generally dairy manufacturing processes in Malaysia are continuous and at great volume all year round. So, higher level of process control during manufacturing is required. Simulation modelling approach able to contributes in the design processes and maintenance of equipment. As a result, efficiency of process is significantly boosted. Simulation software assist manufacturer to test some changes in their processes without suffering drawback and economic risk. Furthermore, application of simulation is cost and time saving.

Lastly, manufacturer can have a better understanding and view of his own processes because simulation required the model developer to fully understand the system during model building.

1.7 SCOPE OF STUDY

In this study, the main focus is on dairy industry in Johor, Malaysia. A simulation model is formed to solve the problems faced by a milk processing plant in Johor, Malaysia.

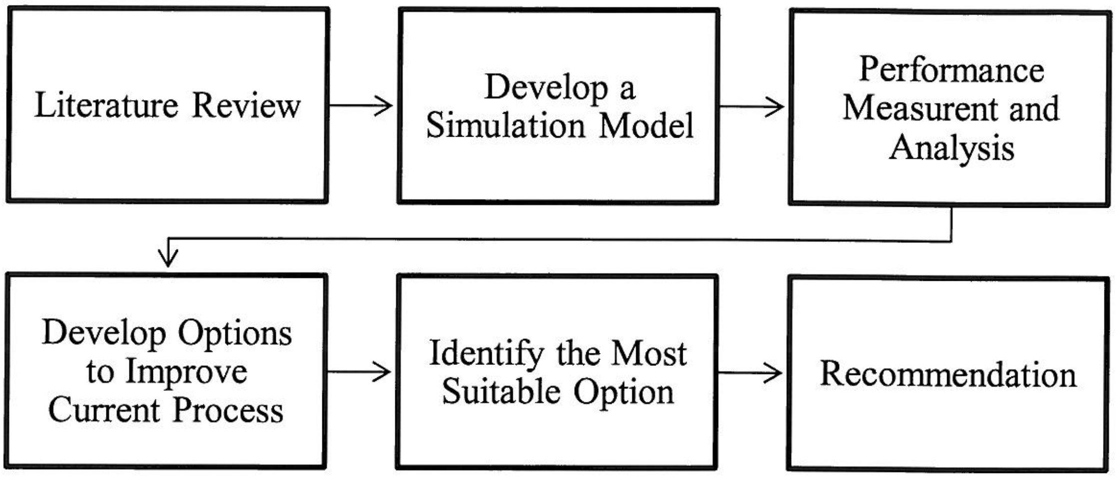

Figure 1.2: Flow of Study Approach

Figure 1.2 gives a picture of the approach taken in this study. The research is beginning with Literature Review (Chapter 2) of the simulation industry. The articles and thesis that concerned with manufacturing systems and simulation is studied. This is because buildings of a model that stimulate the real system require in-depth understanding of simulation and the system itself (Chapter 3). Next, the outcome of simulation is used for performance measurement and analysis (Chapter 4). The bottleneck found in the system is then overcome by via different measures, for example capacity planning. Several scenarios are suggested to improve the production rate of the plant. Each scenario is tested by using simulation to decide the most fitting strategy for the plant. Finally, recommendation will be stated and discussed (Chapter 5).

1.8 OPERATIONAL DEFINITION

Key Terms	Definition
Simulation	Mimic a real world situation or condition using equation, computer graphic model, physical model or game without exposure to risk.
Bottleneck	A phenomenon where the performance or capacity of an entire system is limited by a single or limited number of components or resources.

1.9 EXPECTED RESULT

By the end of this project it is expected that:

- The throughput of the milk processing plant is improve and able to fulfill customer demand.
- The workers and machine is fully utilized in a way that will not stress them out while not slacking too.
- The profitability is increase by reducing manufacturing and labor cost.

CHAPTER 2

LITERATURE REVIEW

2.1 SIMULATION

The operation of a model of a system is called simulation. According to Banks, simulation is defined as "the imitation of operation of a real-world process or system over time" (Banks, 1998). Whereas Shannon further explains simulation as " the process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behavior of the system and /or evaluating various strategies for the operation of the system" (Shannon, 1998). Simulation allows people to do experiments and answer various questions without messing with the real world system. The statistical power of many models cannot be estimated directly through power tables and other classical methods, such as mediation analyses, hierarchical linear models, and structural equation models, however, simulation capable to do it.

2.1.1 Simulation Modelling

Simulation modelling is an approach that models a system mathematically. It can modify or interrogate system in question to collect information which user interested in. Modelling is the action of formulating a simplified version of a complicated system with the objective of offering forecast of the system's performance measures of concern. A model has to be a close approximation to the actual system and combine all of its noticeable characteristics. Model validity is a vital concern in modelling. By comparing model yield with system yield, model validation can be secured. Another technique to measure model validation is simulate the model under know input situation.

Simplification and conceptual is the characteristics of modelling. Actually, if every single detail of the system is included in the model, the model cost may approach the cost to modeled system. This would have contrary to the reason to build model in the first place. Modelling is popular to be used in manufacturing because of its economic consideration. Following are the several reasons for using modelling:

a) Performance prediction for experimental system design.
   When there is no basic system exists yet, model building is way cheaper than develop the real-world system or its prototype.

b) Performance measurement of system under typical or uncommon condition.
   In some cases, the regular routine process of real-life system cannot be interrupted, for example, trying to upgrade a production line while it is having tight schedule for orders. This issue can be work out by using modelling.

c) Grade multiple plans and exploring their tradeoffs.

There are mainly 3 types of models:

- Physical model - simplified tangible object
- Mathematical/Analytical model – a set of calculation among statistical variables
- Computer model – a course which portraying the system

As stated by Rubinstein, simulation model can be categorized in few different ways as below (RibinStein, 1998):

a) Static and Dynamic Models
   Static models signify a system that progress with time while dynamic model signify a system that evolves with time.

b) Deterministic and Stochastic Models

Deterministic model only include non-random elements. A stochastic model consists of one or more random elements.

c) Continuous and Discrete Simulation Models

The observation needed by discrete simulation is during the period where changes arise. Continuous simulation needs to constantly collect data during simulation.

2.2 SIMULATION IN MANUFACTURING INDUSTRY

Since its origin, simulation has been utilized to a wide range of sectors, for example, manufacturing, healthcare, military and community services. It is considered having the status of second best broadly used approach in the area of operation management. Modelling is the most liked techniques used.

Discrete event simulation (DES) is the very regularly used methods to explore and comprehend the dynamics of manufacturing systems. DES is a tool with high flexibility as it let us to evaluate diverse options of system configurations and operating plans to backing decision making in the manufacturing perspective. In this computerized era, the use of DES has further spread.

The manufacturing system design can be classified into the general system design and facility layout, material handling system (MHS) design, cellular manufacturing system (CMS) design, and flexible manufacturing system (FMS) design (Ashkan Negahban, 2014). The detailed of each class will be discussed later.

2.2.1 General System Design and Facility Layout

Overall execution of manufacturing systems is highly affected by facilities design. Facilities layout design has a significant control on the effectiveness and efficiency of manufacturing operation. By giving suitable allocation of machines in a facility, an effective layout is formed, which means there will be reduction in manufacturing cost and improvement in system's performance. Hence, there are few researchers that used simulation in various facility layout problems.

Altuntas and Selim (2012) use the application of computer simulation to assess and compare several new weighted association rule-based data mining techniques for facility layout problem. Bottleneck analysis, work measurement, floor space requirements and facility layout analysis are done by using simulation in Vasudaven et al. (2010)'s research. He wants to improve the cost-effectiveness of steel-mill manufacturing.

2.2.2 Material handling system design

A major part of the total production cost is linked with material handling system (MHS). Hence, it has become a hot title for many studies. When the system becomes more and more complex, analytical models turn out to be less efficient. Discrete event simulation will be a better choice to solve MHS design problems.

With the purpose of improve throughput, product quality and system flexibility, automated guided vehicle (AGV) systems have been frequently used in manufacturing environments. The design of AGV is very complicated because of the high randomness and great number of variables implicated. However, simulation is particularly useful to deal with these complex systems. Hsueh (2010) has discovered this situation and suggest a load exchangeable AGV system design. This design allows two AGVs to switch their loads and scheduled works in order to increase process efficacy. While in semiconductor industry, Huang et al. (2012) create a simulation model of real world fab with the aim of getting optimal vehicle allocation.

2.2.3 Manufacturing Operation Planning and Scheduling

There are numerous researcher make use of discrete event simulation to tackle diverse operations planning and scheduling problems. When simulation is used in personnel scheduling problems, analysts give preference to discrete event simulation (DES) over Monte Carlo simulation. According to (Shannon, 1998), Simulation Based Production Scheduling Systems are popular because of the following:

- Typical production scheduling models are not adequate to symbolize a realistic factory model. They use simplifying assumptions to model the complexity of the manufacturing systems
- Realistic production scheduling problems cannot be solved by algorithmic methods
- Moreover, typical production scheduling methods cannot handle unpredicted events in a dynamic manufacturing environment such as machine breakdown, material shortage, etc. If a surprising event befalls, the existing production schedule might be nullified.

For food industry, Kopanos et al (2010) take up the scheduling problem in a yogurt production line. They formed a Mixed-Integer Linear Problems (MILP) formulation of the scheduling problem. They employed a cost-based objective function and used a hybrid discrete- and continuous-time representation. They implemented their approach in a case study and illustrated its efficiency. But, they put timing and capacity constraints on the processing stage on an aggregate level, and the scheduling problem they consider only involves the packaging stage.

Both simulation and optimization is used by Harper et al. (2010) to state the size and skill-mix of nursing teams. The output of the research proposes the optimal amount of nurses to hire matching to skill-mix and the corresponding numbers according to shift.

2.2.4 Real-time Control

Although simulation is an effective tool for real-time system control, it is still a hard task due to response time, data collection and aggregation matters.

A new scheduling system is proposed by Metan et al. (2010) for selecting dispatching rules in real time using simulation, data mining, and statistical process control charts., Huand Zhang (2012) propose a scheduling method for real-time control of semiconductor fabs by integrating vector ordinal optimization (VOO) and response surface methodology. The execution of the proposed VOO-based simulation technique had been compared with old-style simulation.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this study, several instruments and approaches will be used to measure the performance of the process. The throughput of the process will be increase and become more efficiency. In this chapter, I will discuss about the research methodology used in this research.

3.2 SYSTEM DESCRIPTION

When the plant receipt raw milk from supplier, the milk will be filtering and tasting before put into storage. Some of the milk from the storage will be sending via piping to a mixing tank. Vitamin C, coloring, natrium citrate, fruit concentrate, flavoring, sugar and stabilizer will be added to produce flavored milk such as chocolate milk, mango milk, and strawberry milk. After being well mixed, the flavored milk will be heated in boiler. Whereas, a part of original milk straight away flow to be heated. There will be a worker position at boiler. His mission is to clean the boiler every day and control it. Then, the milk is processed in pasteurizer. Next, the milk is homogenized to avoid milk fat form into creamy layer. The milk is cooled and sent to filling machine and pack into milk carton. Extra milk will be placed in storage. A worker is responsible to arrange all the milk cartons and place in boxes. Lastly, the milk is stored and shipped to customer by lorry on the next morning. The milk production process is shown in Figure 3.1.

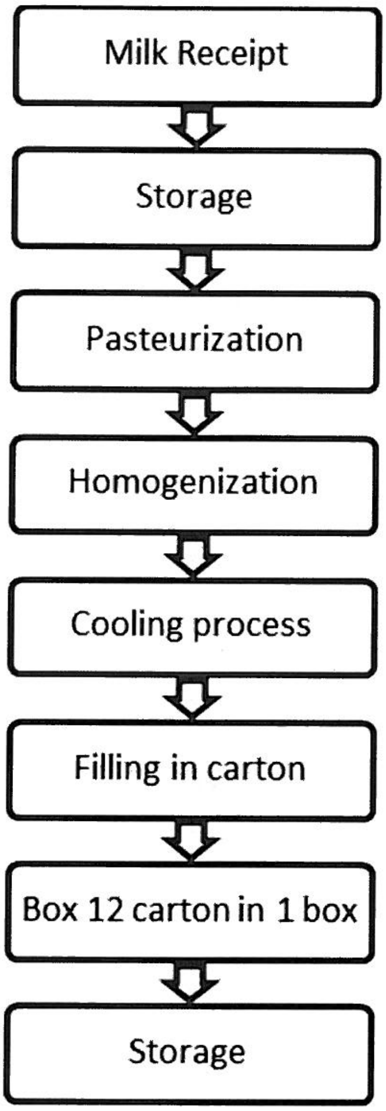

Figure 3.1: Milk Production Process Flow Chart

As usual, the working hour is eight hours. Normally, the milk is make-to-order as it cannot be stored for long period. Occasionally, the raw milk is out of quality and will be rejected.

3.3 METHOD OF DATA COLLECTION

During data collection, I observe the operation of the real system and done some record. I also surf for information from internet to get better understanding of the system and gain historical data from company.

Through observation, I recorded process flow time, worker arrangement, resource quantity and so on. These data are needed for model building. Instrument such as stopwatch is used to ensure the data collected is accurate. I had repeatedly collected the same data for several days and average it to obtain a more reliable estimate.

In order to run and complete the model, I acquired past data from the company. The reports and documents are reviewed to acquire working schedule and production data.

Finally, I had done some research via internet. I got some information as a guideline in doing my research writing. I learned some information like calculation and analysis method by studying material provided in internet.

3.4 MODELLING WITH ARENA

Arena is the simulation tool that will be used in this study. It uses an entity-based, flow chart methodology to model dynamic processes. Arena is functioning based on SIMAN language constructs. SIMAN was the predecessor to Arena and was the world's first PC-based simulation language when it was introduced in 1982.

Arena Runtime feature allows analysts to perform what-if simulation analysis using an Arena model built by himself or someone else. During runtime mode, analyst can modify the characteristics of any objects in the model, which includes module data, object positions, animation and more.

Below are the steps to create and run a model in Arena:

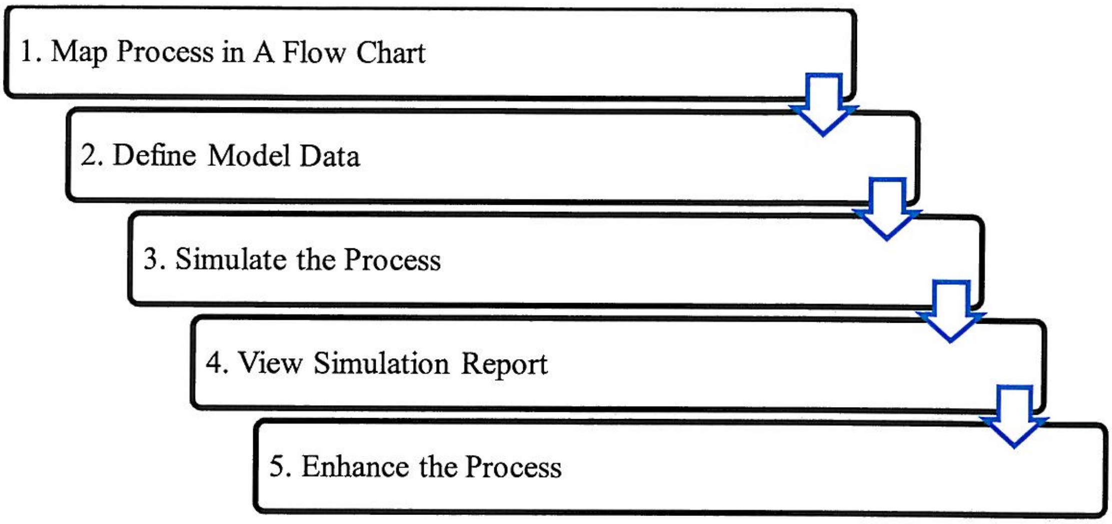

Figure 3.2: Steps to build and analyse model in Arena

1. Map Process in A Flow Chart

   From here, I am going to build a flowchart of milk production procsss. First, the process entities are created. Then, add all the process modules. Next, put a decide module and lastly dispose module.

   Create: The beginning of the process flow.

   Process: An activity that executed by one or more resources and demanding some time to fulfil.

   Decide: A branch in process flow.

   Dispose: The ending of the process flow.

2. Define Model Data

   Key in all the data collected accordingly to the module. Those data include beginning and end of process time, distance of workstation, and resource amount.

3. Simulate the Process

   Run the simulation model. Decide the speed accordingly.

4. View Simulation Report

   The performance measure of current process is recorded in the report. Average process time, average cost, longest time, number of waiting and utilization will be shown.

5. Enhance the Process

   Improve the process by eliminate problems found until a new efficient model is acquired.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter will provide an organize data analysis and result summary of the data collected from milk processing plant. A software named Arena is used to help in analyze the data and findings. So, in this chapter, the method to input data into Arena will be shown. Then, the findings will be presented in the form of graph, table and explanation.

A process model is constructed according to current milk production process using Arena. In this chapter, it will show how the model is being setting up. Next, an improved efficiency process will be developed by using different alternative solution. This can be achieved by changing number of machine used, machine capacity, number of worker or even the layout. The result of each solution will be analyzed and compared in order to choose the solution which optimize the production process the most.

4.2 ANALYSIS OF DATA FINDINGS

The main processes of milk processing plant are pasteurization process, homogenization process, filling and boxing process. All the machines are connected using pipe. The milk processing plant able to produces flavoured milk, whole milk and orange juice. However, in this thesis, the process of producing whole milk is choose to be studied and developed as a model using Arena. In order to develop a valid model, data such as worker schedule and process time is collected.

Milk production process is a combination of discrete and continuous process. The flow of milk during the process, which is the main part, is continuous process. The arrival of milk truck, filling process and boxing process are discrete processes. In the next section, all these processes will be evaluated using Arena and discussed.

To start a simulation model in Arena, a starting point for entities is required. Create module is the type of module used to do so. At the starting point of milk production plant, milk truck delivered milk from farm to the plant in the morning. According to my observation and data collected, the arrival of milk truck is minimum 1 unit which carried 1500 liter of milk. The arrival of milk truck is varies according to the order number on that day. So, arrival schedule is used in create module. Usually on the week day, there will be 2 units of milk truck arrive, while during weekend, there will be 3 units or more. However, the capacity of the milk plant is to produce more or less 6000 liter of milk. So, the max arrival is set to 4.

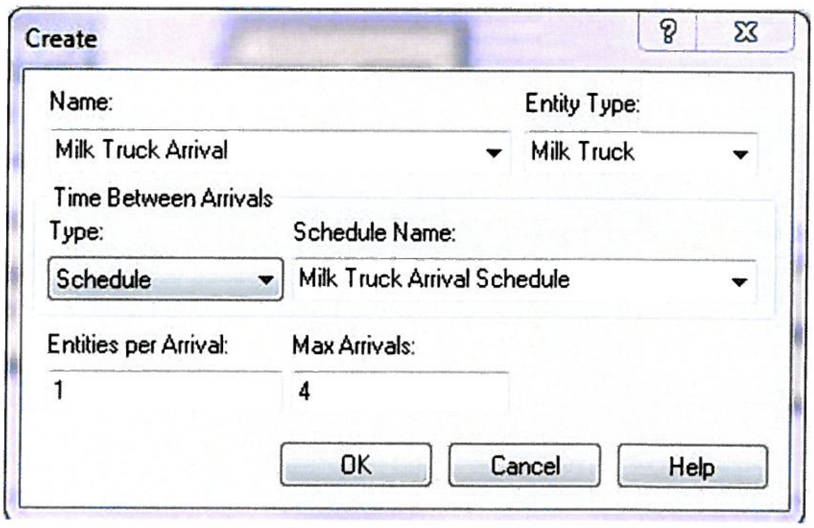

Figure 4.1: Create module

	Name	Type	Time Units	Scale Factor	Durations
1	Worker Schedule	Capacity	Hours	1.0	3 rows
2	Milk Truck Arrival Schedule	Arrival	Days	1.0	7 rows

Figure 4.2: Schedule list

Durations

	Value	Duration
1	1/2	1
2	1/2	1
3	1/2	1
4	1/2	1
5	1/2	1
6	1/3	1
7	1/3	1

Double-click here to add a new row.

Figure 4.3: Milk Truck Arrival Schedule

Figure 4.2 and 4.3 showed how the milk truck arrival schedule to be setting up. The time unit is "days" and seven days data is inserted. In the first five days, there had been 2 milk truck arrivals and on the last 2 days, there were 3 milk truck arrivals. According to equation,

Arrival rate = 1/inter-arrival time.

So, the value entered is inter-arrival time, which is 1/2, 1/2, 1/2, 1/2, 1/2, 1/3, and 1/3. The duration is 1 day.

4.3 MODEL DEVELOPMENT

Simulation software called Arena is used to develop model of the milk production process. The process of milk from unloading, pasteurizing, homogenizing, cooling, filling and lastly boxing, then put to storage was construct into a model. Next, the model created is run and the outcomes are evaluated.

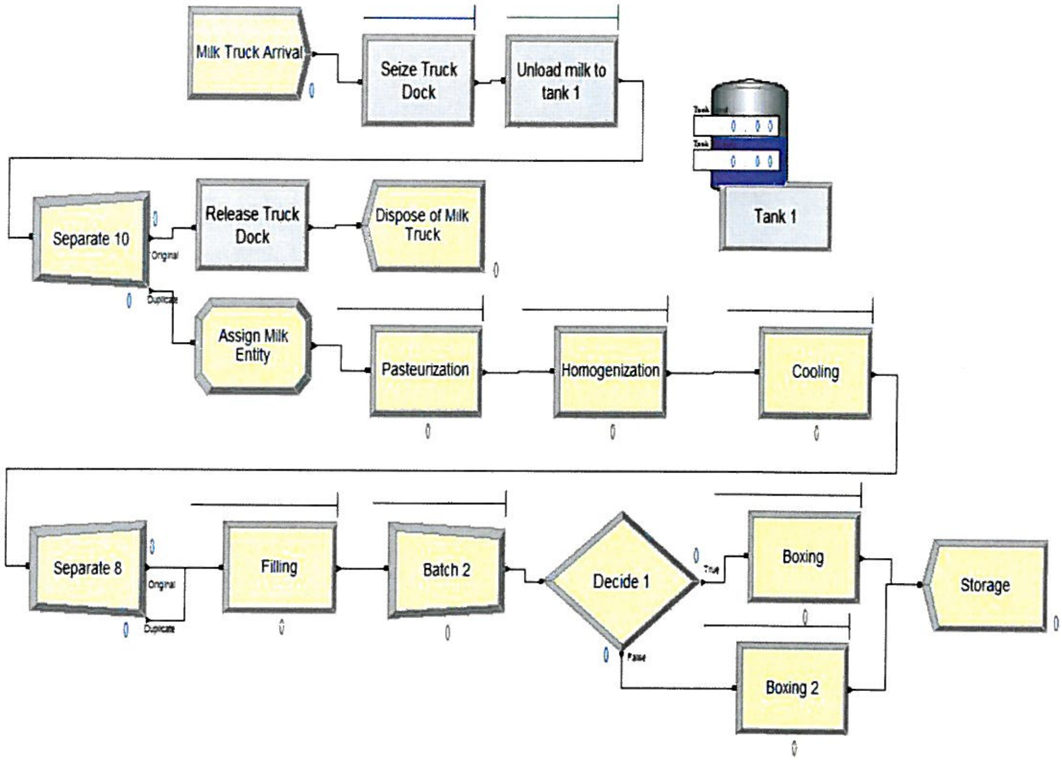

Figure 4.4: Model of milk production process

In the model, the milk trucks entities will arrives and seize a place in truck dock. Then, the milk is unloading from milk truck to tank 1. This process takes twenty minutes as the flow rate is 75 litre per minute and each milk truck carries 1500 litre of milk.

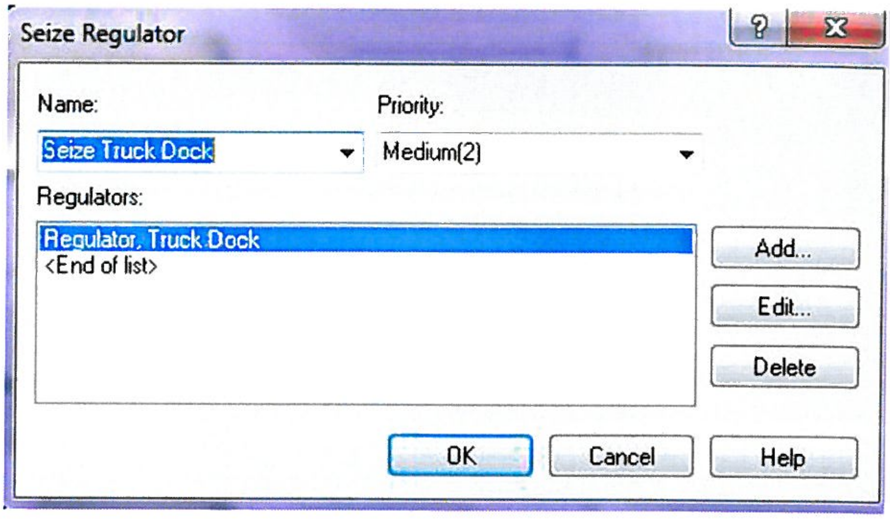

Figure 4.5: Seize Truck Dock

The block named "Seize Truck Dock" is a Seize Regulator module. It allows entity to seize a regulator at truck dock and let the milk to flow.

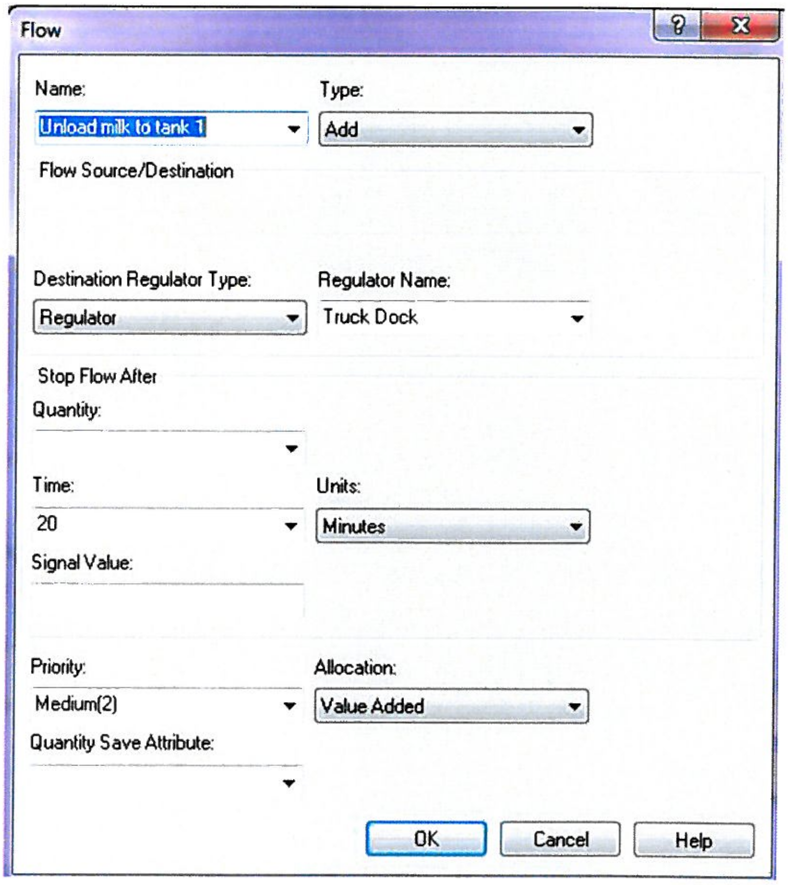

Figure 4.6: Unloading Milk to Tank 1

The block named "Unloading Milk to Tank 1" is a Flow module. Flow operation like adding, removing or transferring material to a tank, can be modelled in Arena by using flow module in conjunction with Tank module. The type is ADD because this flow process adds milk to Tank 1. This flow process will stop after 20 minutes, which means stop after 1500 litre of milk is flow through.

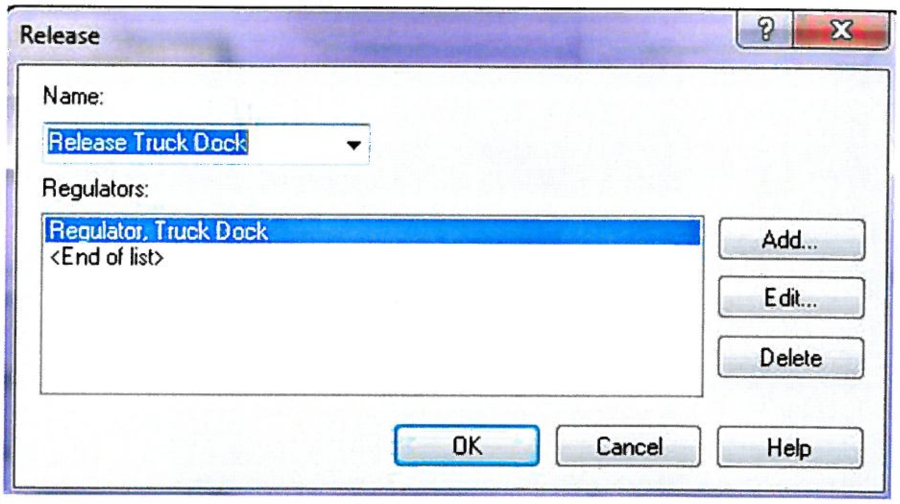

Figure 4.7: Release Milk Truck

The block called "Release Milk Truck" is a Release Regulator module. This module is used to release tank regulators that had previously assigned to an entity using Seize Regulator module. After release, those regulators are available for other entities that are waiting to seize the regulators.

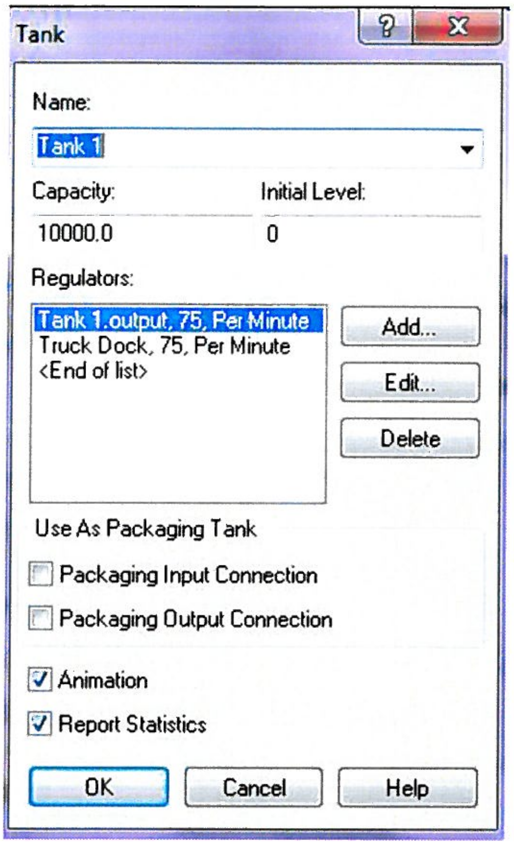

Figure 4.8: Tank 1

The block named "tank 1" with animation indicates the tank that stores milk. When the milk is unloading from milk truck to Tank 1, the level of the tank will increase. The maximum capacity of Tank 1 is 10000 litre. Figure show that there are two regulators connect to Tank 1, which are Tank 1.output and Truck Dock. Both have a flow rate of 75 litre per minute.

Process - Basic Process

	Name	Type	Action	Priority	Resources	Delay Type	Units	Allocation	Minimum	Value	Maximum	Report Statistics
1	Pasteurization	Standard	Seize Delay Release	Medium(2)	2 rows	Constant	Minutes	Value Added	.5	50	1.5	☑
2	Homogenization	Standard	Seize Delay Release	Medium(2)	1 rows	Constant	Minutes	Value Added	.5	35	1.5	☑
3	Cooling	Standard	Seize Delay Release	Medium(2)	1 rows	Constant	Minutes	Value Added	.5	45	1.5	☑
4	Filling	Standard	Seize Delay Release	Medium(2)	1 rows	Constant	Seconds	Value Added	.5	2	1.5	☑
5	Boxing	Standard	Seize Delay Release	Medium(2)	1 rows	Triangular	Minutes	Value Added	1	1.3	1.5	☑
6	Boxing 2	Standard	Seize Delay Release	Medium(	1 rows	Triangular	Minutes	Value Added	1	1.3	1.5	☑

Figure 4.9: Main process of milk production process

The process time for pasteurization, homogenization, cooling and filling is constant as it is process by machine. However, the boxing process is triangular in the value of 1, 1.3 and 1.5 because it is a process done by human. Pasteurization functions by using one machine and operate by one worker. Homogenization and cooling process used one machine each. Filling process uses filler with a capacity of two. Lastly, there are two personnel work at boxing process.

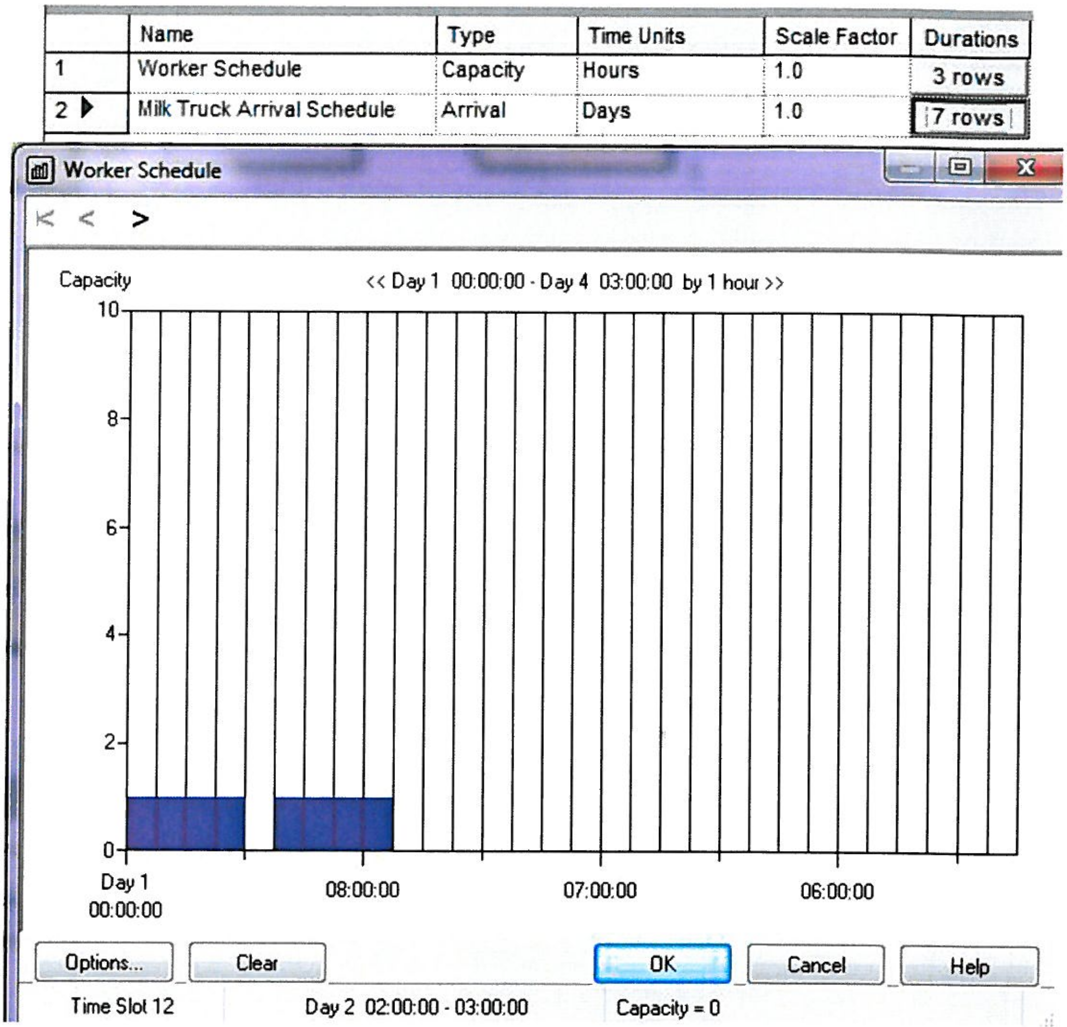

Figure 4.10: Worker schedule

There are 3 personnel work in this milk production process. They work for eight hours per day and there is an hour of lunch time is given. As shown in the figure above, worker will do their job for four hours from 8.00am, then rest for an hour, and continue to work until 5.00pm daily according to the worker schedule.

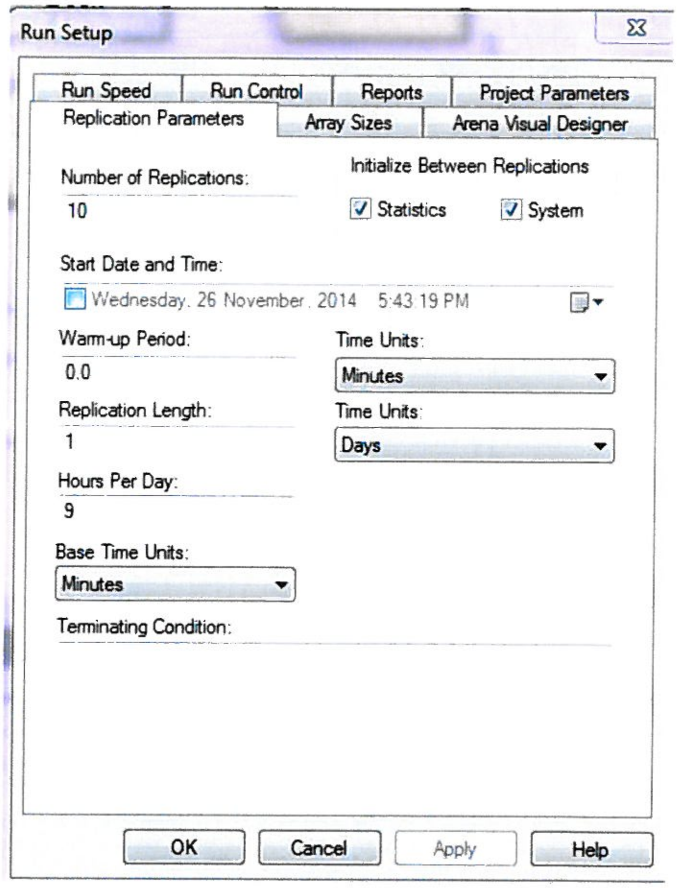

Figure 4.11: Run Setup

Run Setup Menu is used to control how the model will be run and run for how long. In this case, this model will be replicate for 10 times. As mention before, the plant work 9 hours per day. The time unit for this model is Minutes. The report also will use Minutes as base units. Hence, each replication will be started at time 0 and stop at 540 minutes.

Resource - Basic Process

	Name	Type	Capacity	Busy / Hour	Idle / Hour	Per Use	StateS...	Failures	Report Statistics
1	Truck Dock	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☐
2	Boiler	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
3	Homogenizer	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
4	Cooler	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
5 ▶	Worker 1	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
6	Worker 3	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
7	Worker 2	Fixed Capacity	1	0.0	0.0	0.0		0 rows	☑
8	Filler	Fixed Capacity	2	0.0	0.0	0.0		0 rows	☑

Figure 4.12: Resource list

4.4 DATA VERIFICATION AND VALIDATION

The verification and validation of model is vital as the aim of develop a simulation model is to produce an exact and reliable model. Simulation modelling can only approximately imitate the real system and cannot exactly the same as the real world system. Hence, model created should be verified and validated to ensure it is up to par with the real system to the degree that the model is able to fulfil its purpose.

As the computer simulation verification of a model, it is a process of checking the model is matching with the requirement and hypothesis for the given purpose of application. To ensure the accuracy of the simulation result, the model is run for ten replications. In Arena, the result of each of the replication is shown. Also, there is a version of average result of the ten replications.

For validation, the output of the model needed to be compared with company records. To validate the model, the difference between actual output and the simulation output must within the range of plus or minus ten percent. This can be calculating by using the equation as below:

$$Differences\ (\%) = \frac{Simulation\ Output - Actual\ Output}{Actual\ Output} \text{ x } 100\% \qquad \text{(Eq 4.1)}$$

According to the Arena result, the maximum boxes of milk produced is 504. The actual output of the company is averagely 500. There is only a difference of four. After the calculation, the difference is 0.8%, which means within the range of 10%. Hence, it can be concluding that this model is valid.

Figure 4.13: Arena check model

Lastly, Arena can help to check if there is any error or "bugs" in the model. After run the "check model" process, a notification as in Figure 13 is pop out. This means that there is no error in the model. Hence, data analysis can be started.

4.5 ANALYSIS OF SIMULATION RESULT

After finished running the simulation model, there is statistical result recorded. The data such as value added time, total time, wait time, resource utilization and output summary will be documented and observed. These data is important as it can help to evaluate the efficiency and productivity of the process. All the results are in minute time base.

Table 4.1: Value added time per entity

	Value Added Time per Entity (Minutes)		
Process	**Average**	**Minimum Average**	**Maximum Average**
Pasteurization	50.0000	50.0000	50.0000
Homogenization	35.0000	35.0000	35.0000
Cooling	45.0000	45.0000	45.0000
Filling	0.0333	0.0333	0.0333
Boxing	1.2643	1.2451	1.2836
Boxing 2	1.2651	1.2547	1.2749

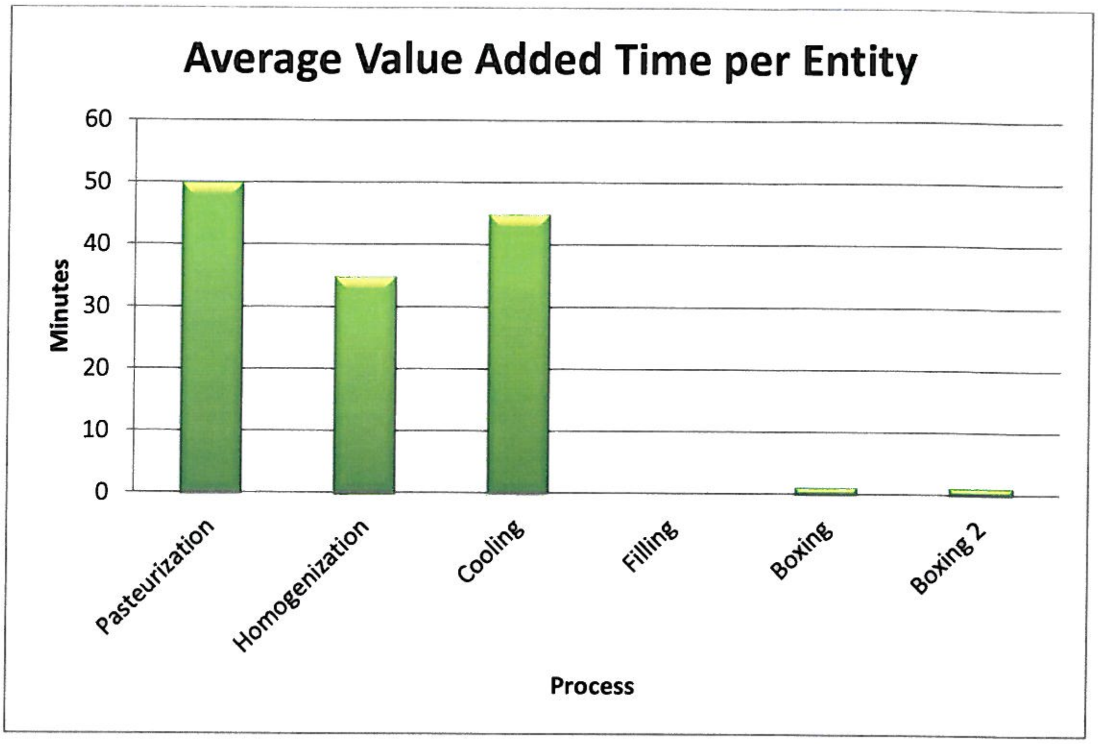

Figure 4.14: Average value added time per entity (minutes)

Table 4.2: Accumulated value added time

Accumulated Value Added Time (Minutes)				
Process	**Average**	**Half-Width**	**Minimum Average**	**Maximum Average**
Pasteurization	145.00	49.01	50.0000	200.00
Homogenization	101.50	34.31	35.0000	140.00
Cooling	126.00	45.01	45.0000	180.00
Filling	140.00	50.05	50.0000	200.00
Boxing	204.59	68.78	73.1667	309.94
Boxing 2	214.64	78.06	65.0186	346.07

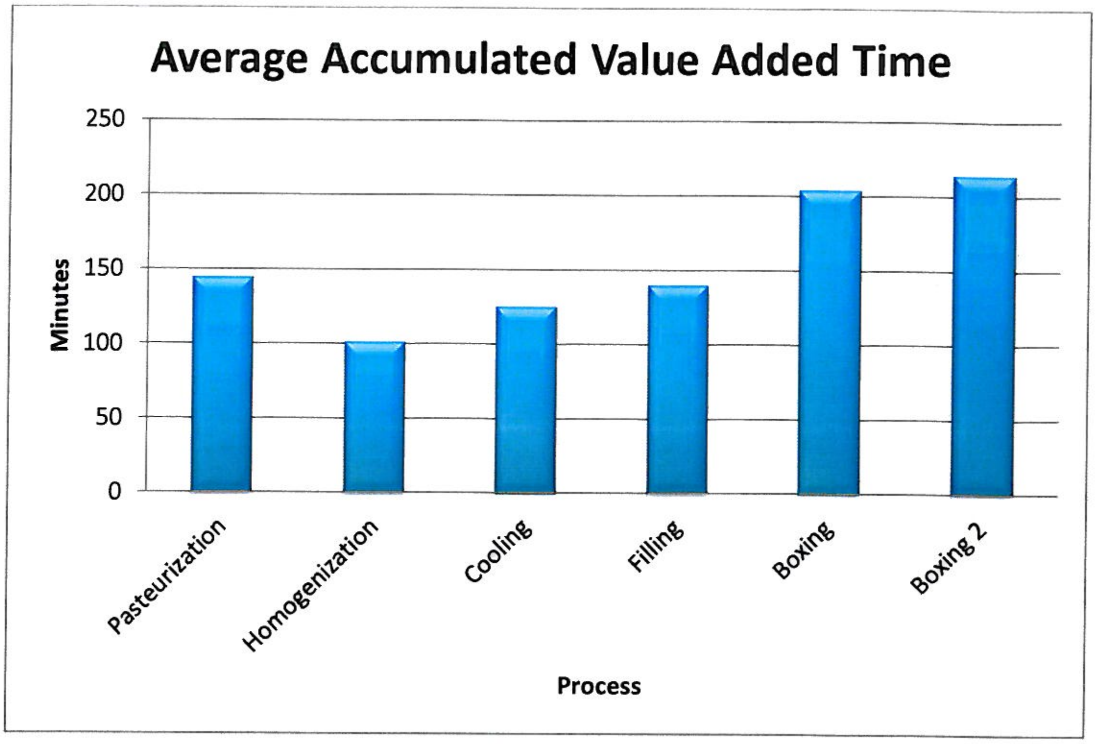

Figure 4.15: Average accumulated value added time

Table 4.3: Total time per entity

Total Time per Entity (Minutes)				
Process	**Average**	**Half-Width**	**Minimum Average**	**Maximum Average**
Pasteurization	55.8972	5.18	50.0000	66.2858
Homogenization	35.0000	0.00	35.0000	35.0000
Cooling	45.0000	0.00	45.0000	45.0000
Filling	12.5167	0.00	12.5167	12.5167
Boxing	40.6465	11.21	24.4414	64.7403
Boxing 2	42.7439	17.10	21.1205	85.5345

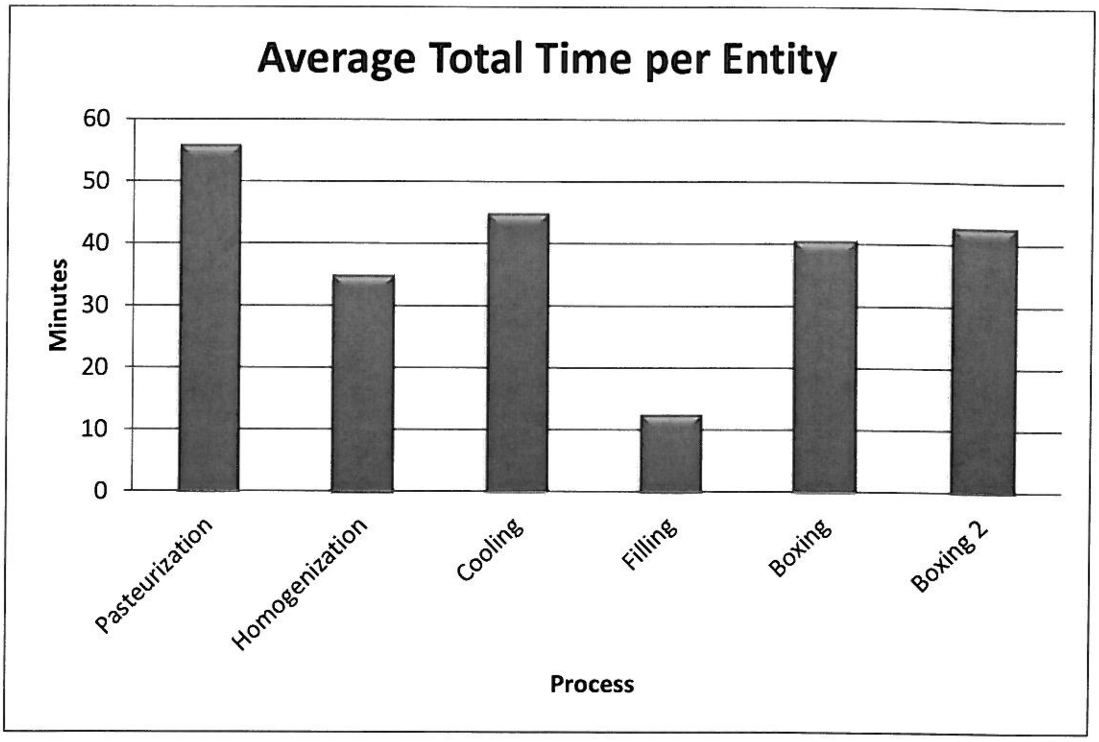

Figure 4.16: Average total time per entity

All the tables, figures and data above are the result recorded after running simulation model in Arena. Referring Table 4.1 and Table 4.3, the value added time and total time of pasteurization, homogenization and cooling process is almost the same. This indicates that there is a very short wait time in these processes, which is a continuous process. As shown in Figure 4.5, the average accumulated value added time for boxing and boxing 2 processes is much higher than others. This is because these process are done by human, which is slower than machine. Human also need to rest and eat. Worker who has a negative emotion during work may influence his work.

Table4.4: Worker Utilization

Worker Utilization					
	Average	**Percentage (%)**	**Half-Width**	**Minimum Average**	**Maximum Average**
Worker 1	0.2764	27.64	0.09	0.0926	0.3704
Worker 2	0.3793	37.93	0.13	0.1355	0.5740
Worker 3	0.3976	39.76	0.14	0.1204	0.6409

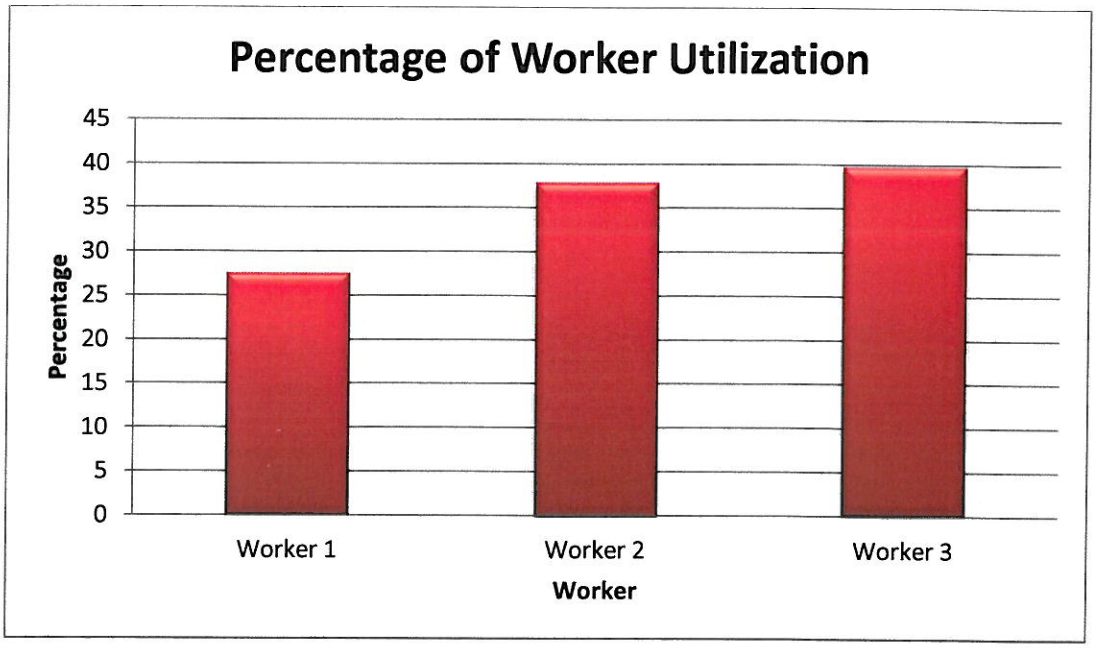

Figure 4.17: Percentage of worker utilization

Table 4.5: Machine utilization

Machine Utilization					
	Average	**Percentage (%)**	**Half-Width**	**Minimum Average**	**Maximum Average**
Boiler	0.2764	27.64	0.09	0.0926	0.3704
Homogenizer	0.1880	18.80	0.06	0.06481481	0.2593
Cooler	0.2350	23.50	0.08	0.08333333	0.3333
Filler	0.1296	12.96	0.05	0.04629630	0.1852

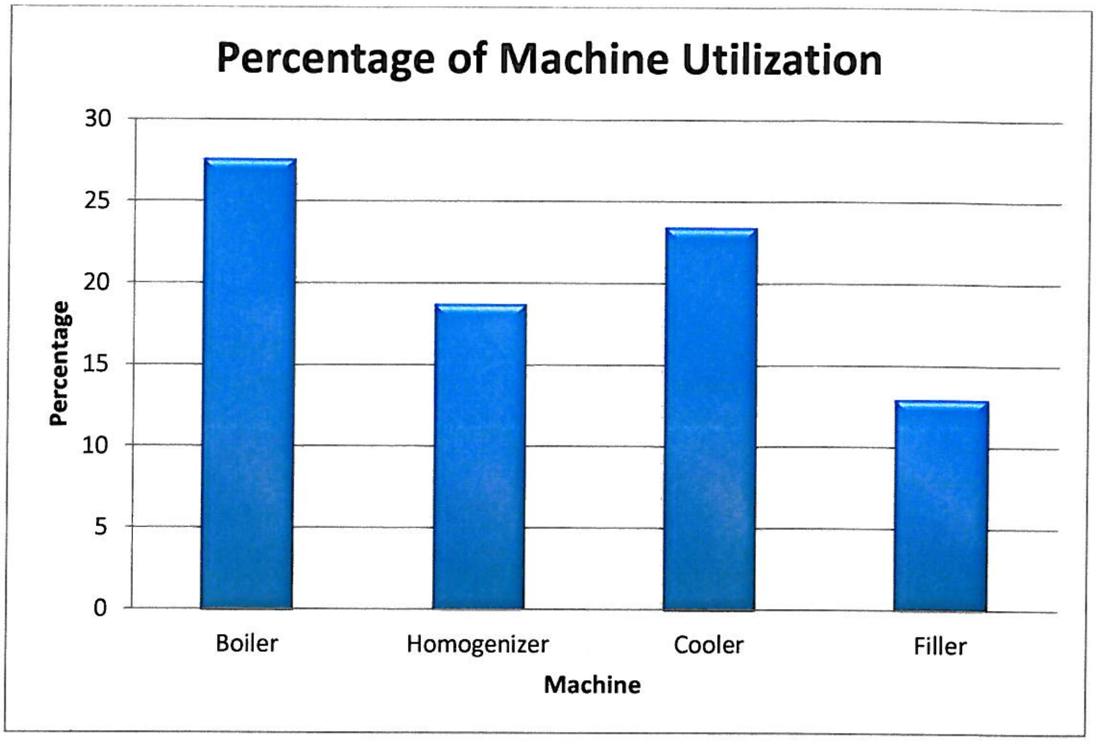

Figure 4.18: Percentage of machine utilization

To achieve the objective of improve production process; the resource utilization is crucial to be studied and evaluate. A worker who has too much works to do will bring disaster, whereas worker who is too free is a waste of cost and resource. A machine which had been bought and need to be maintenance regularly uses a large cost. Hence, proper planning of worker placement and machine work time will increase the resource utilization and hence improve throughput.

As shown in Figure 4.17, the worker utilization of three workers is not more than 40%. Usually, operator with utilization of 60% is considered proper utilized as he is not too busy or free. So, this shows that the worker utilization is low and needed to be improved. Some amendment of worker schedule might solve this situation.

Figure 4.18 show that most machines are having a low utility. Boiler has the highest utilization of 27.64% among four machines. On the other side, homogenizer and filler having utilization lower than 20%. This point out that there is still have free capacity to operate for longer time.

Table 4.6: Wait time per entity

Wait Time per Entity (Minutes)			
Process	**Average**	**Minimum Average**	**Maximum Average**
Pasteurization	5.8972	0.00	16.2858
Homogenization	0.00	0.00	0.00
Cooling	0.00	0.00	0.00
Filling	12.4833	12.4833	12.4833
Boxing	39.3822	23.1577	63.4865
Boxing 2	41.4789	19.8456	84.2622

According to Table 4.6, Boxing and Boxing 2 process have the highest wait time. This happens because boxing process is done by worker. As for pasteurization, homogenization and cooling process, the wait time is as low as zero.

Table 4.7: Output summary

Output Summary (Number In)				
Process	**Average**	**Half-Width**	**Minimum Average**	**Maximum Average**
Pasteurization	3.0000	1.01	1.0000	4.0000
Homogenization	2.9000	0.98	1.0000	4.0000
Cooling	2.9000	0.98	1.0000	4.0000
Filling	4200.00	1500.44	1500.00	6000.00
Boxing	174.10	61.06	57.0000	259.00
Boxing 2	175.90	64.76	51.0000	272.00

Table 4.8: Output summary

Output Summary (Number Out)				
Process	**Average**	**Half-Width**	**Minimum Average**	**Maximum Average**
Pasteurization	2.9000	0.98	1.0000	4.0000
Homogenization	2.9000	0.98	1.0000	4.0000
Cooling	2.8000	1.00	1.0000	4.0000
Filling	4200.00	1500.44	1500.00	6000.00
Boxing	162.00	54.63	57.0000	246.00
Boxing 2	169.80	61.83	51.0000	272.00

Table 4.9: Productivity of every Process

	Productivity		
Process	**Average Number In**	**Average Number Out**	**Productivity (%)**
Pasteurization	3.0000	2.9000	96.67
Homogenization	2.9000	2.9000	100.00
Cooling	2.9000	2.8000	96.55
Filling	4200.00	4200.00	100.00
Boxing	174.10	162.00	93.05
Boxing 2	175.90	169.80	96.53

$$\text{Productivity} = (\text{Average Number out} / \text{Average Number in}) \times 100 \qquad \text{(Eq 4.2)}$$

By using Equation 4.2, productivity can be calculated. The productivity of all processes is high. So, it means that the efficiency of machine in this milk production process is high as its productivity is over 90 percent. However, there is still has room to be improved for the system. Throughput can be improved by arranging worker schedule and machine operation time.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

For this chapter, there is discussion on how to improve the production of the milk plant by model experimentation. Arena will be in conjunction with what-if analysis to find out how the changes of the model affect the output of the process. The result shown in Chapter 4 will be revised to discover the solution which could improve the current model. Next, some recommendation will be proposed in order to enhance the milk production process.

5.2 RESULT DISCUSSION

The statistical data such as value added time and resource utilization are gathered from simulation. By revising these data, the problems of the production process can be recognized. Then, appropriate solution should be introduced to resolve those issues.

According to Table 4.6, the waiting time for pasteurization, homogenization and cooling process is very short and near to zero. This shows that these processes are continuous process. As for boxing and boxing 2 process, the average accumulated value added time is high. Both of the process is done by workers, hence it needs more time as human need to rest and unlike machine which can work for whole day, human will become fatigue after working for a long time.

As in the Chapter 4 showed, the resource utilization of this production process is low. Workers 1, 2 and 3 have utilization of fewer than 40%. So, the worker schedule should be changed to make full use of the workers and hence enhance the efficiency of the process. One way to increase the worker utilization is to increase the speed of filling process. This allows milk to flow faster to be boxing. Next, the machine utilization of the plant is an average of 20%. This indicates that the machines still have extra capacity that could be used.

5.3 WHAT IF ANALYSIS APPROACH

What-if analysis is also known as sensitivity analysis. It is a brainstorming method used to define in what way changes in the expectations that those predictions are based upon affect planned performance. Using What-if analysis, different settings can be change without risking the real system. Different scenario will be created with varying circumstance, and then its outcomes will be compared. This can help people to predict the effect of his decision over given performance measures. The scenario formed will be based on the difficulties that need to be resolved or improved. In this study, there will be three different scenario implemented by using simulation modeling and its results, especially productivity and resource utilization, will be considered.

5.3.1 Case 1: What if adding one more filler machine

One more filler machine to be added in the process to allows the milk flow through this process faster. Then, workers will be able to start their work earlier.

Table 5.1: Comparison of worker utilization for Case 1

	Worker Utilization	
	Current Model (%)	**New Model (%)**
Worker 1	27.64	44.88
Worker 2	37.93	42.67
Worker 3	39.76	42.41

Table 5.2: Process output for Case 1

	Average Output	
	Current Model	**New Model**
Boxes of milk	335	367

Table 5.3: Productivity for Case 1

	Productivity	
	Current Model (%)	**New Model (%)**
Pasteurization	96.67	88.46
Homogenization	100.00	93.48
Cooling	96.55	93.02
Filling	100.00	98.69
Filling 2	-	98.58
Boxing	93.05	72.54
Boxing 2	96.53	74.27

As shown in Table 5.1, after adding one more filler machine, the utilization of the 3 workers has increased from about 20% to 40 %. Worker 1's utilization has the most significant upsurge of 17.24%. Worker 2 and 3's utilization had increased 4.74% and 2.65%. The average output also rises from 335 boxes of milk to 367 boxes of milk, which is an increase of 384 litre of milk. However, the productivity of all the processes in the new model has decreased as in Table 5.3.

5.3.1 Case 2: What if the filler machine process time change to 1 second

This scenario is set up to increase the utilization of worker 2 and 3. To increase the utilization of worker 2 and 3, the filler machine need to pass the entities faster so the worker can start to work. So, the process time of the filler machine is lower from 2 seconds to 1 second.

Table 5.4: Comparison of worker utilization for Case 2

	Worker Utilization	
	Current Model (%)	**New Model (%)**
Worker 1	27.64	27.98
Worker 2	37.93	38.61
Worker 3	39.76	39.80

Table 5.5: Process output for Case 2

	Average Output	
	Current Model	**New Model**
Boxes of milk	335	338

Table 5.6: Productivity for Case 2

	Productivity	
	Current Model (%)	**New Model (%)**
Pasteurization	96.67	90.88
Homogenization	100.00	93.61
Cooling	96.55	96.67
Filling	100.00	100.00
Boxing	93.05	100.00
Boxing 2	96.53	96.77

As shown in Table 5.4, all of the worker utilization has increase. Worker 2 has the most increase which is 0.68% in utilization. Furthermore, the average output of the process also increases. The number of boxes of milk produced by current model is 335 while number of boxes of milk produced by new model is 338. There is an increase of 3 boxes. One box consists of 12 litre of milk, so it means that there is an increase of 36 litre of milk produced. Referring Table 5.6, the productivity of pasteurization and homogenization process is dropped, whereas the productivity of cooling, filling, boxing and boxing 2 process has increased.

5.3.3 Case 3: What if both Case 1 and 2 apply together

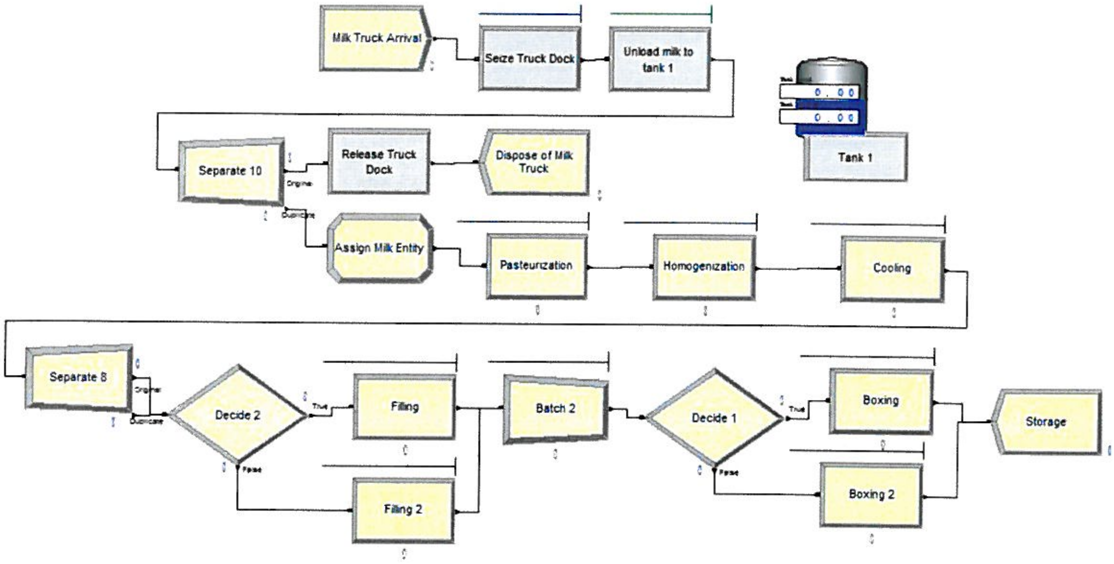

Figure 5.1: Modified model for Case 3

Figure 5.1 shows the model which combine Case 1 and Case 2. There are 2 filler machine, each has a capacity of 2 and process time of 1 second. The entities have 50% to either choose Filling or Filling 2 process.

Table 5.7: Comparison of worker utilization for Case 3

	Worker Utilization			
	Current Model (%)	**Case 1 (%)**	**Case 2 (%)**	**Case 3 (%)**
Worker 1	27.64	44.88	27.98	41.12
Worker 2	37.93	42.67	38.61	42.58
Worker 3	39.76	42.41	39.80	42.55

Table 5.8: Process output for Case 3

	Average Output			
	Current Model	**Case 1**	**Case 2**	**Case 3**
Boxes of milk	335	367	338	367

Table 5.9: Productivity for Case 3

	Productivity			
	Current Model (%)	**Case 1 (%)**	**Case 2 (%)**	**Case 3 (%)**
Pasteurization	96.67	88.46	90.88	85.42
Homogenization	100.00	93.48	93.61	95.12
Cooling	96.55	93.02	96.67	94.87
Filling	100.00	98.69	100.00	99.80
Filling 2	-	98.58	-	99.69
Boxing	93.05	72.54	100.00	77.92
Boxing 2	96.53	74.27	96.77	79.04

Referring Table 5.7, the worker utilization in Case 3 is higher than Case 2 and current model, more or less the same as Case 1. According Table 5.8, the average production process output of Case 1 and 3 is the same, which are 367 boxes of milk. The average output of current is the lowest of 335 and Case 2's process output is 338. Table 5.9 shows that

5.4 SCENARIO PLANNING

Scenario planning is used to forecast what might happen in the environment and how an organization might survive within that particular environment. It is not predict what might be happen in the future, it is to forecast when a situation is happening, what effect it will lead to. Then, people could be prepared before that situation happens and cause severe effect.

5.4.1 Scenario 1: Filler machine has a failure time

Failure - Advanced Process

	Name	Type	Up Time	Up Time Units	Down Time	Down Time Units	Uptime in this State only
1 ▶	Failure 1	Time	EXPO(3)	Hours	15	Minutes	

Figure 5.2 Failure module

In this scenario, the filler machine has been given a failure time with mean of 3 hours and down time of 15 minutes. This failure is often occur when the carton cannot be sealed completely.

Table 5.10: Machine and worker utilization

Scheduled Utilization	Average	Half Width	Minimum Average	Maximum Average
Boiler	0.2421	0.10	0.00	0.3704
Cooler	0.1833	0.09	0.00	0.3333
Filler	0.0977	0.05	0.00	0.1852
Homogenizer	0.1492	0.07	0.00	0.2593
Worker 1	0.2421	0.10	0.00	0.3704
Worker 2	0.3033	0.17	0.00	0.5960
Worker 3	0.3061	0.17	0.00	0.5850

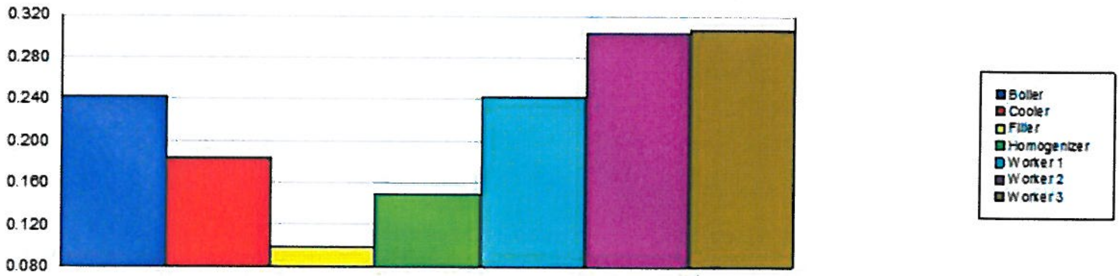

Figure 5.3 Machine and worker utilization graph

Compared with current model, this model with filler machine failure has higher machine utilization but lower worker utilization.

Table 5.11: Productivity

	Productivity	
	Current Model (%)	**New Model (%)**
Pasteurization	96.67	82.76
Homogenization	100.00	91.67
Cooling	96.55	100.00
Filling	100.00	95.93
Boxing	93.05	97.59
Boxing 2	96.53	99.62

Compared with present model, the new model with failure time has lower productivity for pasteurization, homogenization, filling process. Cooling, Boxing and Boxing 2 has higher productivity.

Table 5.12: Process output

	Average Output	
	Current Model	**New Model**
Boxes of milk	335	263

However, the process output of the new model is 263, which is lesser than current model output of 335 by 72 boxes. This is because failure time has caused the operation of the whole system stopped and need to be repaired. Hence, the time has been wasted while waiting engineer to repair it.

5.5 RECOMMENDATION

In this milk production plant, the milk production process is mainly run by machines and some part run by human. The processes run by machine have a constant time and it is fast. Whereas, the processes run by human are slow and error may occur. However, machine also will have failure time. The failure can be caused by jamming or function failure during long operation. So, the machine needs to be sent for maintenance regularly to avoid major failure.

After the result analysis, this milk production plant is recommended to buy a second filler machine in order to smoothen and improve process output. Although the cost to buy a new machine is very high, but in a long run, it is an investment that is worth to risk. A new machine will have lower failure as it is brand new and haven function for a long time. If there is a budget problem, milk production plant can plan to rent or buy a second hand filler machine. After earn enough profit, then, may buy a new machine.

This study is recommended to be further developed. With the increasingly well-known simulation, many companies are trying to study about simulation modeling. The benefit of simulation which allows company to test run in virtual world before launch the plan in reality which had reduce much risk is much favour by many people. The thesis or report about modeling of milk production plant is not much. Hence, it is an area which is still has space to be explored. By using the flow module, this milk production process can be developed with animation and detailed specification which is suitable for Master or PHD studies. Therefore, this research should be encouraged to further study.

5.6 CONCLUSION

The study of milk production process comprises five main processes which are pasteurization, homogenization, cooling, filling and boxing. By using simulation, the problem faced by these processes is found.

Before starting to run the model develop using ARENA, the model need to be verified and validated. Next, What-if analysis is done to try out different scenario. Then, according to the result of these scenarios, an enhanced model can be formed.

The current process of the milk processing plant had been developed into a model. After running this model in ARENA, the data is analyzed and found out the utilization of worker and machine is quite low. Hence, What-if analysis is performed to discover the difference between the results of different situation. Next, a recommendation is made which is suggest the milk processing plant to buy or rent one more filler machine in order to increase the throughput and efficiency of the system. Therefore, the objective of this research is accomplished.

The whole simulation development and analysis of model is done virtually using ARENA. So, it has save time and cost. It also avoid unwanted risk occurred while trying to change the system. Thus, simulation is encourage to be used in vary area in doing research.

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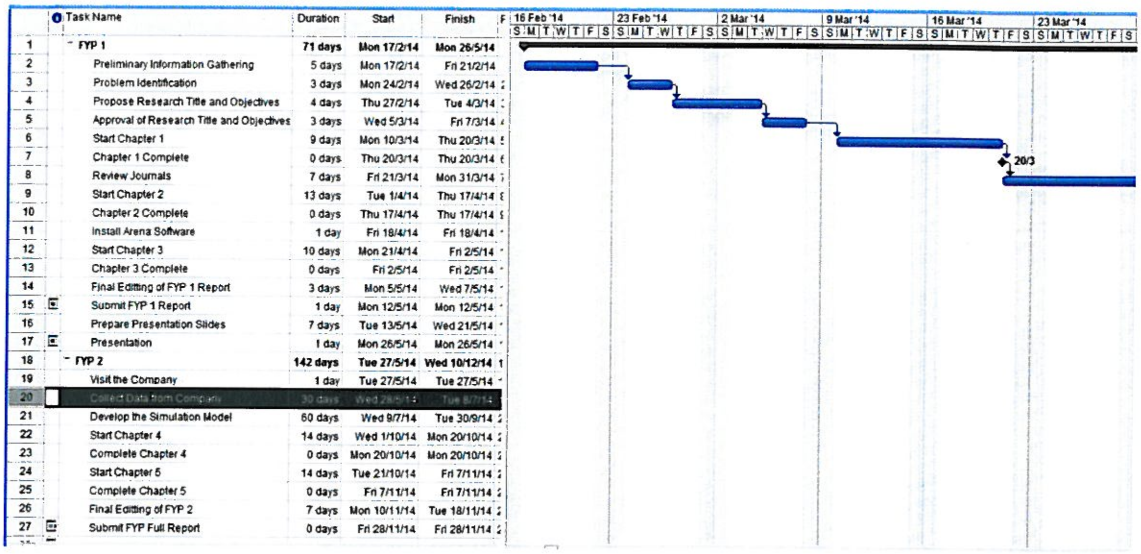
APPENDICES

Gantt chart



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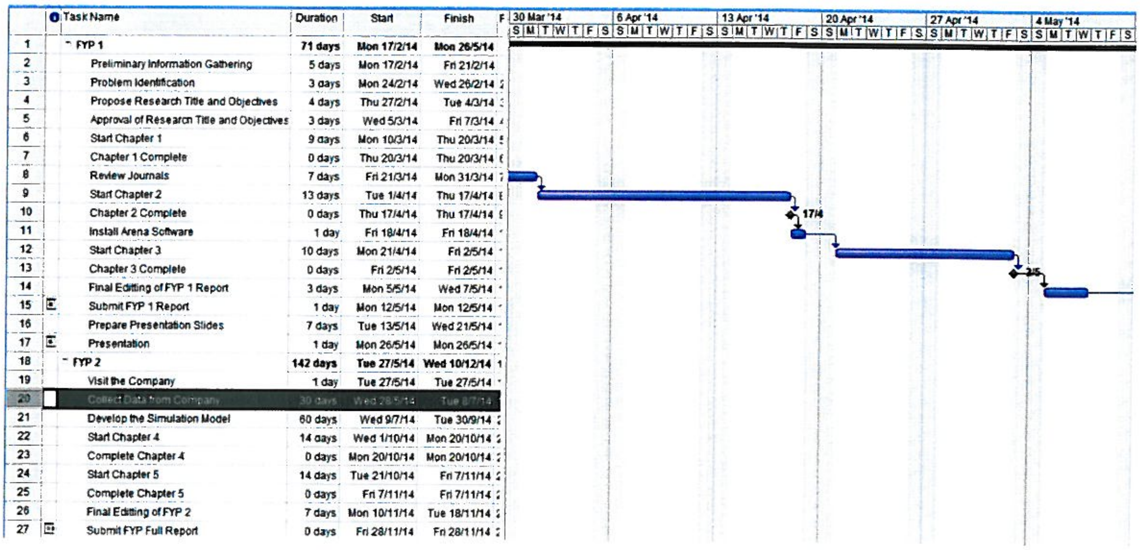

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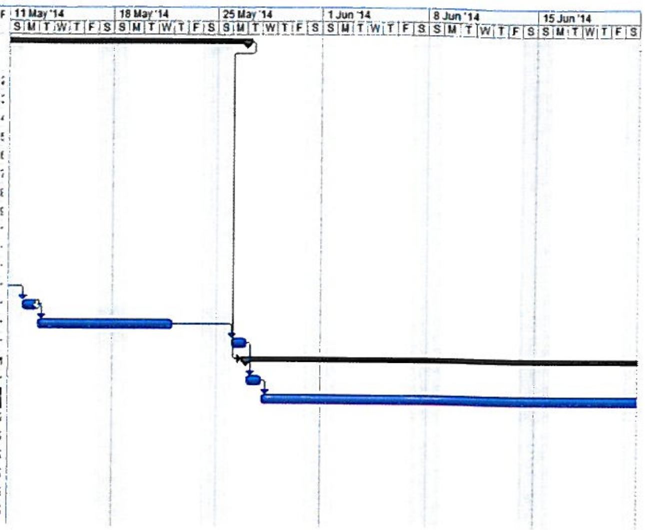

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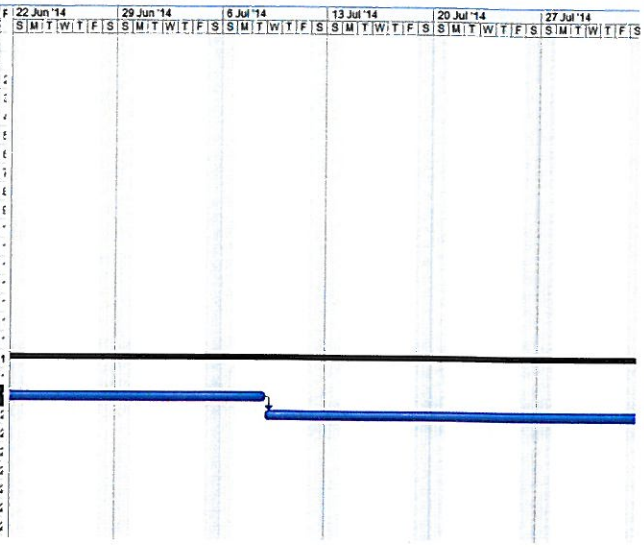

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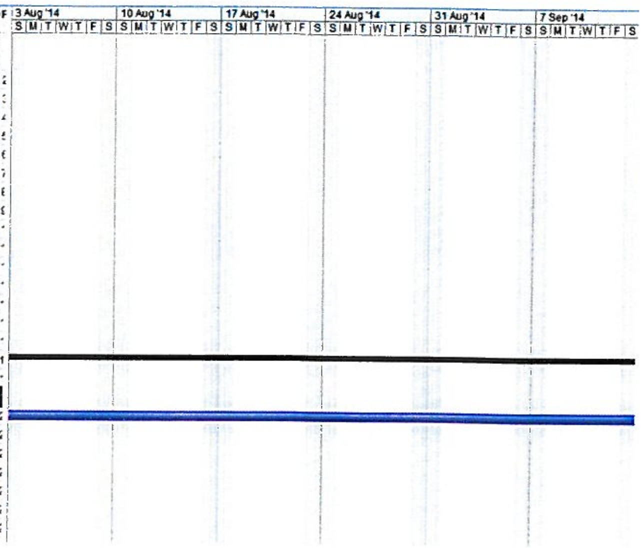

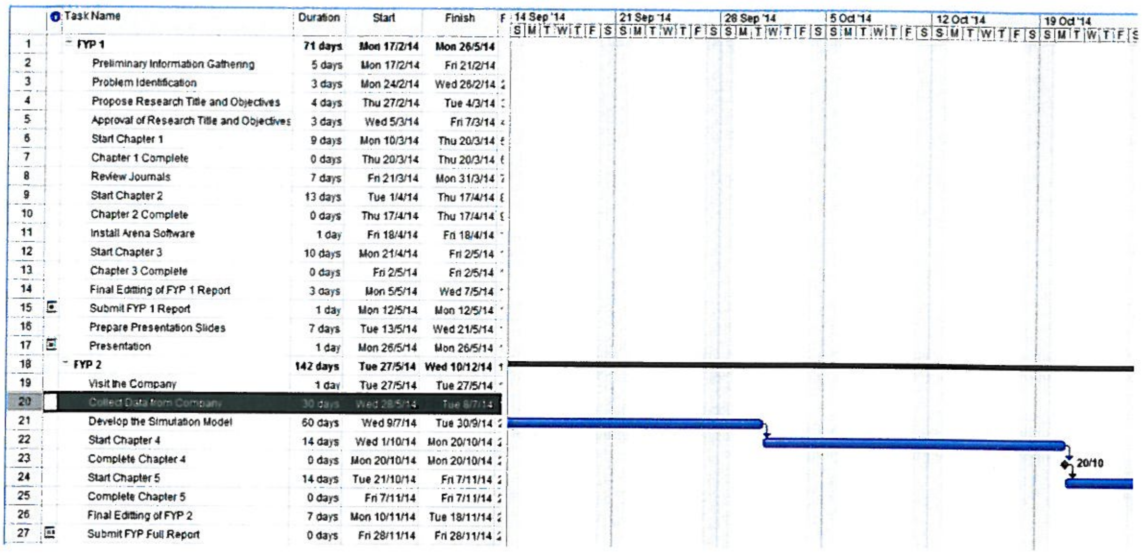

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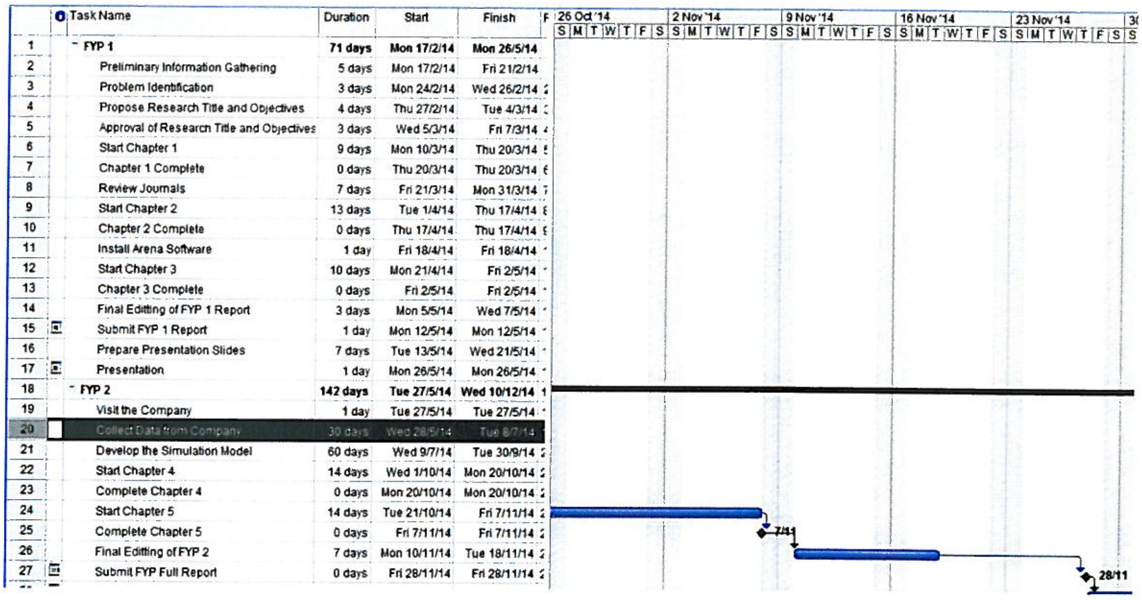

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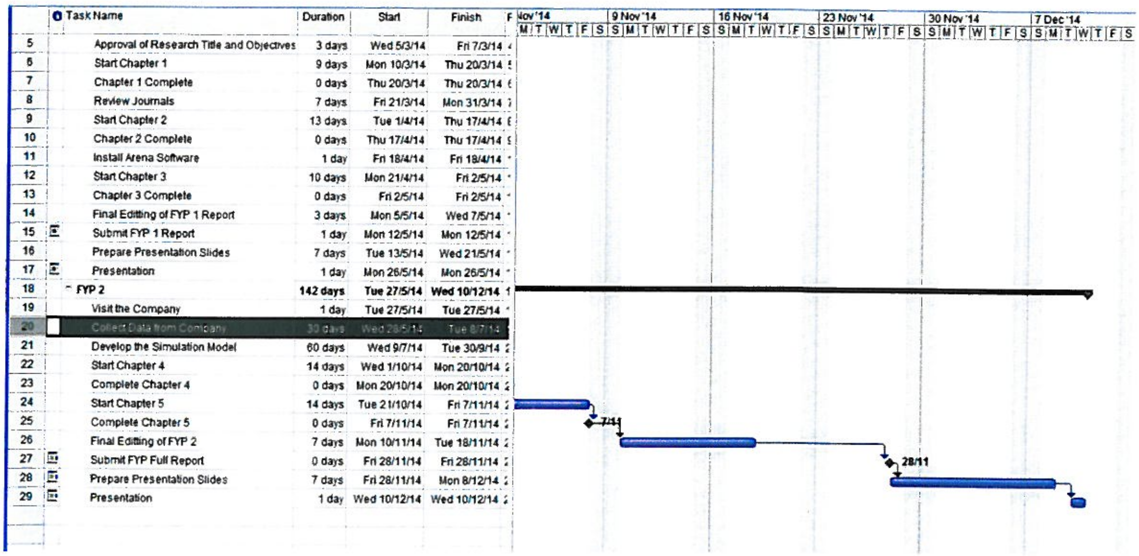

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