PRODUCTIVITY IMPROVEMENT VIA SIMULATION IN MANUFACTURING INDUSTRY

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I certify that the project entitled "*Productivity Improvement via Simulation in Manufacturing Industry*" is written by *Syed Muhammad Adib bin Syed Mohd Zaki*. I have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering. I herewith recommend that it be accepted in partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

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STUDENT'S 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 concurrently submitted for award of other degree.

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DEDICATION

To my family and friends

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Firstly, I would like to thank Allah S.W.T because give me a chance and time to complete my thesis. Besides that, I would like to thank to my family especially to my beloved mother and father because always encourage me to completed this thesis and my study.

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ABSTRACT

Productivity improvement effort such as better layout arrangement, minimize the total production cost or maximize the throughput had been given great attentions in today manufacturing industries. However, to execute such improvements involve a big amount of money which normally be the cause that obstruct the improvements. Simulation has become one of the solutions to this problem and rapidly gaining the industry confident nowadays. This study aims to make improvement in terms of the company's production layout which focusing to the sandwich bread production line. The study is conducted at Roti Temerloh Enterprise, a company which produces products such as sandwich breads, buns and cakes. Being considered as one of the Small and Medium Enterprises (SMEs), cost certainly be the big issues when improvement planning to be considered. Using WITNESS simulation software, the production of the sandwich bread will be modeled and some adjustment then reviewed through the simulation to come up with the improved alternatives layouts. Comparison analysis is carried out and the results show in increased of production up to 265 breads per day for alternative 1 and 581 breads per day for alternative 2 and 3. Machine utilization in term of idle time, busy time and blocked for; Alternative 1 86.69%, 13.49% and 0.49%, Alternative 2 66.49%, 26.82% and 6.69%, Alternative 3 69.64%, 25.04% and 5.32%. From the cost effectiveness analysis, the cost is RM2.06 per unit for Alternative 1 and RM1.49 per unit for Alternatives 2 and 3. Thus the suggested alternative is Alternative 3.

ABSTRAK

Peningkatan produktiviti seperti pengubahsuaian susun atur premis, pengurangan kos atau memaksimumkan pengeluaran telah diberi perhatian yang penting dalam industri pembuatan masa kini. Akan tetapi, keperluan kewangan yang tinggi sering manjadi penghalang bagi melakukan perubahan tersebut. Disebabkan itu, penggunaan simulasi semakin diterima secara meluas bagi menyelesaikan masalah tersebut. Tujuan kajian ini adalah untuk membuat penambahbaikan dalam barisan pengeluaran roti sandwich di Syarikat Roti Temerloh yang menghasilkan produk-produk seperti roti sandwich, bun dan kek. Bagi pengusaha kecil dan sederhana, faktor kos sememangnya diambil berat dalam melaksanakan sebarang perubahan. Proses pengeluaran roti sandwich sedia ada akan dimodel menggunakan perisian simulasi WITNESS, dan tiga alternatif baru dicadangkan. Analisis perbandingan menunjukkan jumlah pengeluaran sebanyak 261 unit sehari bagi Alternatif 1 dan 581 unit sehari bagi Alternatif 2 dan 3. Peratus penggunaan mesin dari segi waktu senyap, waktu sibuk dan sekatan dalam proses bagi; Alternatif 1 adalah 86.69%, 13.49% dan 0.49%, Alternatif 2 66.49%, 26.82% dan 6.69%, Alternatif 3 69.64%, 25.04% dan 5.32%. Kos penghasilan produk bagi Alternatif 1 ialah RM 2.06 seunit manakala bagi Alternatif 2 dan 3 kosnya adalah RM 1.49. Maka Alternatif 3 dipilih sebagai alternatif terbaik untuk dicadangkan.

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LIST OF ABBREVIATIONS

AGV	Automated Guided Vehicle
DES	Discrete Event Simulation
DoD	Department of Defend
HVAC	Heating, Ventilation, and Air Conditioning
IIE	Institute of Industrial Engineers
M&S	Modeling and Simulation
MEE	Manufacturing Enterprise Engineering
MRS	Manufacturing Related Services
MTM	Method Time Measurement
OR	Operations Research
PCB	Printed Circuit Board
R&D	Research and Development
SEE	Service Enterprise Engineering
SME	Small and Medium Enterprise

CHAPTER 1

INTRODUCTION

1.0. INTRODUCTION

Manufacturing industry play an important role in providing all the things needed in human daily life. Many types of products through various processes are involved to create product from raw materials. All parties involved in this industry struggling to come out with a new and improved ways to fulfill the market need. However, money is always be the main obstacle in making necessary improvement as better improvement might require advance tools to identify the improvement needed and much more to implement the new improved methods. In such cases, simulation is one of the preferred ways to meet the desire in making essential improvement with minimum funds.

There are a few examples of researches which had been conducted using simulation as a method to conduct and evaluate their study. Brown and Sturrock (2009) used simulation to model multiple process improvement opportunities for a HVAC manufacturer in order to reduce facility's operating cost. The study results in cost reduction by minimizing inventory, eliminating over-time labor and increase throughput.

Dengiz (2009) was able to obtain 46.63 percent of the total cost reduction of the printed circuit board (PCB) production system for the alternative system with optimal working conditions obtained from the optimization of simulation. Another example is the productivity improvement in drill collar manufacturing process by

Vasudevan et. al. (2009) which recommended an improvement of productivity by 47% which contribute to the approximated annual revenue increase of **$**1,800,000.

The simulation capabilities to produce alternatives solution to the current problem by using given data which suites the problem makes it preferable tool as no other cost involved compared to research conduct on site. Comparing few layouts suggested, reducing idle time, redesign assembly line are much simpler to be conducted through the use of simulation. Riddick and Lee (2008) stated that here are many potential simulation applications that might make use of layout information, such as simulations looking at ergonomic issues, material handling issues, or comparisons of the effects of different layouts on production operations. Simulation can provide an effective means to evaluate many different alternatives involving layout issues, without incurring the cost and effort of physically modifying existing facilities.

1.1. PROBLEM STATEMENT

Small and Medium Enterprises (SMEs) has an important role in supporting growth of Malaysian economic development. In the 2012 budget announced by the Prime Minister, it contributes almost 31 percent of KDNK, 56 percent of work force and 19 percent of the total export. Many incentives and programs being run by the government to generate the improvement of SMEs. For example in the 2012 budget, the government announcing the SME Revitalization Fund which worth RM100 million which offers loans to the entrepreneur with maximum amount of RM1 million to re-established their business which affected by the economic crisis and the cost increment.

Despite all the incentives offers by the government, some of the SMEs participants are facing challenges which can bring their business down. According to Saleh and Ndubisi (2006), among the challenges are the low level of technological capabilities and limited skilled human capital resources, a low level of technology and ICT penetration, low levels of research and development (R&D), a substantial orientation towards domestic markets, a high level of international competition (for example, from China and India), a high level of bureaucracy in government agencies, and internal sourcing of funds.

Focusing to the technologies capabilities problem, many SMEs participant are still bind to their old ways in manufacturing their product. The usage of traditional methods and facilities has made their business failed to compete with the others big company with advanced method. Narrowing the problem down to their production floor layout it seemed that their design of layout sometimes just being prepared according their own desires without any details consideration of the production productivity involved throughout the process.

This research aim is to make use of the simulation methods provided nowadays in making productivity improvement in manufacturing fields. With the use of WITNESS simulation software, the improvement was made by focusing to the current layout used and come out with several other alternatives. Cost production also considered in choosing the best alternative.

1.2. OBJECTIVES

The objectives of this project are:

1.2.1. To identify and evaluate the problems in existing production floor layout.

1.2.2. To design and improve manufacturing production layout by using simulation software and observation during the collection data of cycle time.

1.2.3. To propose the best layout improvement with the lowest cost involved.

1.3. SCOPE OF THE STUDY

The scopes of the study are:

1. This study took place at Roti Temerloh Company.
2. Concerned in the production layout design.
3. One production line involved; which is the sandwich bread production line.
4. Data analyze and run using WITNESS Simulation software.
5. This study only recommends the best alternative layout design with lowest production cost without further implementation towards the existing design.

1.4. IMPORTANCE OF THE STUDY

Due to lack of knowledge of the production layout many SMEs just applied trial and error process in determining their company's layout. As the result, there are several problems such as bottleneck and overlapping occurred. This kind of problems can affect their production process and exposed them to great losses in business. From this project, it will at least help the SMEs participant to get better layout arrangement with the help of simulation tools used which hopefully will also increase their productivity.

1.5. EXPECTED OUTCOMES

From this study, it is hope that it will result in some good improvements based on the proposed alternative layout compared to the existing one and can benefits the SMEs industries in term of improving their productivity.

1.6. REPORT ARRANGEMENT

This study is divided into five chapters. In the first chapter, the introduction of the study is discussed. This chapter provides the problem statement of the study and the objectives of the study are stated. Some information about the scopes of study is reviewed. The importance of the study then stressed the used and importance of simulation in suggesting better production layout towards company productivity. Lastly, the expected outcomes of the study also stated in this chapter.

Chapter two provides an academic review of simulation study in manufacturing industry. This chapter starts defining key terms which are productivity and simulation and small and medium enterprises in general. Under the simulation general definition, the simulation method is mentioned, which briefly described the steps taken in building a good simulation. Further, some areas where simulation is applied are stated. The advantages and disadvantages of simulation method are revealed. Lastly, reviews of previous study that have been conducted in manufacturing industry discussed briefly.

Chapter three provides a discussion of methodology taken to execute this project from the start until the end of. This chapter begins with design of project study, where the methodology used in conducting this project is discussed. Then, discussion of data collection and simulation study is discussed in general. Some of the information regarding standard procedure, process flow, time study and cycle time are included in this chapter.

Chapter four consists of the results from the simulation process done. The results then presented in the table provided which includes the production output and the machine utilizations for each alternatives suggested. From that the cost analysis is done for each alternative and the cost per unit for each alternative is obtained. A discussion on the selection of which alternatives is the best to suggested also included in this chapter.

Chapter five is the last chapter in this report which concludes all the results obtained from the study which must be achieved based from the objective of the study. Some recommendations also given as an improvement for the study to be perform in future.

CHAPTER 2

LITERATURE REVIEW

2.0. INTRODUCTION

This chapter elaborates all the relevant keywords in this title project. The keywords were given its definitions from various perspectives and some other importance parameters such as its importance, advantages and disadvantages, tools and methods, and any other elements that are considered appropriate to be suite together. Besides explaining those keywords, some of the past researches and journals which related to this project were included and presented briefly afterwards.

2.1. PRODUCTIVITY

According to Rogers (1998), productivity is defined as the ratio of output to input for a specific production situation. It is can either refers to the cost production, labor or working time during the process of production. The more effective in planning the process can help contribute to increase the productivity in various elements.

Productivity as defined by Forbes and Ahmad (2011) is the measure of how well resources are brought together in organizations and utilized for accomplishing a set of goals. Productivity reaches the highest level of performance with the least expenditure resources. Productivity is measured as the ratio of outputs to inputs.

Berman (2008) views productivity from its standard usage which refers to the level of output-amount of services delivered, given a certain level of inputs. If an agency increases outputs without requiring more inputs or if it maintains the same level of outputs after reducing inputs, then that agency has increased in productivity.

Based from these definitions, if a productivity improvement is to be applied a company or agency needs to find the ways to maximize their number of productions with same of minimal resources, fully utilized their working time and workers. An example in describing the importance of productivity improvement is as stated by Clements (2000). With 70-90% of the cost running an organizations consisting of the salaries of the workforce, small increase in worker productivity can reap high financial return. From this example, not only the organization cost can be reduced, the profit gained in becoming future can also be increased significantly.

2.2. SIMULATION

Simulation has been used in studying all disciplines. General review on how simulation works is stated by Banks (2009). To engage modeling and simulation, students must first create a model approximating an event and then followed by simulation, which allows for the repeated observation of the model. After one or many simulations of the model, a third step takes place and that is analysis. Analysis aids in the ability to draw conclusions, verify and validate the research, and make recommendations based on various iterations or simulations of the model.

Simulation is defined as “the process of designing a model of a real system and conducting experiments with this model for the purpose either of understanding the behavior of the system or of evaluating various strategies (within the limits imposed by a criterion or set of criteria) for the operation of the system (Shannon, 1975).

Based on White and Ingalls (2009), simulation involves creating a model which imitates the behaviors of interest; experimenting with the model to generate observations of these behaviors; and attempting to understand, summarize, and/or generalize these behaviors. In many applications, simulation also involves testing and comparing alternative designs and validating, explaining, and supporting simulation outcomes and study recommendations.

Another definition of simulation by Banks (2009) refers simulation as an applied methodology that can describe the behavior of that system using either a mathematical model or a symbolic model. Simply, simulation is the imitation of the operation of a real-world process or system over a period of time. Definitions of simulation range from:

a) A method for implementing a model over time.
b) A technique for testing, analysis, or training in which real-world systems are used, or where real-world and conceptual systems are reproduced by a model
c) An unobtrusive scientific method of inquiry involving experiments with a model rather than with the portion of reality that the model represents
d) A methodology for extracting information from a model by observing the behavior of the model as it is executed
e) A nontechnical term meaning not real, imitation (the correct word here is the adjective simulated)

2.2.1. Simulation Method

Law (2006) in his paper discussing the way to develop a valid and credible simulation models, includes a seven-step approach for conducting a successful simulation study. This steps are important things to be reviewed as one common argument regarding simulation is does the simulation can actually simulate the real problems and validated. Validation is the process of determining whether a simulation model is an accurate representation of the system, for the particular objectives of the study (Law, 2006). All these seven step approach pointed by Law are listed as followed:

Step1. Formulate the Problem

Problem of interest is stated by the decision maker. It may not be stated precisely or in quantitative terms. An iterative process is often necessary. A kickoff meeting(s) for the simulation project is (are) conducted, with the project manager, the simulation analysts, and subject-matter experts (SMEs) in attendance. The following things are discussed at this meeting:

a) The overall objectives for the study
b) The specific questions to be answered by the study (without such specificity it is impossible to determine the appropriate level of model detail).
c) The performance measures that will be used to evaluate the efficacy of different system configurations.
d) The scope of the model
e) The system configurations to be modeled
f) The time frame for the study and the required resources (people, computers, etc.).

Step2. Collect Information/Data and Construct Assumptions Document

Step two consists of collect information on the system layout and operating procedures. Data collected to specify model parameters and probability distributions (e.g., for the time to failure and the time to repair of a machine). Document the model assumptions, algorithms, and data summaries in a written assumptions document (sometimes called a conceptual model). The level of model detail should depend on the following:

a) Project objectives.
b) Performance measures of interest.

c) Data availability.

d) Credibility concerns.

e) Computer constraints.

f) Opinions of SMEs.

g) Time and money constraints.

There should not be a one-to-one correspondence between the model and the system. Then, collect performance (output) data from the existing system (if any), to be use for model validation in Step 5.

Step3. Is the Assumptions Document Valid?

Perform a structured walk-through of the assumptions document before an audience that includes the project manager, analysts, and SMEs. Within the DoD community, this is sometimes called conceptual-model validation. If errors or omissions are discovered in the assumptions document, which is almost always the case, then the assumptions document must be updated before proceeding to programming in Step 4.

Step4. Program the Model

Program the assumptions document in a commercial simulation-software package or in a general purpose programming language (e.g., C, C++, and Java). Verify (debug) the computer program.

Step5. Is the Programmed Model Valid?

If there is an existing system, then compare simulation model output data for this system with the comparable output data collected from the actual system (see Step 2). This is called results validation. Regardless of whether there is an existing system, the simulation analysts and SMEs should review the simulation results for reasonableness. If the results are consistent with how they perceive the system should operate, then the simulation model is said to have face validity. Sensitivity analyses should be performed on the programmed model to see which model factors have the greatest impact on the performance measures and, thus, have to be modeled carefully.

Step6. Design, Conduct, and Analyze Experiments

For each system configuration of interest, decide on tactical issues such as run length, warm up period, and the number of independent model replications. Analyze the results and decide if additional experiments are required.

Step7. Document and Present the Simulation Results

The documentation for the model (and the associated simulation study) should include the assumptions document (critical for future reuse of the model), a detailed description of the computer program, and the results of the current study. The final presentation for the simulation study should include an animation and a discussion of the model building/validation process to promote model credibility.

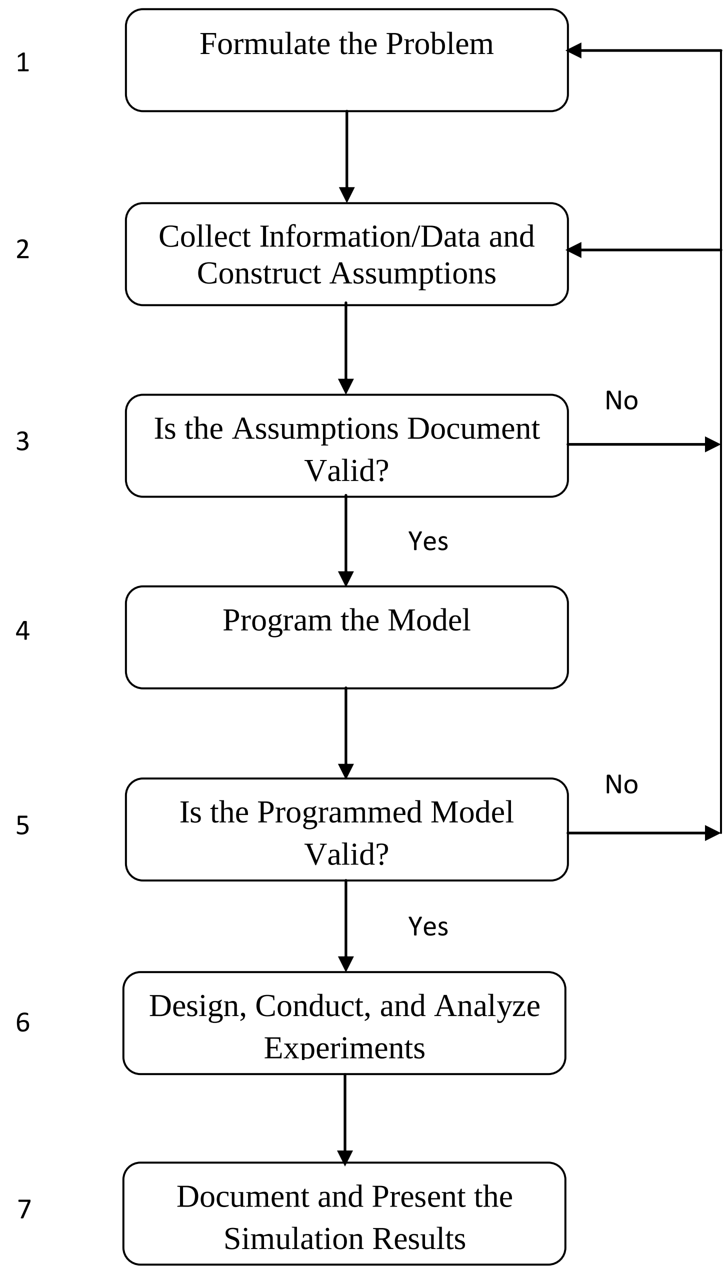

Figure 2.1: A Seven-Step Approach for Conducting a Successful Simulation Study (Law, 2006)

2.2.2. Areas of Application

The area of application for simulation is not restricted to certain field only. The fact that it can be used at any time without interfering with the current and real system makes it applicable in many fields. These are some of the areas where simulations are applied which has been sorted from Banks (2009):

a) Military usage - M&S applications are used primarily for analysis, experimentation, and training. Analysis refers to the investigation of the model's behavior. Experimentation occurs when the behavior of the model changes under conditions that exceed the design boundaries of the model. Training is the development of knowledge, skills, and abilities obtained as one operates the system represented by the model.

b) Transportations - Traffic engineers employ simulation to test these adjustments for just this reason. It is far better to see the results in a simulation and watch traffic back up there than it is to have hundreds of frustrated motorists wasting valuable time traveling at a speed far below their expectation.

c) Business - It can be defined as a system of business endeavors within a particular business environment created to provide products and services to customers. Here are some of the core research areas:

i. M & S in Manufacturing Enterprise Engineering (M & S - MEE) addresses research on design, planning, and control of operations in manufacturing enterprises. Contributions extend the range of analytical and computational techniques addressed to these systems, and novel models offering policy knowledge of applicable solutions in manufacturing environments.

ii. M & S in Operations Research (M & S - OR) addresses research on progress in the structures and properties of models and procedures derived from studying operations. The focus of the cluster is on researching, creating, and/or improving analytical and computational techniques while emphasizing the relevance of the work in significant applications.

iii. M & S in Service Enterprise Engineering (M & S - SEE) addresses research on design, planning, and control of operations and processes in commercial and institutional service enterprises. As in M&S-MEE, contributions extend the range of analytical and computational methods addressed to these systems and novel models offering policy knowledge of applicable solutions. Research areas include: supply chain management, health care operations, retailing, and hospitality.

d) Medical - assist many fields within the medical profession including training, treatment, and disease modeling which targeted some of core areas such as Improved Training of Medical Professionals and Improve Treatment.

2.2.3. Advantages and disadvantages

According to Banks (2009), there are advantages and disadvantages in using modeling and simulation (M&S) listed by the Institute of Industrial Engineers (IIE) in 1998. Some of the advantages to using modeling and simulation are as follows:

a) The ability to choose correctly by testing every aspect of a proposed change without committing additional resources.
b) Compress and expand time to allow the user to speed up or slow-down behavior or phenomena to facilitate in-depth research.
c) Understand why by reconstructing the scenario and examining the scenario closely by controlling the system.

d) Explore possibilities in the context of policies, operating procedures, methods without disrupting the actual or real system.

e) Diagnose problems by understanding the interaction among variables that make up complex systems.

f) Identify constraints by reviewing delays on process, information, materials to ascertain whether or not the constraint is the effect or cause.

g) Develop understanding by observing how a system operates rather than predictions about how it will operate.

h) Visualize the plan with the use of animation to observe the system or organization actually operating.

i) Build consensus inferences for an objective opinion because M&S can avoid.

j) Prepare for change by answering the "what if" in the design or modification of the system.

k) Invest wisely because a simulated study costs much less than the cost of changing or modifying a system.

l) Better training can be done less expensively and with less disruption than on-the-job training.

m) Specify requirements for a system design that can be modified to reach the desired goal.

Besides having such numerous advantages, the IIE also made note of some of the disadvantages to using M&S such as:

a) The special training needed for building models

b) The difficulty in interpreting results when the observation may be the result of system inter-relationships or randomness.

c) Cost in money and time due to the fact that simulation modeling and analysis can be time consuming and expensive

d) Inappropriate use of modeling and simulation when an analytical solution is best.

2.3. SMALL MEDIUM ENTERPRISES (SMEs)

As approved for Adoption by National SME Development Council on 9 June 2005 and issued by the Secretariat to National SME Development Council, Bank Negara Malaysia in 13 September 2005, the SMEs in the manufacturing (including agro-based) and manufacturing related services (MRS) are classified into these definitions.

General definition refers to a small and medium enterprise in manufacturing (including agro-based) and MRS is an enterprise with full-time employees not exceeding 150 or with annual sales turnover not exceeding RM25 million. While the specific definitions are as followed:

a) A micro enterprise in manufacturing (including agro-based) and MRS is an enterprise with full-time employees of less than 5 or with annual sales turnover of less than RM250,000;

b) A small enterprise in manufacturing (including agro-based) and MRS is an enterprise with full-time employees of between 5 and 50 or with annual sales turnover of between RM250,000 and less than RM10 million; and

c) A medium enterprise in manufacturing (including agro-based) and MRS is an enterprise with full-time employees of between 51 and 150 or with annual sales turnover of between RM10 million and RM25 million.

Saleh and Ndubisi (2006), small and medium enterprises in the Malaysian manufacturing sector are involved in activities such as processing and production of raw materials, for instance, food, beverages, textiles, petroleum, wood, rubber and the assembling and manufacturing of electrical and electronics appliances and components, among others.

2.4. PREVIOUS RESEARCH

Longo et. al. (2006) in a journal “Effective Design of an Assembly Line Using Modeling & Simulation” researching the effective design of an assembly line for heaters production. Since the actual assembly line still did not exist, the simulation is used to carry out ergonomic analysis in each workstation. The design of an assembly line and its workstations is characterized by two critical factors, the line balancing and the ergonomic optimization of each single workstation. Line balancing is studied by using the work measurement. MTM-1 (the acronym MTM stands for *Methods-Time Measurement*) is used as it is the most widely used system for evaluating times standard for manual operations. The design of the layout is carried on using CAD software and then simulated by the eM-Workplace. The simulation model recreates and the ergonomic analyses have revealed different problems on lifting and transportation operations and on working postures. Problems related to Lift analysis have been fixed providing the operator with a forklift and avoiding to use manual operated dollies. The high stress level, due to legs bending, of the third workstation has been deleted modifying the conveyor height and adding a step for the workers of the last workstation.

Silva et. al. (2000) in a journal titled “Using Simulation for Manufacturing Process Reengineering. A Practical Case Study” conducts a study in a medium size manufacturer of chest freezers, which required an in-depth analysis of its manufacturing operations in an attempt to increase its throughput and overall productivity. The actual manufacturing system was developed using the Arena simulation software to allow for a better understanding of the actual system, ascertain the critical resources of the system, gain the confidence of the decision makers regarding the used methodology and validate the assumptions made to build the simulation model. A few modifications such as procure a new machine to partially replace the existing machine and some manual operation, to automate suitable process, to subcontract a new part to replace the external case bottom and lining that did not required any processing and some addition to the work force are proposed. The result was increase in through put, a shift in the bottleneck operations, a significant decrease in the work-in-process and the assembly line in the post-drying department was able to absorb the throughput increase, with minor adjustments.

Ingemansson, A. et. al. (2004) in a journal titled “Reducing bottle-necks in a manufacturing system with automatic data collection and discrete-event simulation” were searching suitable methodology for working with bottle-neck reduction by using a combination of automatic data collection and discrete-event simulation (DES) for a manufacturing system. The bottle-neck was identified by studying the simulation runs based on the collected automatic data from the different machines in the manufacturing system. The simulation software used to perform the simulation was QUEST simulation. An improvement of the availability is shown in one machine from 58.5 to 60.2 percent. This single alteration with a minimum of investment resulted in a 3 percent increase of the overall output in the manufacturing system consisting of 11 numerically controlled machines and six other stations. One year after the first study a new simulation was performed in order to see how the improvement work has progressed with the suggested method which resulted in an increase of 6 percent in overall output.

Brown and Sturrock (2009) in a journal titled “Identifying Cost Reduction and Performance Improvement Opportunities through Simulation” addressed how Deloitte Consulting partnered with Simio LLC to model multiple process improvement opportunities for a HVAC manufacturer in order to reduce the facility’s operating costs. The simulation was build using Simio simulation package. Through the use of simulation, the team was able to determine the impact of reducing the cost burden for the HVAC Company by minimizing WIP inventory, eliminating over-time labor and increasing throughput. Four separate improvement opportunities which are Operations Baseline, Schedule Integration, Kitting Availability and Part Presentation were modeled independently and conjointly to provide insight into the size of the savings opportunities as well as to enable the prioritization of those efforts. From the study, a training policy to the workers also develop by Deloitte team which allow workers to help other assembly areas in the event that they do not have a unit to be assembling that can eventually helps capture lost productivity and will further reduce the throughput time for units.

Vasudevan, K.K. et. al. (2008) in a journal titled “Iterative Use of Simulation and Scheduling Methodologies to Improve Productivity” presents the integrated use of process simulation, production scheduling, and detailed analysis of material-handling methods and their improvement. The tools for simulation modeling in this study are AutoMod® and Excel®. Machine availabilities, processing rates, part dimensions, fixed sequences, buffer size details, etc. were read into the model from Excel®. The system bottleneck was identified to be the post magnetic test buffer due to its inability to accumulate enough bars to feed the polish station. It was suggested that these two operations be de-coupled by adding buffer capacity on the floor. This allows the efficient utilization of the polish station (when it is available). A 25% increase in throughput was observed in the simulation model as a result of the decoupling efforts. Lastly, recommendations were made to improve productivity by 47% resulting in an annual revenue increase of approximately$1,800,000.

Harrell and Gladwin (2007) in a journal titled “Productivity Improvement in Appliance Manufacturing” describe an application in which simulation was used to identify the bottleneck of a dishwasher tub manufacturing line. To simulate the process for this study, engineers used simulation software known as Pro-Model. The model was run under several assumptions and found to be a valid representation of the actual system producing essentially the same throughput as the actual system. Engineers familiar with the process further watched the animation to confirm that the model accurately reflected what was actually going on in the tub line. The average tub WIP increased from 36 units to just over 48 units which is about a 34% increase. This project was completed in two weeks using Pro-Model software and services. By eliminating the additional partial shift, the company realized an annual savings of $275,000. The return on investment (ROI) in the first year alone from this project was 1,100% and the payback period was less than 2 months.

Cavalli, R. et. al (2011) in a journal titled "Evaluation Of The Manufacturing Of Desk And Stringer Boards For Wood Pallets Production By Discrete Event Simulation" made an analysis was carried out on a representative sawmill in north-eastern Italy. The selected manufacturing line was consist of a band-saw, a cut-saw and a multi circular saw machine connected by rollers and belts conveyors provided with buffers. To investigate any possible influence, a discrete event simulation model was built and the simulation was built using WITNESS simulation software. Once the model was validated, three different analyses were defined in order to: (1) estimate the current system productivity (2) evaluate the opportunity for selection of the input material and investigate bottlenecks (3) perform a sensitivity analysis of the improved layout. By adopting a different cutsaw machine, the productivity of the manufacturing line could increase up to + 56% in the daily production of deck and stringer boards showing an increased daily productive time of + 13%. The effects of this change are evident especially for log diameters lower than 65 cm.

Hasgül and Büyüksünetçi (2005) in a journal titled "Simulation Modeling and Analysis of a New Mixed Model Production Lines" describe a recently completed project involving the development of simulation models for a mixed model production line in a refrigerator company where bottleneck is to be determined. To achieve the overall goals of the project, the following steps were performed which are to developed an Arena simulation model to analyze the vacuum station and identify the AGV bottlenecks, conducted experiments with the model in order to understand and evaluate the system performance and identified the system bottlenecks and suggested solutions to eliminate bottlenecks and to increase the production line capacity. The production line was modelled using Arena to identify bottlenecks and evaluate vacuum station and an AGV performance, cycle times, and production data. By changing the AGV's cell selection rule, cycle time of the system is reduced. The results showed that the vacuum station is capable of serving the new mixed model production line system, by modifying the logic of the AGV's cell selection rule. The vacuum station has enough capacity for the different product mix. The analysis also demonstrated that the suggested AGV's cell selection rule more efficient than actual cell selection rule.

Harrell, R. et.al (2010) in a journal titled “Increasing Throughput in an Automated Packaging Line with Irreducible Complexity” study the most cost-effective way of increasing the theoretical throughput capacity of their Pesmel® automated packaging system at Avery Dennison by 20%.The simulation of the Pesmel system was created using the Pro-Model® simulation software. After the base simulation is verified, it then modified according several options of improvement. By comparing the theoretical throughput resulting from the modifications, an accurate ranking of the concepts was achieved. Four out of six options were indentified to be a reasonable option to be taken. Each of these four combinations achieves the required 20% increase in throughput, ranging from a gain of 22% to 32% over the current system. Using simulation allowed each concept and combination to be tested quantitatively, not only permitting concepts to be ranked in relation to one another, but also giving management enough data to use in cost-benefit analyses. After reviewing the simulation result the management is now ready to make a decision based on the throughput and cost information provided.

Tjahjono and Fernández (2008) in a journal titled “Practical Approach to Experimentation in a Simulation Study” were going to make an improvement to the engine production line. The approach was deployed in the form of a methodology that was used to select the most feasible outcome from a series of simulation experiments, taking into account the minimum effort/investment needed to implement the improvement. The tool used in this simulation study is a proprietary Excel spreadsheet that acts as input/output interface to Witness Manufacturing Performance edition. The methodology consists of bottleneck detection, bottleneck reduction/elimination and finally efficiency improvement. After that, the experiment with the highest increased in efficiency was compared to the potential investment/effort to achieve to result. The study has provided a deeper understanding of the possible causes for poor performance of the assembly line, and the findings have helped the manufacturing engineers at the company identify the most feasible sets of parameters in order to improve efficiency and productivity.

Table2.1: Summary of previous research.

Author(s)	**Objective**	**Product(s)**	**Methodology**	**Findings.**
Longo, Mirabelli, Papoff (2006)	Effective design of assembly line workstations by means of integration between ergonomic analyses and Modeling & Simulation.	Heaters	Simulation (eM-Workplace), Design (CAD software) Study line balancing (Methods-Time Measurement, MTM1)	The simulation model recreates and the ergonomic analyses have revealed different problems on lifting and transportation operations and on working postures. Problems related to Lift analysis have been fixed providing the operator with a forklift and avoiding to use manual operated dollies. The high stress level, due to legs bending, of the third workstation has been deleted modifying the conveyor height and adding a step for the workers of the last workstation
Silva, Ramos, Vilarinho (2000)	Attempt to increase its throughput and overall productivity.	Chest freezers	Simulation (ARENA)	The outcome of the simulation study showed: • an increase in the throughput (from 231, 231, 231, 231 to 602, 300, 301, 301 units per day of the HC240, HC320, HC370, and HC460 versions, respectively); • a shift in the bottleneck operations from the machining ones to the manual assembly ones • a significant decrease in the work-in-process • the assembly line in the post-drying department was able to absorb the throughput increase, with minor adjustments

Table2.1: Summary of previous research. (*continued*)

Author(s)	**Objective**	**Product(s)**	**Methodology**	**Findings.**
Ingemansson, A. et. al. (2004)	The study of methodology for working with bottle-neck reduction by using a combination of automatic data collection and discrete-event simulation (DES) for a manufacturing system.	Engine blocks	Simulation (QUEST)	Improvement of the availability in one machine from 58.5 to 60.2 percent. Single alteration with minimum investment result 3% increase of overall output.
J. Ethan Brown, David Sturrock (2009)	To model multiple process improvement opportunities for a HVAC manufacturer in order to reduce the facility's operating costs.	HVAC system	Simulation (Simio)	Four separate improvement opportunities were modeled independently and conjointly to provide insight into the size of the savings opportunities as well as to enable the prioritization of those efforts. The four opportunities are Operations Baseline, Schedule Integration, Kitting Availability and Part Presentation
Vasudevan, K.K. et. al. (2008)	This case study presents the integrated use of process simulation, production scheduling, and detailed analysis of material-handling methods and their improvement.	Drill collar	Simulation model (AutoMod® & Excel®) Scheduling model (Asprova®)	Recommendations were made to improve productivity by 47% resulting in an annual revenue increase of approximately $1,800,000.

Table2.1: Summary of previous research. (*continued*)

Author(s)	**Objective**	**Product(s)**	**Methodology**	**Findings.**
Harrell, Gladwin (2007)	This paper describes an application in which simulation was used to identify the bottleneck of a dishwasher tub manufacturing line.	Dishwasher tub	Simulation (ProModel)	By eliminating the additional partial shift, the company realized an annual savings of $275,000. The return on investment, (ROI) in the first year alone from this project was 1,100% and the payback period was less than 2 months.
Cavalli, R. et. al. (2011)	A discrete event simulation model was built in order to investigate the possible influence of the variability of log diameter and of the productive layout on the actual production level.	Deck and stringer boards	Simulation (WITNESS)	By adopting a different cutsaw machine, the productivity of the manufacturing line could increase up to + 56% in the daily production of deck and stringer boards showing an increased daily productive time of + 13%. The effects of this change are evident especially for log diameters lower than 65 cm.
Hasgül, Büyüksünetçi (2005)	Describes a recently completed project involving the development of simulation models for a mixed model production line in a refrigerator company. Decision maker wants to determine the bottlenecks before changing the traditional line to a mixed model production line.	Refrigerator	Simulation (Arena) (Excel User Interface Module)	The production line was modelled using Arena to identify bottlenecks and evaluate vacuum station and an AGV performance, cycle times, and production data. By changing the AGV’s cell selection rule, cycle time of the system is reduced. The results showed that the vacuum station is capable of serving the new mixed model production line system, by modifying the logic of the AGV’s cell selection rule.

Table2.1: Summary of previous research. (*continued*)

Author(s)	**Objective**	**Product(s)**	**Methodology**	**Findings.**
Harrell, Winsor, Teichert (2010)	Avery Dennison was faced with the challenge of finding the most cost-effective way of increasing the theoretical throughput capacity of their Pesmel® automated packaging system by 20%.	Pressure-sensitive labeling material	Simulation (Pro-Model®)	Four options were identified and proposed to Avery. Each of these four combinations achieves the required 20% increase in throughput, ranging from a gain of 22% to 32% over the current system. Using simulation allowed each concept and combination to be tested quantitatively, not only permitting concepts to be ranked in relation to one another, but also giving management enough data to use in cost-benefit analyses.
Tjahjono, Fernández (2008)	To increase the productivity and efficiency of the engine assembly line.	Engine	Simulation (Excel spreadsheet & Witness)	The study has provided a deeper understanding of the possible causes for poor performance of the assembly line, and the findings have helped the manufacturing engineers at the company identify the most feasible sets of parameters in order to improve efficiency and productivity.

CHAPTER 3

METHODOLOGY

3.0. INTRODUCTION.

This chapter will explain the overall flow in conducting the study from it's initial stage such as comforming the project title towards the end of analyzing and data presentation as the result for the study. Design of study will gives the information on how the study is done throughout the two years semester period. Framework of the study then explain the process of identifying the tools for simulation, data gathering, analysis the results.

3.1. DESIGN OF THE STUDY

The first step is confirming the titile of the study. There are many titles that being suggested from the lecturers consisting all sort of mechanical engineering related studies, however this is not compulsary as it can be modified if necessary. After the title had being comfirmed, the next step is to set a weekly appointment with the supervisor incharged.

Based from the basic ideas of the study, starts the step of searching the journals or reference books the might be related to the study from various resources such as the internet and library. Any journals which discussed and related to the manufacturing fields and simulation methods are searched and taken in order to get the knowledge about these two important keyword for the study and understannding the general views how the previous research which involves simulation modelling in solving the problems in manufacturing industries were conducted. Out of all the journals found, ten are specifically studied in order to know the methods and tools other researches used or preferred and what kind of result they obtained. The journals also shown the procedure used by the previous researcher. Reference books in the other hand helps to define and explain the concept and thoery regarding the manufacturing industries, productivity improvement and simulations methods. All of the informations gathered are then reviewed.

Then this study proceed with the methodology of the study. The design of studies explains generally about steps taken in order to run the study from the beginning while the framework of the study foccused on the simulation activities procedure, methods and tools. Brief review on the company the process and the software used will be given. At the same time, the efforts in finding a company in the small and medium enterprises (SMEs) to do the project are initiated. A few companies are found and listed, and after discussing this matter with the supervisor, one of the companies is chosen to be the place where this project will be conducted. Verification letter as well as request letter to conduct the project then sent to the company. The company is Roti Temerloh Enterprise.

During the visit, the manager gives a brief explanation about the company background, products that they produced, number of workers they had and working time. After the briefing, a visit to the production line accompanied with the company supervisor was carried on to get the whole picture of how sandwich bread and other products produced. During the visit, some of the problems are observed and stated. Since the company produce several products, it is obvious that some overlapping is occurred during the process due to the layout arrangement. This is a common problem in SMEs participant as they do not have advanced knowledge about the layout arrangement. The layout arrangement used in the SMEs companies is either based on try and error basis or with some guidance from the local authorities. To focus in the entire company layout to be improved, would requires a lot of data and more complex simulation had to be build. Thus, one production line that produced the sandwich bread is taken to consideration for data collection.

Next, the case study progress are proceed with the data collection. A second visit was planned to collect necessary information to construct simulation model such as company layout, products process flow, standard operation procedure, standard time documents and daily production data. Then, the project proceeds with data analysis. Twenty readings of process cycle time data were collected for each process and then their sample size sufficiency will be determined. All the data needed are stated in the constructed tables.

After it is confirmed that all the data obtained are sufficient, this project proceeds with simulation and modeling stage. In this stage, the simulation of the actual production line is modeled using WITNESS simulation software. All the elements involved to build the simulation are created according to the production plan layout. The data collected such as the cycle time, machine setup time and machine downtime data are input in the software. Then, the simulation model is demonstrated by running the animation in order to make sure that it runs according to the desired functions. Corrective actions will be done if there are any problems while running the simulation until satisfied. The next step is to validate the simulation built. Usually this is done by comparing the results generated by the simulation with the actual production process. A range 1%-5% difference between the simulation and the actual production is acceptable (Salaam, 2006). This means that if the simulation generates for example 779units of output and the actual existing output is 805 units, with a different about 3.23%, the simulation is validated.

The warming up period is the time for the simulation to run before the data from simulation is recorded. The simulation result somehow not consistent at the beginning the through time it will come out with more constant result. Thus, it is important to know needed time for warm-up period in order o get better result. According to Wong (2008), after running the simulation for 1000 minutes, the steady state starts at 565 minutes. Chramcov et. al. (2011) using 86400 seconds which is equals to 24 hours for warm up period. Thus, warming up period of 1000 minutes is enough to make sure the result is constant. To test it, warming up period for 1000 minutes and 10000 minutes are used before running it for 8 hours and it yield the same results of 253 sandwich breads per day for the actual layout.

After the simulation is validated, some modifications that are considered to be able to make improvement to the existing simulation layout are then applied. Although the focus is just on one production line, but the modifications must be compatible with the other production processes. To come out with the best option to be proposed afterwards, some methods might be suitable which is the analysis of cost of effectiveness can be done in order to measure the layout suggested is effective or not compared to the cost for actual modification of the layout.

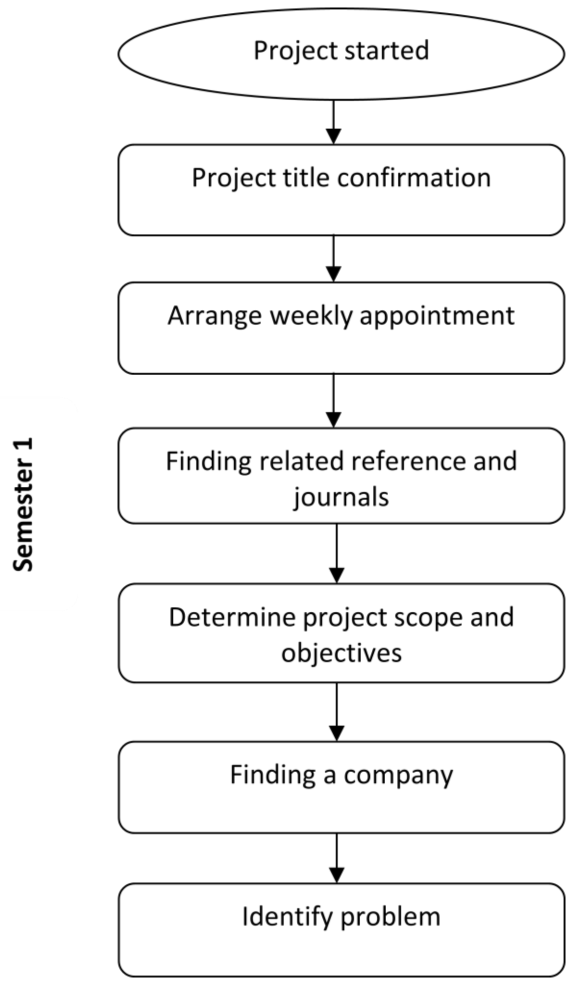

Figure 3.1: Flow Chart for Semester 1 Final Year Project Progress.

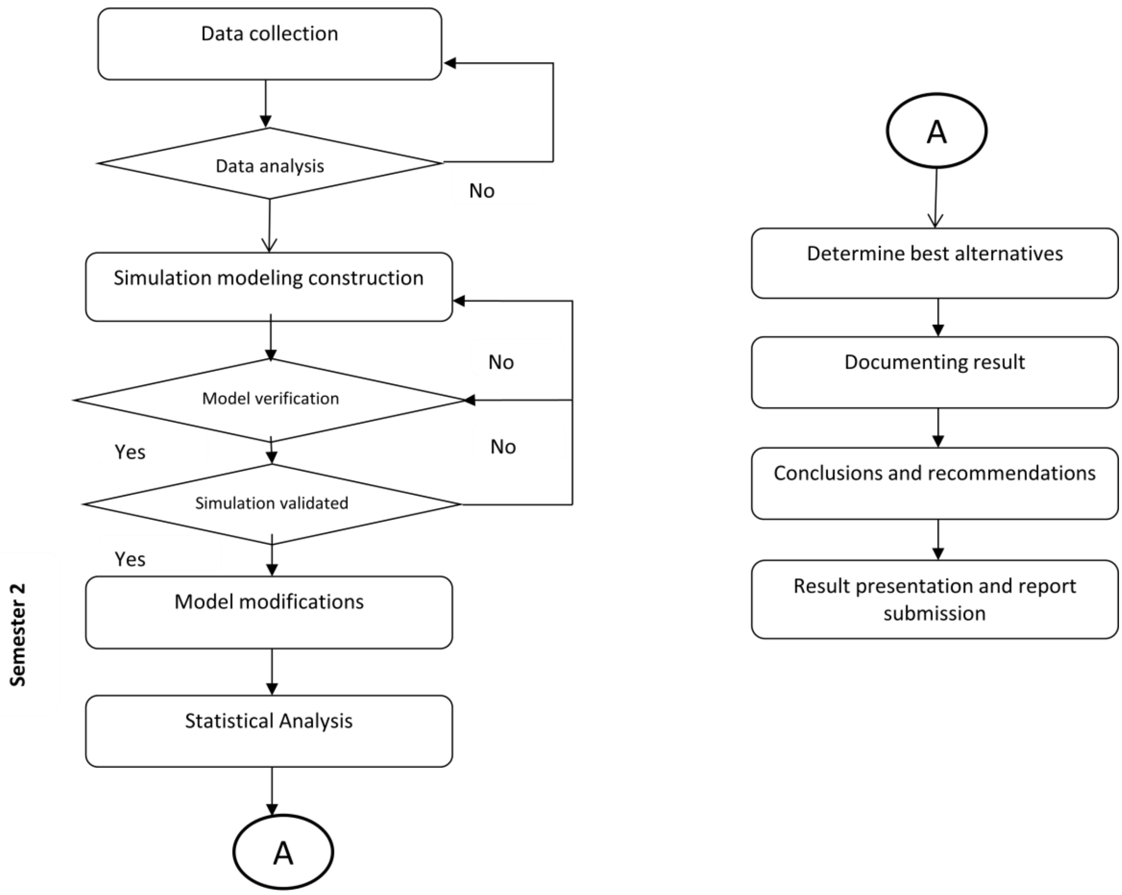

Figure 3.2: Flow Chart for Semester 2 Final Year Project Progress.

3.2. SIMULATION SOFTWARE

The model of the production floor layout was built by using the simulation program WITNESS software. WITNESS software gives the power and flexibility to model very complex operations and procedures. Whatever your modeling requirements, the principles behind the process are simple to understand and implement.

3.3. SIMULATION MODEL

In the first phase, a detail process layout was developed from which entities, location, resources, path network for resources and process were identified. In the next step which included incorporation of logic for entity flows through location including processing time.

Several assumption were made while developing this study model since a tradeoff has to be made between complexity and realism. The assumption are:

a) No lack of raw material occurs.
b) Operator do not leave the production floor while the processing progress.
c) No machine breakdown during this period. (sufficient data was not available to accurately model the breakdown times).

3.4. CONCEPTUAL MODEL

This study is done at Roti Temerloh which is located in Temerloh, Pahang Darul Makmur. Roti Temerloh is among the company which consider under the definition of SMEs. The major product for this company is Sandwich Bread and buns which produced based on the orders make through tenders.

This company has one main production line which used to produced all of their products. The starting phase of their productions of most products relatively the same and then differs at certain point of process as some products might need certain process and machines to be made. The sandwich bread production line for this company consist of processes such as mixing, kneading, weighting, shaping, fermenting, baking and lastly slicing and packaging. By stating this processes help generate conceptual model which is useful for the next stage in simulation.

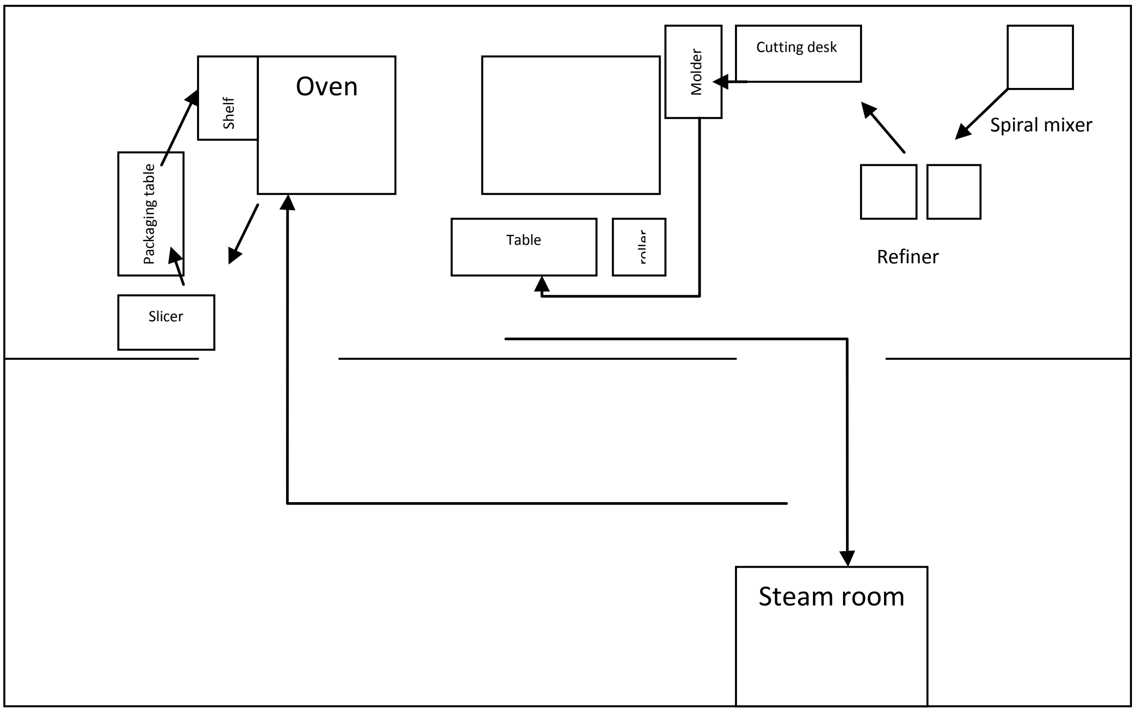

Figure 3.3: Sandwich Bread Production Layout.

3.5. SETTING UP DATA COLLECTION

Before starting with the raw data collection, studying the process flow can give better and details description on what is happening to the product and the processes it going through.

Process flow is a document that shows various processes that a product undergo in order to produce part or a product while standard operation procedure guides the operators to do every task in the process and handling important machines and tools.

3.5.1. Process Flow Chart

A process flow chart refers to a chart that consists of all the activities involved in producing a product. It shows more detail such as where each of the process have been perform, the transportations, delays and as well as operation, inspections and storages and quite similar to the operation process chart.

There is a lot of example in developing process flow charts. The example of the flow charts for the sandwich bread production is shown in the next page.

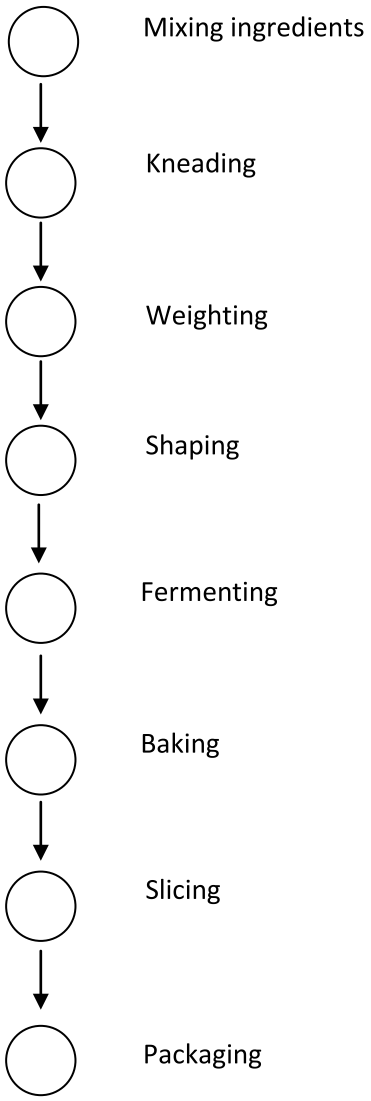

Figure 3.4: Process flow chart to make Sandwich Bread.

3.5.2. Standard Operation Procedure / Work Instruction

Standard operation procedure can be defined as a document that shows rules and methods to produce a product that meets its qualifications, safe and efficient way to work. In a standard operation procedures, there are information on how to locate the sub-part in the machine, setting machine information, information of method to use a machine and prevention method if the part or product not accurate. However, only big and well-established companies had their own standard operation procedure. In this case, Roti Temerloh does not really have their detailed standard procedures. Thus, developing the procedures also another concern before built a simulation. By observing the operators work and discussing with them, the standard operation procedure for making sandwich bread is prepared as follows:

3.5.2.1.Mixing.

i. All the ingredients is inserted in the spiral mixer as followed:
   a. Flour 2 ½ sacks (1sack =25kg)
   b. Sugar 2 ½ kg
   c. Salt 1.25 kg
   d. Improver 250 g
   e. Calcium 400 g
   f. Softening/vegetable fats 2 ½ kg

ii. Switch on the spiral mixer.

iii. 2 packets of dry yeast are inserted into the mixer, each weighted 500g.

iv. Then, water is poured into the mixer.

v. The entire ingredients are stirred until smooth.

vi. After the process is finished, switch off the machine.

vii. The dough then transferred to the refiner.

Figure 3.5: Spiral Mixer

Figure 3.6: Refiner

3.5.2.2.Kneading/Refining.

i. Switch on the refiner.
ii. There are two units of refiner used.
iii. The dough from the spiral mixer is divided and transferred into the refiner.
iv. Knead the dough until smooth and springy for about 3 minutes.
v. Make sure the dough inserted into the refiner is not too big for proper kneading process.
vi. After that, switch off the refiner.
vii. Kneaded dough then transferred to the next station to be weight and cut.
viii. The same process is repeated until all the dough from the spiral mixer are all kneaded.

3.5.2.3.Weighting.

i. Before the process started, the operator must make sure that the weighting and cutting desk is clean.
ii. Grease the desk surface so that the dough will not stick to it.
iii. Kneaded dough will be cut into smaller dough, weighted 700g each.
iv. Weighted and cut dough will be shape into rounded dough.
v. All the dough is then placed on the desk.
vi. Compressed air from the compressor used to spray the grease onto the dough upper surfaces and left it rest until it rise.
vii. After that, the dough is put into the long moulder to be shaped.

Figure 3.7: Weighting & Cutting Process

Figure 3.8: Long Moulder

3.5.2.4.Shaping.

i. Before the process started, the operator must make sure the all the needed baking tray already arranged nearby the long moulder.
ii. Compressed air from the compressor used to spray the grease into the inner part of the baking trays.
iii. Switch on the long moulder.
iv. The dough then inserted into the long moulder one by one to be shape into desired loaf.
v. The operator than put the shaped dough into the baking tray.
vi. Baking tray which contents the dough then transferred to the next desk.
vii. During this process, one operator will positioned a trolley closed to the desk.
viii. At the next desk, the operator will take the baking tray covers and closed it properly.
ix. All the baking trays will then be stacked onto the trolley.
x. After that, the trolley will be pushed and placed into the steam room.

Figure 3.9: Place dough into baking tray

Figure 3.10: Close the baking tray.

Figure 3.11: Arrange baking tray onto trolley.

Figure 3.12: Steam Room.

3.5.2.5.Fermentation.

i. Before the process started, operator must switch on the bulb in the steam room.
ii. In the steam room the fermentation process took place.
iii. The trolley will be left inside the steam room for about 1 hour to let the dough rise doubled.
iv. After that the trolley transferred to the oven.

3.5.2.6.Baking.

i. At the beginning of shift, turn on the diesel oven.
ii. Make sure the oven is hot.
iii. Open the oven door seal.
iv. The oven consists of 8 rotating platform tray and the oven can support until 175 baking trays.
v. Put the baking tray on the oven rotating tray.
vi. When one of the rotating trays is full, press the switch to rotate the tray.
vii. Repeat the process until all the baking trays are placed in the oven.
viii. Bake the dough at the temperature of 160˚C for about 20 minutes.
ix. After 20 minutes, open the oven door seal.
x. During the process, operator will placed another movable shelf to place the baked bread afterwards.
xi. Take out the baking trays and placed it on the table in front of the oven.
xii. The baking tray cover is removed and the bread is knocked out from the baking tray.
xiii. The empty baking tray is stack back on the trolley while the break is placed in the movable shelf.
xiv. The trolley then push and the baking trays are placed back at the long moulder for next cycle.
xv. The breads are left to cool down for about 1 hour.
xvi. The breads then push to the slicer.

Figure 3.13: Diesel oven.

Figure 3.14: Cooling process.

3.5.2.7.Slicing and packaging.

i. Before slicing the bread, the bread needs to be check first to ensure there is no dirt on the bread.
ii. Switch on the slicer.
iii. Placed the bread into the slicer.
iv. The sliced bread then packaged manually by the operator.
v. The breads which will be sent to the prison are not sliced.
vi. The packaged bread is placed on the shelf.
vii. The driver then takes the bread to be transport according to the orders.

Figure 4.15: Quality check.

Figure 4.16: Slicer.

3.6 DATA COLLECTION TABLE

These tasks were carried out started from 2 December 2011 at Roti Temerloh Enterprise. However, it took almost two months to collect the data for the cycle time as the company does not have their own standard procedure and the process flow chart information.

Familiarization on standard procedure and process flow will help to understand the detailed processed involved on the production line. Data collection table also need to be constructed so that the data can clearly stated. This is crucial for the next stage which is calculating the sample size. The lists of the information that have been included in the table are:

i. Product.
ii. Process.
iii. Job procedures.
iv. 20 set of cycle time data
v. Average of the cycle time data.

In the appendix there is the example of data collection table.

3.7 CYCLE TIME DATA IN SIMULATION

Before start modelling simulation in the WITNESS Simulation Software, the cycle time for each process need to be known. For example, the machines cycle time is the time which the machines operate or perform its process.

Each process in the production of the sandwich bread are divided into few elements which are as follows:

3.7.1 Machine cycle time.

3.7.1.1.Mixing.

The elements considered in this process are:

i. Take and insert the flour.
ii. Take and insert the sugar.
iii. Take and insert the salt.
iv. Take and insert the improver.
v. Take and insert the calcium.
vi. Take and insert the fat.
vii. Switch on – Mixing process.
viii. Send to refiner

2.7.1.2.Kneading.

The elements considered in this process are:

i. Switch on – Kneading process.
ii. Sent to weighting table.

3.7.1.3.Weighting.

The elements considered in this process are:

i. Cut and weight the dough.
ii. Shape the dough in round.
iii. Let the dough to rise.
iv. Sent the dough to long moulder.

3.7.1.4.Shaping.

The elements considered in this process are:

i. Switch on the moulder.
ii. Moulding process.
iii. Put dough into baking tray.
iv. Carry tray to the table.
v. Close the baking tray.
vi. Stack the baking tray onto trolley.
vii. Push trolley to the steam room.

3.7.1.5.Fermenting.

The elements considered in this process are:

i. Leave the trolley in the steam room.
ii. Push trolley to the oven.

3.7.1.6.Baking.

The elements considered in this process are:

i. Open the oven.
ii. Arrange all the baking trays in the oven.
iii. Close the oven.
iv. Baking time.
v. Open the oven.
vi. Take out baking trays and placed bread on shelf.
vii. Close the oven.

3.7.1.8.Cooling and slicing.

The elements considered in this process are:

i. Sent to slicer and let the bread cool down.
ii. Transfer bread from shelf to table.
iii. Quality check of each bread.
iv. Slicing time for each bread.

3.7.1.9.Packaging.

The elements considered in this process are:

i. Packaging.
ii. Place packaged bread into shelf.
iii. Expired date placed on every bread.

The summary of the cycle time data are shown in the Table 3.1.

Table 3.1: Machine / Process cycle time for actual layout.

No.	Process	Machine	Producing Time (s)
1	Mixing	Spiral Mixer	613.36
2	Kneading	Refiner	163.42
3	Weighting	Cutting Table	2306.24
4	Shaping	Long Moulder	7.76
5		Table 1	774.32
6	Fermenting	Steam Room	4199.94
7	Baking	Diesel Oven	3180.69
8	Slicing	Buffer	3630.40
9		Slicer	48.28
10	Packaging	Packaging	17.96
	Total		**14942.37**

Table 3.2: Machine / Process cycle time for alternative 1.

No.	Process	Machine	Total Producing Time (s)
1	Mixing	Spiral Mixer	613.36
2	Kneading	Refiner	163.42
3	Weighting	Cutting Table	892.03
4	Shaping	Long Moulder	7.76
5		Table 1	774.32
6	Fermenting	Steam Room	4199.94
7	Baking	Diesel Oven	3180.69
8	Slicing	Buffer	3630.40
9		Slicer	48.28
10	Packaging	Packaging	17.96
	Grand Total		**13528.16**

Table 3.3: Machine / Process cycle time for alternative 2.

No.	Process	Machine	Producing Time (s)
1	Mixing	Spiral Mixer	613.36
2	Kneading	Refiner	163.42
3	Weighting	Cutting Table	2306.24
4	Shaping	Long Moulder	7.76
5		Table 1	774.32
6	Fermenting	Steam Room	4199.94
7	Baking	Diesel Oven	3180.69
8	Slicing	Buffer	3630.40
9		Slicer	48.28
10	Packaging	Packaging	17.96
	Total		**14942.37**

Table 3.4: Machine / Process cycle time for alternative 3.

No.	Process	Machine	Total Producing Time (s)
1	Mixing	Spiral Mixer	613.36
2	Kneading	Refiner	163.42
3	Weighting	Cutting Table	892.03
4	Shaping	Long Moulder	7.76
5		Table 1	774.32
6	Fermenting	Steam Room	4199.94
7	Baking	Diesel Oven	3180.69
8	Slicing	Buffer	3630.40
9		Slicer	48.28
10	Packaging	Packaging	17.96
	Grand Total		**13528.16**

CHAPTER 4

RESULT AND DISCUSSION

4.0. INTRODUCTION

Through this chapter, the simulation modeling conducted for this study is reviewed and the result from the simulation is then presented. Basically, the simulation modeling involved steps which are building the simulation, verification and validation on the simulation created and applying the desired alternatives to see what will be the outcome. The layout that involved in this case study is the actual layout and the alternatives for the sandwich bread production line.

Following this introduction, brief information regarding the actual layout is discussed. The explanations on the alternatives layout suggested which includes how the ideas for getting these alternatives and it significant towards improving the productivity are given afterwards. Lastly, the results from each alternatives layout in terms of the new production output and the machine or tools utilization are presented.

4.1. MODEL VERIFICATION AND VALIDATION

According to Sargent (2008), model verification is often defined as "ensuring that the computer program of the computerized model and its implementation are correct". It used to determine whether the simulation model correctly reflects the conceptual model or not as stated by Salaam (2006). In order to do that, after all the data and element are set in the simulation the simulation is then ran. If there are no error notifications for instance typing command error or bugs when running the simulation, it is verified.

Sergeant (2008) also defines model validation as substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model. In a simple word, does the simulation really mimicking the desired processes or system in the actual world? Several techniques suggested by Sergeant (2008), one which is used in this study is event validity which means the “events” of occurrences of the simulation model are compared to those of the real system to determine if they are similar. For this case, comparison between the production output from the simulation with the actual production output in the production layout.

The model is run with the same conditions and input as the actual production process to see whether the results are the same. For this case study, the comparison is based on the actual layout and actual cycle time.

4.2. ACTUAL LAYOUT

4.2.1 Sandwich Bread Production

In sandwich breads production, there are eight (8) ingredients that must be mixed together. They are flour, sugar, salt, improver, calcium, softening, yeast and water. The machines and instruments that have been used to assemble this product are:

i. Spiral Mixer Machine
ii. Refiner Machine
iii. Cutting Table
iv. Long Moulder Machine
v. Table
vi. Steam Room
vii. Diesel Oven

viii. Slicer
ix. Packaging table.

Producing the sandwich breads, all the processes are performed at the sandwich bread production line. The processes involved in producing the sandwich breads are:

i. Mixing process (Spiral Mixer)
ii. Kneading (Refiner)
iii. Weighting (Cutting Table)
iv. Shaping (Long Moulder and table)
v. Fermenting (Steam Room)
vi. Baking (Diesel Oven)
vii. Slicing (Slicer)
viii. Packaging (Packaging Table)

In order to mix all the ingredients in making sandwich breads, the first step to do is to take all the ingredients needed which located in a container near the spiral mixture and put it in the Spiral Mixer according to the fixed weight or amount for each ingredient.

After the mixing process, all the mixed ingredients become large dough and transferred to the refiner for the kneading process. This is the process to soften the large dough which usually gross after being mixed. The dough usually divided into four parts as the refiner is not capable to knead the large dough in one run. There are 2 refiner used for this production. It needs four times of kneading process to completely knead all the dough mixture which means each refiner needs to run two times to finish it.

The operator then takes out the dough from refiner and brings it to the cutting table to be weight and cut according to the desired weight of the dough which is 700 grams for single dough. This process is done repeatedly until all the dough is cut. An average of 164 cut dough can be obtained from the starting large dough. The dough that already cut then shaped into round-like shape and arranged on the table to let it rise for some time. The numbers of operator performing this task are two.

Next, the operator positioned himself at the long moulder which is beside the cutting table. He then turns on the long moulder. The dough is inserted into the long moulder one by one. The dough that get out from the machine is then put into the the baking trays which already being stack in front of the long moulder. An operator then carries 4 baking trays at once to the table where the baking trays will be closed by another operator. After closing a few baking trays he will stack the trays onto the trolley. This operation is done by carrying 8 trays at once and repeatedly until all the baking trays is properly closed and placed on the trolley.

Two operators will then push the trolley into the steam room. After setting the proper time at the control panel the dough are left to let it rise. Two operators will push the trolley from the steam room to the diesel oven. At the oven, one operator will open the oven and arranged all the baking trays in the oven. Next, the oven is closed and the dough are left till its' baked properly. The baking trays then take out from the oven and the breads also take out from the baking trays and placed on the shelf.

All the breads are left for some period of time to let it cool. Then, the breads are inspected for any defects such as corrosion at the baking trays that might stick to the bread. If there any of defects, the affected parts will be slightly cut out. The bread then put into the slicer which will cut it thin slices. The bread that already cut then undergoes packaging process. After the process is done the bread will be place on the other shelf and the expired date is stick on the packet. The sandwich breads are ready to be delivered to the customers according to the demand.

The layout and the results are shown in figure and table below.

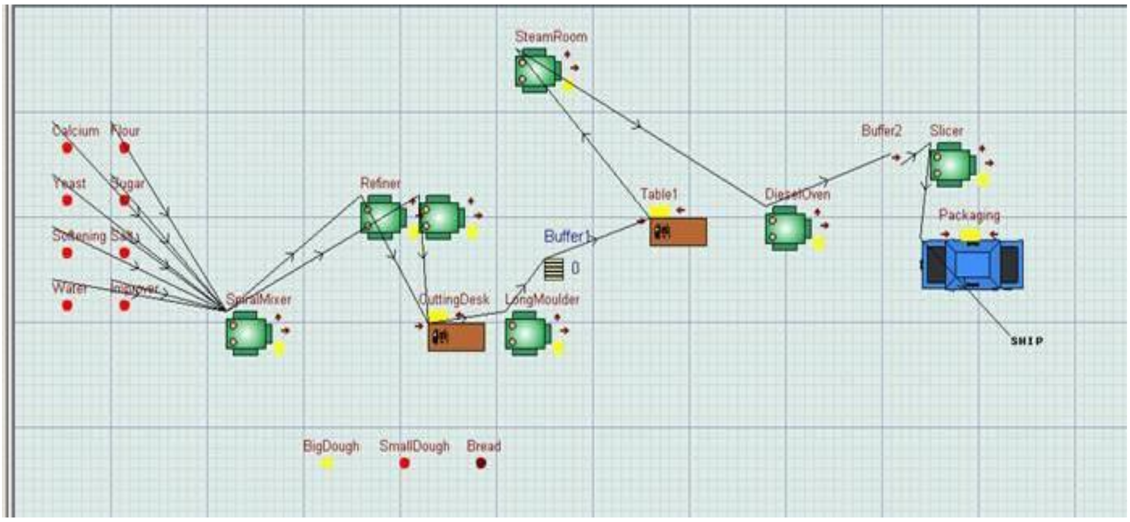

Figure 4.1: Actual Production Layout of Sandwich Breads.

Table 4.1: Actual Production Results of Sandwich Breads.

Machine/Process		**Idle**	**Busy**	**Blocked**	**No. of Operation**
Spiral Mixer		97.30	2.13	0.57	1
Refiner	1	98.87	1.13	0.00	2
	2	98.87	1.13	0.00	2
Cutting Desk		84.44	8.01	7.56	1
Long Moulder		92.39	7.61	0.00	275
Table 1		94.62	5.38	0.00	2
Steam Room		70.83	29.17	0.00	2
Diesel Oven		77.91	22.09	0.00	2
Slicer		57.51	42.49	0.00	254
Packaging		84.22	15.78	0.00	253

Idle time is the time that the machine is not in use. The busy time indicate the time the machine operates and it is said for the process or machine to have blocked when a machine or process has just finished processing a part, but it cannot push it to next machine or buffer because it is busy or full.

Table 4.2: Actual Part Movement at Buffer/Shelf for Sandwich Breads.

Buffer/shelf	Total In	Total Out	Now In
1	283	283	0
2	344	254	90

In order to validate whether the simulation model is correct or not, the method that had been used is by comparing the daily output between the actual output and the simulation model output. The model is considered good if the output difference between the actual and the simulation model is 5 % (Salaam, 2006).

For example for the sandwich breads actual output is 258 units per day. This model is validated if the output from the simulation is in the range of 246 to271 units per day. For this simulation model, the results are 253 units which are between the acceptance range for 5 % error and it is consider as a good simulation model.

4.3. ALTERNATIVES LAYOUT

Alternative layout is the ideas proposed as a solution to the existing problem in the current production layout. The alternatives are then run through the simulation model to see what the effects of each change made. In this study, three alternatives are being proposed and the results from each alternatives then reviewed and discussed in the next chapter.

4.3.1. Ideas

The idea for the alternatives layout generated through discussion with the supervisor, operators and based from observation made during the time the study is conducted there. From the observation on the operation time, it shown that the company needs to operate overtime on Thursday and Friday. This is because the company only operates for five days a week; however they received orders for six days a week.

On Monday, Tuesday, and Wednesday the company just need to prepare the order for the next day only for example on Monday the company will operate to make sandwich breads which will be sent on Tuesday and so on. This is quite different on Thursday and Friday, where they need to work overtime to complete the total order for Friday, Saturday and Monday. That is why it is significant for the company to enhance their production capacity in order to reduce the overtime which occurs every week and by having higher production rate the company will has the ability to bid for other contracts or expand their business according their new capacity.

Another consideration is based on the usage of spiral mixer as their main mixing machine not only to make sandwich breads but also other products they supply. The quantity of the spiral mixer the company has is only one and it already use for a long time. Any breaks down involving the spiral mixer will force the company to stop the production of sandwich breads and several other products. As their business has low profit margin, the company cannot afford any changes that cost them too much capital investment otherwise it is really necessary.

Thus, taking account all these aspects there are two alternatives that can be suggested. The first is to eliminate speed up the process by eliminating unnecessary process. This can be done by terminating the procedure during the weighting process which is to make it into round shape and let it rise for certain time. According to the operators, eliminating this procedure can be done because they already include improvers in the bread mixtures which function to speed up the production process.

Another alternative is to add a new spiral mixer which is hope to increase their production rate and also can avoid the production process to stop if one of the spiral mixers is damage and need repair. From here, there is another possibility which is the combination of the two alternatives mentioned above which might boost up the production output.

4.3.2. Layout

From the discussions and observation stated above, the alternatives layout that had been purposed for this case study is:

i. Eliminate procedures in weighting process to reduce cycle time.
ii. Adding one (1) spiral mixer using actual cycle time.
iii. Adding one (1) spiral mixer using termination of procedures in weighting process.

4.3.2.1. Eliminate Procedures in Weighting Process

For this alternative, the working procedure for overall process are the same except at the cutting desk where the procedure of rounded the dough and let it rise for some time are eliminated. As the effect, the cycle time for weighting process is reduced. The layout used for simulation is still actual layout but with adjusted cycle time

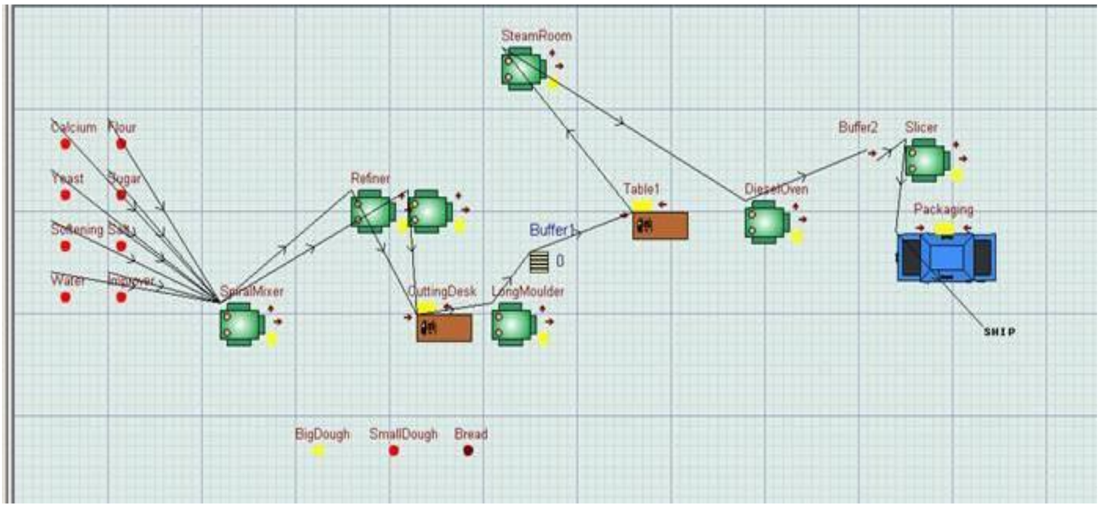

Figure 4.2: Layout of Sandwich Bread Production with Termination of Procedures in Weighting Process.

Table 4.3: Production Results after Elimination of Procedures in Weighting Process.

Machine/Tools		**Idle**	**Busy**	**Blocked**	**No. of Operation**
Spiral Mixer		97.30	2.13	0.57	1
Refiner	1	98.87	1.13	0.00	2
	2	98.87	1.13	0.00	2
Cutting Desk		92.51	3.10	4.39	1
Long Moulder		95.58	4.42	0.00	164
Table 1		96.34	3.66	0.00	2
Steam Room		70.83	29.17	0.00	2
Diesel Oven		77.91	22.09	0.00	2
Slicer		55.35	44.5	0.00	266
Packaging		83.42	16.85	0.00	265

Table 4.4: Part Movement at Buffer/Shelf for Sandwich Breads with Elimination of Procedures in Weighting Process.

Buffer/shelf	**Total In**	**Total Out**	**Now In**
1	164	164	0
2	328	267	61

4.3.2.2. Adding One (1) Spiral Mixer Using Actual Cycle Time

This alternative proposed the addition of new spiral mixer. The actual layout change is just at the number of spiral mixer which is now two instead of one in the actual layout. The cycle time used still based on the actual layout cycle time.

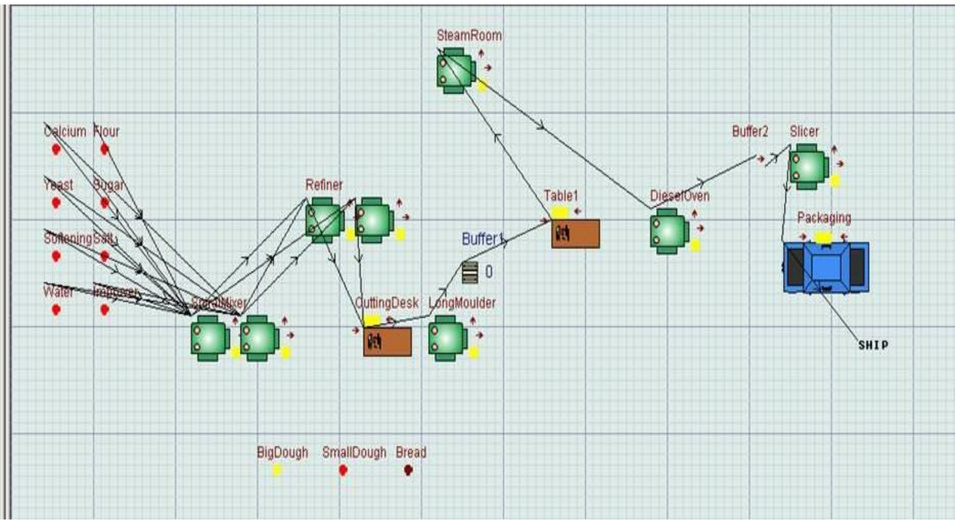

Figure 4.3: Layout of Sandwich Bread Production by Adding One (1) Spiral Mixer Using Actual Cycle Time.

Table 4.5: Production Results after Adding One (1) Spiral Mixer Using Actual Cycle Time.

Machine/Tools		**Idle**	**Busy**	**Blocked**	**No. of Operation**
Spiral Mixer	1	97.30	2.13	0.57	1
	2	81.17	2.13	16.70	1
Refiner	1	82.17	2.84	15.00	5
	2	82.17	2.84	15.00	5
Cutting Desk		59.64	24.02	16.34	3
Long Moulder		83.55	16.45	0.00	611
Table 1		86.01	10.75	3.23	4
Steam Room		41.67	58.33	0.00	4
Diesel Oven		51.46	41.84	6.71	3
Slicer		2.53	97.47	0.00	582
Packaging		63.76	36.24	0.00	581

Table 4.6: Part Movement at Buffer/Shelf for Sandwich Breads after Adding One (1) Spiral Mixer Using Actual Cycle Time.

Buffer/shelf	Total In	Total Out	Now In
1	611	611	0
2	672	582	90

4.3.2.3. Adding One (1) Spiral Mixer Using Elimination of Procedures in Weighting Process

This alternative offers the combination of both the addition of one spiral mixer and also the termination of procedure in weighting process in order to increase the production rate even higher. The result for the production outputs are as follows:

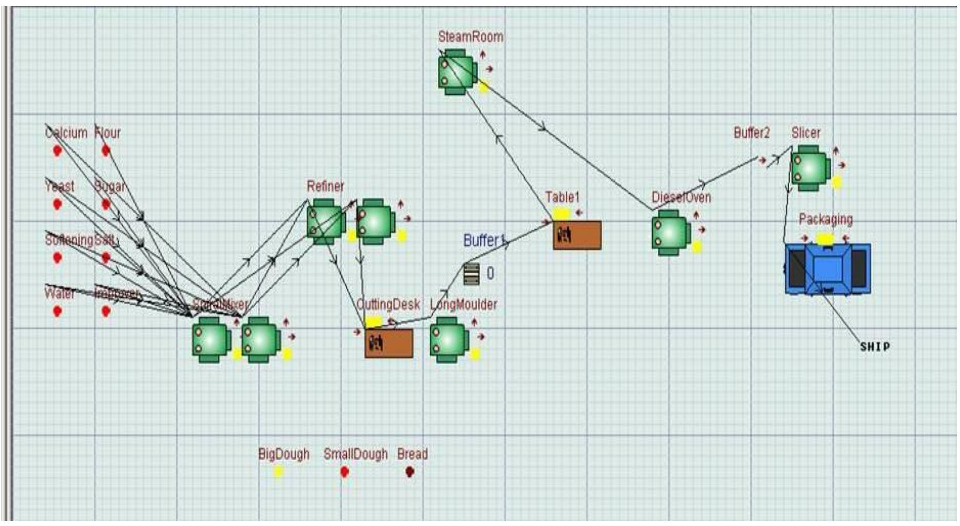

Figure 4.4: Purpose Layout by Adding One (1) Spiral Mixer Using Termination of Procedures in Weighting Process.

Table 4.7: Production Results after Adding One (1) Spiral Mixer Using Termination of Procedures in Weighting Process.

Machine/Tools		Idle	Busy	Blocked	No. of Operation
Spiral Mixer	1	97.30	2.13	0.57	1
	2	89.25	2.13	8.62	1
Refiner	1	90.81	2.27	6.92	4
	2	90.81	2.27	6.92	4
Cutting Desk		78.71	8.11	13.18	3
Long Moulder		86.74	13.26	0.00	492
Table 1		77.91	9.04	13.05	4
Steam Room		41.67	58.33	0.00	4
Diesel Oven		46.55	44.18	9.28	4
Slicer		2.53	97.47	0.00	582
Packaging		63.71	36.29	0.00	581

Table 4.8: Part Movement at Buffer/Shelf For Sandwich Breads after Adding One (1) Spiral Mixer Using Termination of Procedures in Weighting Process.

Buffer/shelf	Total In	Total Out	Now In
1	492	492	0
2	782	582	200

4.4. SIMULATION ANALYSIS

4.4.1. Assumptions

There are a few assumptions that have been made before performing simulation process. They are:

i. The simulation time is eight hour.
ii. Cycle time is in Second.
iii. There is no downtime and setting up machine time.
iv. Parts are available all the time.

For the first assumption, the time for running the simulation is to be decided. The simulation is run for a length of 8 hours based from the total hours they work in a day. The warm up period for the simulation is also decided. Some journals were referred to get the warm-up period. According to Wong (2008), after a run for 1000 minutes, the simulation starts its steady state at 565 minutes or 9.42 hours. Chramcov et. al.,(2011) used warm-up period for 86400sec or 24hours. Thus this simulation model is run two times, which are for 1000 minutes and 10000 minutes. If the result is the same thus the simulation has arrived at its steady stead. For both cases the outputs result from the actual layout both are the same.

Stating the cycle time unit is another important aspect in WITNESS Software. It can be set in seconds, minutes or to be custom. To standardize the unit for the whole operations, the unit that has been use is in second. For the next assumption, during the machining or production time there is no machine downtime and setting up machine time included in the simulation. The parts or ingredients in the simulations are assumed to be available all the time.

4.4.2. Output Target

Based from the problem faced by the company, an increase in the number of output is to be expected to compensate with the higher rate of production needed on Thursday and Friday. The new output is to be set either the same or above the number of production needed for these two days to overcome the overtime taken by the company every week.

4.4.3. Machine Cost

From the information obtained from the company, the cost for 1 unit of spiral mixer is RM 10, 000. The current spiral mixer was bought in cash by the company in 1988 and still in use until now.

4.4.4. Material Cost

In bread making process there are seven ingredients that need to be mixed together which are the flour, sugar, salt, improver, calcium, softening and yeast. The table below showed the quantity and the price of ingredients to produce breads in one cycle. In order to get the cost for 1 unit bread the total cost then divided with 164 units of bread which is the number produced in one cycle.

Table 4.9: Material Cost for 1 Cycle Sandwich Bread.

Materials	Price per kg (RM)	Units (kg)	Cost (RM)
Flour	2.04	62.5	127.50
Sugar	2.40	2.50	6.00
Salt	0.58	1.25	0.73
Improver	9.50	0.25	2.38
Calcium	9.68	0.40	3.87
Softening	4.17	2.50	10.43
Yeast	14.80	1.00	14.80
		TOTAL	165.21

For 1 cycle of production = 164 sandwich breads

Thus, cost for 1 unit of sandwich bread:

= 165.21/164

= RM 1.01/unit

4.5. COST EFFECTIVENESS ANALYSIS

The calculation is made on this basis:

i. Total machine price = RM 10,000
ii. Total machines' price is RM12,800 within 7 years payment (4% interest rate/year)
iii. Total part per day = 253 breads
iv. Working hour = 8 hours, 5 days / week

Table 4.10: Cost Estimation for Actual Production Layout.

Cost Element	**Rate (RM)**	**Units**	**Rate Per Day (RM)**
<u>Primary Cost</u>			
Direct Material	1.01/bread	253/day	255.53
Direct Labour			
1. Operators	16.00/day	7 /day	112.00
Indirect Labour			
1. Clark	16.00/day	1/day	16.00
2. Cleaner	16.00/day	1/day	16.00
<u>Other Cost</u>			
1. Building rental	768.00/month	30days/month	25.60
2. Electricity	761.32/month	22days/month	34.61
3. Water	119.60/month	22days/month	5.44
4. Transportation	1800.00/month	26days/month	69.23
5. Machine Instalment	-	-	-
Total Cost per Day			534.41
Total Cost per Unit			2.11

The calculation is made on this basis:

i. Total machine price = RM 10,000
ii. Total machines' price is RM12,800 within 7 years payment (4% interest rate/year)
iii. Total part per day = 265 breads
iv. Working hour = 8 hours, 5 days / week

Table 4.11: Cost Estimation for Alternative 1 Production Layout.

Cost Element	**Rate (RM)**	**Units**	**Rate Per Day (RM)**
<u>Primary Cost</u>			
Direct Material	1.01/bread	265/day	267.65
Direct Labour			
1. Operators	16.00/day	7 /day	112.00
Indirect Labour			
1. Clark	16.00/day	1/day	16.00
2. Cleaner	16.00/day	1/day	16.00
<u>Other Cost</u>			
1. Building rental	768.00/month	30days/month	25.60
2. Electricity	761.32/month	22days/month	34.61
3. Water	119.60/month	22days/month	5.44
4. Transportation	1800.00/month	26days/month	69.23
5. Machine Instalment	-	-	-
Total Cost per Day			546.53
Total Cost per Unit			2.06

The calculation is made on this basis:

1. Total machine price = RM 10,000
2. Total machines' price is RM12,800 within 7 years payment (4% interest rate/year)
3. Total part per day = 581 breads
4. Working hour = 8 hours, 5 days / week

Table 4.12: Cost Estimation for Alternative 2 Production Layout.

Cost Element	**Rate (RM)**	**Units**	**Rate Per Day (RM)**
<u>Primary Cost</u>			
Direct Material	1.01/bread	581/day	586.81
Direct Labour			
1. Operators	16.00/day	7 /day	112.00
Indirect Labour			
1. Clark	16.00/day	1/day	16.00
2. Cleaner	16.00/day	1/day	16.00
<u>Other Cost</u>			
1. Building rental	768.00/month	30days/month	25.60
2. Electricity	761.32/month	22days/month	34.61
3. Water	119.60/month	22days/month	5.44
4. Transportation	1800.00/month	26days/month	69.23
5. Machine Instalment	152.38/month	30days/month	5.08
Total Cost per Day			870.77
Total Cost per Unit			1.49

The calculation is made on this basis:

i. Total machine price = RM 10,000
ii. Total machines' price is RM12,800 within 7 years payment (4% interest rate/year)
iii. Total part per day = 581 breads
iv. Working hour = 8 hours, 5 days / week

Table 4.13: Cost Estimation for Alternative 3 Production Layout.

Cost Element	Rate (RM)	Units	Rate Per Day (RM)
Primary Cost			
Direct Material	1.01/bread	581/day	586.81
Direct Labour			
1. Operators	16.00/day	7 /day	112.00
Indirect Labour			
1. Clark	16.00/day	1/day	16.00
2. Cleaner	16.00/day	1/day	16.00
Other Cost			
1. Building rental	768.00/month	30days/month	25.60
2. Electricity	761.32/month	22days/month	34.61
3. Water	119.60/month	22days/month	5.44
4. Transportation	1800.00/month	26days/month	69.23
5. Machine Instalment	152.38/month	30days/month	5.08
Total Cost per Day			870.77
Total Cost per Unit			1.49

From the cost effectiveness analysis, the actual production layout manufacturing cost is RM 2.11 for the production of sandwich bread. For the first alternative, the manufacturing cost for the sandwich bread is RM 2.06. The second alternative comes out with the cost production of RM 1.49 while for the third alternative; the manufacturing cost is the same with the second alternative. The manufacturing cost for all alternatives can be summarized in the Table 4.14.

Table 4.14: Summary of the Number of Output per Day and the Cost per Unit.

Alternative	Output / Day (Units) and Cost / Unit (RM)	
	Sandwich Bread	
	Output	Cost
Actual	253	2.11
Option 1	265	2.06
Option 2	581	1.49
Option 3	581	1.49

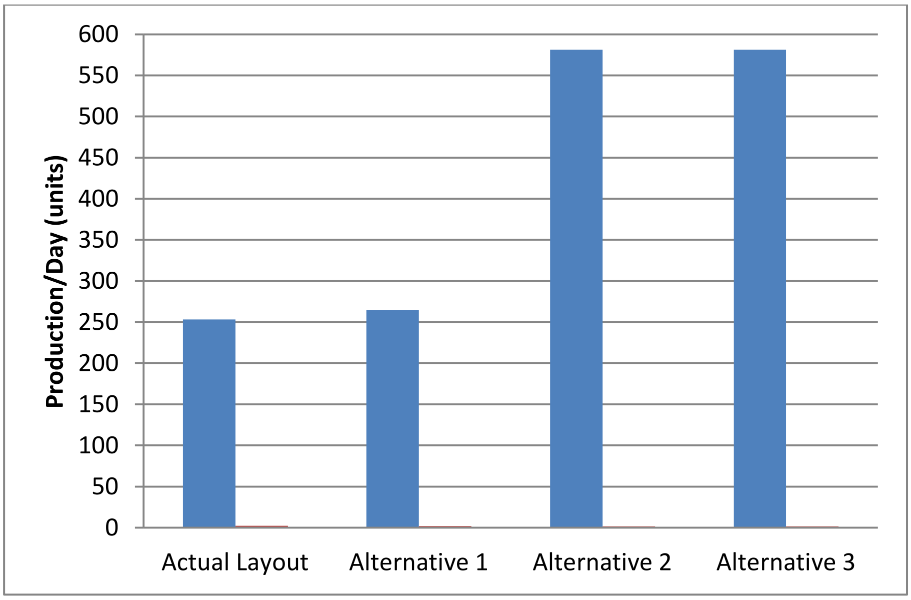

Figure 4.5: Summary of Actual and Alternative Output for Sandwich Bread Production.

From the summary in Table 4.14, the manufacturing cost for alternative 2 and 3 are the lowest which both cost 1.49 per unit. Whilst, the cost per unit of sandwich bread for alternative 1 is RM 2.06 compared to the actual production cost of RM 2.11 per unit. Based from the table, it shown that both alternative 2 and 3 are the best in term of the productions cost.

Table 4.15: Summary of Idle and Busy Time for the Actual and Alternatives Layouts.

Layout	**Machine Utilization (%)**		
	Idle	**Busy**	**Blocked**
Actual	85.70	13.49	0.81
Alternative 1	86.69	13.49	0.49
Alternative 2	66.49	26.82	6.69
Alternative 3	69.64	25.04	5.32

From the Table 4.15, the overall machine utilization for actual layout is 85.70% idle time, 13.49% busy time and 0.81% blocked occur in the process. Meanwhile for alternative 1, the idle time is 86.69%, busy time is 13.49% and 0.49 blocked occurred. Alternative 2 yields a result of 66.49% idle time, 26.82% busy time and 6.69% blocked occurred. Alternative 3 has 69.64% idle time, 25.04% busy time and 5.32% blocked throughout the process.

For the first alternative, termination of cycle time by eliminating the shaping and raising the dough during weighting process result in the increase of production up to 265 units per day. In term of the machine utilization, this alternative does not have very significant change. It helps smoothen the operation by reducing the blocked in the process and adding up idle time with no increase in the busy time.

Alternative 2 and 3 both has significant increase in the busy time and quite a decrease in the idle time. The busy time is 26.82% and 25.04% and the idle time is 66.49% and 69.64% respectively. Usually, the best option to be chosen is the alternative with the higher busy time and lower idle time, however in this case some of the machines are used not only to make sandwich bread but other products as well. With the addition fact that the number of production and the cost are the same for both alternatives, alternative 3 is to be proposed as the best alternative.

By choosing the third alternative, although the idle time is slightly higher it allocate more time for the machines to be used for processing other product. Besides, the blocked in the process for alternative 3 is lower than that occur in alternative 2. Thus, the best alternative to be suggested in this study is the alternative 3.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS.

5.1. CONCLUSION

Improvement effort in layout productivity is very important because it help identify possible changes that can be perform in the current system. These changes can be done from time to time because the cost and conditions in the operating system are changing based on financial, politics and social effects. The results can either in better utilization of machine and labour, reduce in processing time and cost, or modification of current procedures.

From this study, the actual layout of the company is studied. The time study then done to obtained the cycle time for the process involved in sandwich bread production. Based from the observation and the discussion with the supervisor and operators the problems from the existing layout are known. From the identified problems, the alternatives layout then suggested as a countermeasure to the problem. Due to financial restriction the company face, a discussion made to come out with the alternative layouts. The alternatives are run through the simulations to see what the results of each change made.

From the simulation, it showed that improvement in term of increasing number of production, utilization of machines in the process, reduce in production cost in the operation and reduce or eliminate the overtime problem the company faced for some time. Based from the result for all the three alternatives, the cost effectiveness analysis is done to determine the best alternative to be suggested. The analysis shows the best options from the three alternatives is alternative 3. From the result obtained, the objectives for this study are achieved.

5.2. RECOMMENDATIONS

In order to come out with more accurate and real simulation, the time for the study needs longer time. This is because, the data for some of the parameter was not available or not sufficient enough to be put in the simulation. It was suggested that more extensive study which will includes the downtime, setting up machine and the arrival time of the parts to be develop. By doing this, more real simulation can be obtained with more accurate mimic of the operations and production output cam be obtained.

Study on the rejected parts in the process also suggested to be done so that the rejected parts can be includes in the simulation for a better result. With more input data in the simulation allow the software to mimic the operation more accurately. More detailed defining and language program for each machines used in the simulations is another important aspect to be apply for further studies.

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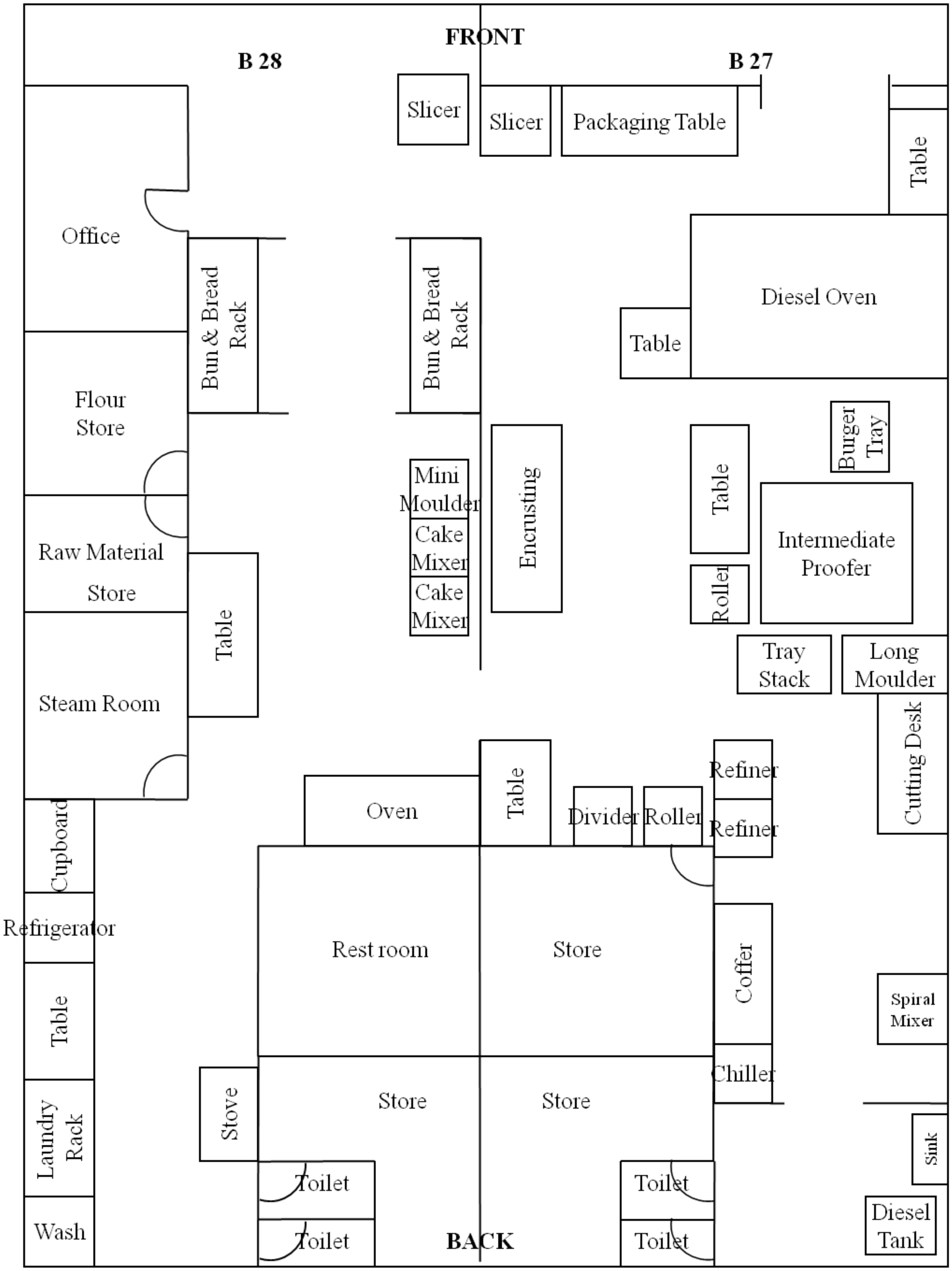
APPENDIX A

COMPANY'S LAYOUT



APPENDIX B

ROTI TEMERLOH SDN. BHD.

DOC NO.	
REV. NO	

Prepared By	Checked By	Approved By

TIME STUDY

Product	Sandwich bread
Part Name	Assemble
Process	Overall
Machine	
Date	

			Reading of Machining Time												Man Power Time					1unit	1cycle
No.	Process		1	2	3	4	5	6	7	8	9	10	**Average**	**Total/cycle**	Loading	Unloading	Walking	Total	Time		**Std. time**
1	Mixing		465.30	444.80	425.60	433.50	474.60	444.30	429.90	341.00	342.00	457.60									
			449.80	451.20	429.60	455.30	439.70	456.30	475.20	436.50	439.80	447.30	**436.97**	**436.97**	138.93		11.01	149.94	176.39		**613.36**
2	Kneading		154.70	149.70	156.60	159.30	162.10	153.80	176.30	145.40	158.20	159.10									
			154.10	126.80	179.00	156.50	162.50	139.30	167.00	157.60	160.30	163.00	**157.07**	**157.07**			5.40	5.40	6.35		**163.42**
3	Weighting		8.60	9.10	7.50	7.60	7.00	6.40	7.70	7.30	7.50	6.80									
			7.30	5.50	6.30	8.40	7.50	6.60	7.20	7.50	7.10	7.60	**7.33**	**600.65**	597.37	604.75	247.64	1449.76	1705.59		**2306.24**
4	Shaping	Long Moulder	4.40	4.40	4.40	4.40	4.40	4.20	4.50	4.70	4.30	4.40								7.76	
			4.30	4.30	4.50	4.90	4.40	4.40	4.40	4.40	4.50	4.50	**4.44**		1.29	0.49	0.30	1.82	2.14		**1272.64**
		Table 1	2.30	2.50	2.50	2.40	2.80	2.50	2.50	2.40	2.70	3.30									
			2.50	2.60	2.60	2.30	3.20	2.20	2.70	2.50	2.30	2.60	**2.57**	**421.48**	169.33	80.98	49.61	299.92	352.84		**774.32**
5	Fermenting		4080.00	4320.00	3900.00	4200.00	3990.00	4110.00	4190.00	4210.00	3950.00	4270.00									
													4122.00	**4122.00**			66.25	66.25	77.94		**4199.94**
6	Baking		1080.00	1080.00	1080.00	1080.00	1080.00	1080.00	1080.00	1080.00	960.00	1080.00									
													1068.00	**1068.00**	744.02	1051.77		1795.79	2112.69		**3180.69**
7	Slicing	Cooling	3650.00	3613.00	3623.00	3643.00	3630.00	3629.00	3618.00	3627.00	3645.00	3626.00									
													3630.40	**3630.40**							**3630.40**
		Slicing	22.9	23.5	23.8	21.9	25	22.4	23.4	23.4	24.5	20.6									
			22.3	23.4	21.6	21.9	19.8	23.5	23.2	19.4	14.3	20.5	**22.07**		18.52		3.77	22.29	26.22	48.28	**7917.92**
8	Packaging		13.20	12.20	14.80	12.70	11.50	12.80	12.10	12.00	13.20	12.20									
			13.60	13.70	12.00	11.50	10.80	13.50	12.40	13.00	16.50	11.10	**12.74**		1.17	3.27		4.44	5.22	17.96	**2945.44**
	Total handling time																				**27004.37**

Remarks:
All time in second (S)

Column man power time, time = after adding 15 % allowance
Calculation formula for Time

$$\text{Time} = \frac{\text{Man Power Time}}{(1-0.15)}$$

APPENDIX C

Week / Activity		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Project Progress																
Get the project title and arrange weekly appointment with supervisor.	Planning															
	Actual															
List of company for project	Planning															
	Actual															
State the objective, scope and background of the study. (Chapter 1)	Planning															
	Actual															
Review related journals and references	Planning															
	Actual															
Select a company	Planning															
	Actual															
Data collection	Planning															
	Actual															
Report Progress																
Introduction (Chapter 1)	Planning															
	Actual															
Literature Review (Chapter 2)	Planning															
	Actual															
Methodology (Chapter 3)	Planning															
	Actual															
Data collection (Chapter 4)	Planning															
	Actual															
Report for PSM1	Planning															
	Actual															
Final year project 1 presentation	Planning															
	Actual															

APPENDIX D

Activity / Week		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Project Progress																
Data analysis	Planning															
	Actual															
Simulation modeling construction	Planning															
	Actual															
Model verification	Planning															
	Actual															
Simulation validated	Planning															
	Actual															
Model modifications	Planning															
	Actual															
Statistical Analysis	Planning															
	Actual															
Determine best alternatives	Planning															
	Actual															
Documenting result	Planning															
	Actual															
Report Progress																
Result & Discussion (Chapter 4)	Planning															
	Actual															
Conclusion (Chapter 5)	Planning															
	Actual															
Compile report for PSM2	Planning															
	Actual															
Final year project 2 presentation	Planning															
	Actual															