

PRODUCTIVITY IMPROVEMENT IN SME INDUSTRY  
THROUGH NEW PLANT LAYOUT DESIGN BY USING  
WITNESS SOFTWARE

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### **SUPERVISOR'S DECLARATION**

I have examined the final copy of this report and in my opinion, it is fully adequate in terms of the language standard, and report formatting requirement for the award of the degree Bachelor of Mechanical Engineering.

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I declared that this dissertation entitled "Productivity Improvement in SME Industry through New Plant Layout Design by Using WITNESS Software" is the result of my own research except as cited in the references. The Dissertation has not been accepted for any degree and is not currently submitted in Candidature of any other degree.

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To my beloved father and mother,

Chua Guan

Lee Yak



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## ABSTRACT

Productivity is a measure of performance in the industry, organization or factory. The project is focused on bread production line in a factory of Mama Bake Industry. The study is about improving production productivity, reducing the waiting time in production, increase the production in one day in order to achieve target in shorter time. Initially, collection data in terms of cycle times of each machine or workstations, the area require by the workstations. During the visit to the factory, observation period is about a day, the tools used to record time and measure distance, area required by each workstation, and area of the factory is done by using Smart Phone Atrix 2 with stopwatch and smart measure which have the function to measure the distance of the object to the user. After data are collected, following by using Witness software, the original plant layout model is created, then 4 other new layout model is created and simulate all of them together with the original layout, then the productivity and the efficiency of the layout is calculated and record in the result. From the study, the main problem found is the space are small, some process stuck due to not enough capacity in buffer provide, where the bottleneck occur, but removing the walls, and balanced the production line more buffer capacity can be provided, thus the process can proceed without delay and waiting. Among all new layouts being proposed and simulated in Witness Software, the one with higher improvement in productivity and plant layout efficiency will be chosen.

## ABSTRAK

Produktiviti adalah ukuran prestasi dalam industri, organisasi atau kilang. Projek ini memberi tumpuan kepada pengeluaran roti di kilang Mama Industri Bakar. Kajian ini adalah di atas meningkatkan produktiviti pengeluaran, mengurangkan masa menunggu dalam pengeluaran, meningkatkan pengeluaran dalam satu hari untuk mencapai sasaran dalam masa yang lebih singkat. Pada mulanya, pengumpulan data dari segi masa kitaran setiap mesin atau stesen kerja, kawasan yang memerlukan oleh stesen kerja. Semasa lawatan ke kilang, tempoh pemerhatian adalah kira-kira sehari, alat-alat yang digunakan untuk merekod masa dan jarak langkah, kawasan yang diperlukan oleh setiap stesen kerja, dan kawasan kilang itu dilakukan dengan menggunakan Telefon Pintar Atrix 2 dengan jam randik dan langkah pintar yang mempunyai fungsi untuk mengukur jarak objek kepada pengguna. Selepas data dikumpulkan, berikutan dengan menggunakan Witness Software, model susun atur kilang asal diwujudkan, maka lain 4 model susun atur baru dibuat dan meniru semua mereka bersama-sama dengan susun atur asal, maka produktiviti dan kecekapan susun atur dikira dan rekod keputusan. Dari kajian ini, masalah utama yang terdapat adalah ruang yang kecil, proses beberapa terperangkap kerana tidak kapasiti yang mencukupi dalam menyediakan penampakan, di mana leher botol berlaku, tetapi membuang dinding, dan barisan pengeluaran kapasiti penampakan yang lebih seimbang boleh disediakan, oleh itu proses itu boleh diteruskan tanpa penangguhan dan menunggu. Antara semua susun atur baru yang sedang dicadangkan dan simulasi dalam Witness Software, satu dengan peningkatan yang lebih tinggi dalam produktiviti dan kecekapan susun atur kilang akan dipilih.

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## **CHAPTER I**

### **INTRODUCTION**

#### **1.1 BACKGROUND OF STUDY**

Nowadays, the efficiency of a plant has influenced by its plant layout of the machine for operation. The influence of an efficient layout on the manufacturing function is that it makes it smooth and efficient. The operating efficiency, like the economies in the cost of handling material, minimize the production delays and avoidance of bottlenecks are all depend on a proper layout. Using Witness Software is one of the solution for solving the layout problem .

#### **1.2 STATEMENT OF PROBLEM**

The layout problem will usually occur in SME Companies and it is concern greatly nowadays since will affect the plant efficiency. The sign of lack in efficiency can be discovered when the machine is breakdown and the product need to take longer time to be produced, where with proper layout and allocation of time for maintenance for machine will avoid this problem. Sometimes the improper layout may cause a delay when the half finish product need to deliver to another department or machine in a midway, where the obstacle like other machine or things may have the half finish

product to make a long walk before deliver to the specific machines or department to be processed. So the study is to improve better plant layout as to eliminate bottlenecks and delay by using the WITNESS software simulation analysis.

### **1.3 RESEARCH OBJECTIVES**

The objectives of this project are:

- 1) To identify and eliminate non value added (NVA) activities such as travel distance and bottleneck processes by using WITNESS Simulation Software.
- 2) To develop and propose an efficient layout which could increase company's productivity and manufacturing efficiency.

### **1.4 PROJECT'S SCOPES**

The scopes of this project are:

- 1) Use the data of cycle times and the capacity of the machine process half-finish product and run the simulation by using the WITNESS Software for real time simulation
- 2) The study will be carried out at the selected production line in MAMA BAKE Enterprise.
- 3) Sandwich bread will be chosen in calculating productivity and simulation in the efficiency calculation of the plant layout.

## **CHAPTER II**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

The plant layout plays a major role in improving manufacturing performances. Better layout could give lower production time, avoiding the delays and the bottleneck, so at the same it increases the productivity, saving cost, and thus increase the profit gain. Many manufacturing companies are now working to get a better and more efficient layout for their manufacturing operation, and one of the methods has used WITNESS software to run simulations in determining the most efficient of the layout exist long time already or just proposed.

#### **2.2 ANALYSIS PLANT LAYOUT DESIGN FOR EFFECTIVE PRODUCTION**

In the industry sectors, it is important to manufacture a product which has good quality and at the same time meet the need and demands of the customer quoted from (Watanapa et al. 2011). The analysis can be conducted with existing information or resources such as the employees, machine and other facilities. Plant layout improvement is one of the tools that could increase the productivity. Good plant layout design could influence the company's performance such work efficiency, cycle time (Watanapa et al. 2011).

To create the most effective plant layout, it is needed to appropriately plan and position employees, materials, machine, equipment, and other manufacturing supports

and facilities. They are several methods for plant layout improvement such as systematic plant layout (SLP), algorithms, arena simulation that can be applied to the plant. Firstly, one of the procedures to be followed in doing the plant layout design is first, the fundamental of plant layout have to be studied beforehand. Second, the machine is collected. Third, the process for product production will be used in the analysis. Fourth present layout was analyzed to identify the problem under flow material and operation. The last step is that suggestion was collected then writes the report and proposed to authorize to make decisions for rearrangement for the plant layout.

### **2.3 USING WITNESS SIMULATION SOFTWARE AS A VALIDATION TOOL FOR AN INDUSTRIAL PLANT LAYOUT**

In industry, the modeling and simulation technique have been always the power tools devoted to analyze the best plant layout for an industrial plant.

The implementation of new plant layout is a typical matter which was studied by the logistics experts using the modeling and simulation technique, and now it's also one of the aspects discussed in academics to educate young engineers and researcher in industrial engineering. Several facts are taken into account during the design and implementation of new layouts, such as the number of types of machineries, ancillary facilities, forklifts, human resources, distances between machines and so on. Using Witness Software for application of simulation for design of industrial plant layout with goal of analyzing flows, this tool provides information of “what if” analysis and animated in two of three dimensions.

The Witness software is a process simulation software with the purpose of education and business, and one of the most suitable simulating plant layouts. In different business cases this tool has been successfully used to design plant layout, in recent past Witness software has been used to buy European aeronautics company Airbus in designer the wing production facility for the new passenger aircraft A380, the world's largest airplane ever produced. Airbus in lean wing production process using Witness software to ensure it and at the same time provides a good overall view of the factory life. And Witness software able to give a detailed perspective in all process

phases by using the Witness software it brought significant savings in terms of equipment.

In this section, the simulation of the model by WITNESS reproduces the widget production line, by just using one normal forklift with a capacity of 2000 kilograms. The objective of the author using the simulation model is to identify the criticalities in the system in order to validate a hypothetical plant layout of a certain daily flow material. The model will allow formulating “What If “analysis which will eventually identify “bottleneck “on the system.

The model reproduces a widget plant in which the different flow of material is interfaced. Each of this flow feed to a series of different machines which transform the semi-finished product to finished widget or product and ready to be sent to the shipping warehouse.

In the Witness Software it is possible to set parameters to the machines, forklifts and buffers such as the capacities, the processing times or speed for the forklift. Which allows different scenario to be observed and analyze. The simulation model presents a unique forklift to serve all the machines, and is possible to bring the semi-finished product from out, and move along to the predefined segment which connects machines, buffers and entry point. The forklift presents a list of missions and added to the queue once a buffer or a machine “calls” the forklift. During the uploading process, it is required to set “parking point” to hold it when it is idle along some of the segments. In WITNESS the forklifts and machines can assume to have 6 statuses. Idle which mean the object is inactive; busy mean the object is working; blocked mean the object not able to be managed the missions due to high workload; demand mean the forklift is in motion going to pick up a part; transfer mean the forklift is moving along the tracks searching for a mission; loaded mean the forklift is carrying a part towards a machine or buffer. All the status reported will be in tabular or graphical form showing a chart states for the object. Several input parameters have to be set in the track object. Such as loading and unloading time of forklift, roll length of the track and its capacity (when they are a case of more than one forklift).

## **2.4 PRODUCTIVITY IMPROVEMENT IN INDUSTRY BY USING WITNESS SOFTWARE**

To improve plant layout, every phase of plant operation and diverse consideration such as order taking, utilities, special ventilation requirement, and all process and activities. It is difficult to take different account in any problem, so they are one approach documented in Richard Muther's Simplified Systematic Layout Planning (1994). And this broken down into six steps.

The first step is by identifying department, activities, work centers including in the project. Keep in the range of 10 to 15 different work center with maximum number is 20. Using a relation chart to show closeness (Absolute Necessary; Especially Important; Important; Ordinary; Unimportant; Not desirable) and with value as a symbol (A, E, I, O, U, X) require between 2 working centers. There are some examples of a specific relationship value like to share equipment, shared personnel, movement of material, movement of personnel, shared utilities, Noise, Dirt, contamination, fumes, shared dock, supervision, the cost of material handling. The second step in Muther's method is to prepare an "Activities Area and Feature Sheet". At this point the area required for each activity, WorkCentre, and the department will need to be determined. And the time for each activity should be determined as well. The third step is building up the diagram activity relationship. At first the node diagram is constructed, showing graphically the activities and their close relationship between the department, work center or activities. And show the arrangement before and after improvement layout. The fourth step is draw space relationship between the different department or show the flow of material between the department. Then the fifth step is evaluating alternative arrangement Using a symbol as A,E,I,O,U rating that suggest in a first step and convert the letters to numbers (A=4, E=3, I=2, O=1, U=0), and total up the rate value for each of the layout design, and choose a layout that strike the highest score. The sixth step will be developing final plan we be used as a guide to installing plant.

## 2.5 Facility Layout

In layout decision, it consists in determining the placement of department, work group within departments, machines, workstation, and stock-holding point within the production facility. The department arranged in a facility general defined by their pattern of work flow. Basically there are three basic types: process layout, product layout, fixed-position layout ; and one hybrid layout the cellular layout.

Process layout is arranging department of like process in that optimize relative placement. Taking an example the department in a low-volume toy volume factory might consists of receiving and shipping department, the painting department and the sewing department. Then parts of the toys are manufactured in these departments and then sent to assembly departments where they are put together. The difference between the layout process and product layout is the pattern of work flow. In product layout, the equipment or departments are dedicated to a particular product line. , duplicate equipment is employed to avoid backtracking, and a straight-line flow of material movement is achievable. Using the product layout makes sense when the batch size of the product is large relative to the number of different parts or products produced.

The assembly line is a special case of product layout. Assembly line refers to progressively assembly linked by some material handling device. Some form of pacing is present, and the allowable processing time to all the workstation is equivalent.

There are important differences among line types, a few of these handling device like a belt roller conveyor, overhead crane; line configuration such as U-shape, straight, branching; pacing in mechanical and human; product mix in one product or multiple product; workstation characteristic like workers may sit, stand, walk to the line, or ride the line; and length of the line with just a few or many workers.

Fixed position layout different from process and product layout in aspect of low number production units. While developing the position layout visualize the product as the hub of a wheel with materials and equipment arranged concentrically around the production point in their order of use, where the product is difficult to be moved. Taking



example in building yachts, the rivets that are used throughout construction would be placed close to or in the hull; heavy engine parts, which must travel to the hull only once, would be placed at a more distant location; and cranes would be set up close to the hull because of their constant use.

The cellular layout allocates the dissimilar machines into cell to work on product which have that similar shapes and processing requirement. Taking the example like Group Technology (GT) layouts are now widely used in metal fabricating, computer chip manufacture, and assembly work.

The benefit includes better human relation where Cells consist consist of the few workers who form a small work team; Improve operator expertise, there are only a limited number of different parts of the finite production cycle, repetition brings quick learning for the worker; less in-process inventory and material handling the cell combines several production stages; and faster production setup where fewer jobs mean reduced tooling and hence fasting tooling change.

## **2.6 WITNESS SIMULATION SOFTWARE A FLEXIBLE SUITE OF SIMULATION TOOLS**

In manufacturing enterprise it is found that the simulation tool is used most over time. By using this suite of tools (Witness) , it allows teams of people to take a look at the process from a different point of view, and at the same time able to obtain input of various people within the organization before arriving one solution where it is best suited. The process to come to completion when the presentation-quality simulation tools is used to communicate ideas to those who make the final decision like the upper management, investors, CEO's and CFO's. Product comprise suite of tools is MATFLOW (a material-flow planning system), WITNESS, WITNESSVR (virtual reality software), WITNESS OPTIMIZER simulation software. This product is available from Lanner Group, Inc., a leading international manufacturer of decision-support software.

With WITNESS, the optimization of the manufacturing floor layout, respect to material flow provide by the MATFLOW can be further refined and improve. WINESS used to simulate full production runs over an arbitrary time period. This allows the designing facility to get full glimpse of how the production lines might operate in reality. It is a good way to solve the problem and inefficiencies that present it in the production line in the current configuration. WITNESS present any production bottleneck, overly-idle resources, storage area that is too small or too large and any potential issues with respect to labor attending to the processing parts in the designing plant layout tested,

The Witness simulation package has the capabilities to model a variety of discrete (part-based) and continuous (fluids and fast-moving good) element. Depending on the type of elements, each can be in a number of states like idle (waiting), busy (processing), blocked, in-setup, broken down and waiting labor (cycle/setup/repair).

The basic discrete modeling elements are Parts, Buffers, Machines, and Conveyors. Parts are simply an object which travels from one location to another location. They may be pulled passively by model and push into system by active part arrival schedule.

And Buffers are just passive storage areas of finite capacity. The buffer can be configured as “delay” were part must stay for a minimum amount of time. It also can be configured as “dwell” buffers, where they cannot stay in the buffer more than specified time. The part can be ejected from buffer if it violates any of the condition set. Combinations of First-In-First-Out / Last-In-First-Out sequencing are possible, as well as the ability to have parts to push to and pulled from the locations in the buffer other than the rear and front.

The workhorses of WITNESS are machines. They are a variety of machine type available in WITNESS such as Single, Batch, Assembly, Production, Multiple –Cycle, Multiple –Station.

Machines are useful for modeling real-life failures, retooling, preventive maintenance etc. And it can define with setup and Breakdown parameters. Conveyors are defined by a length and index time which represents the time it takes a part to move from one position on the conveyor to the next position of the conveyor . The conveyor itself actively pulled part from the rear and actively push part of the front. The Conveyor may be queued or fixed. Fixed conveyor maintain between the parts if part at the front of the conveyor is blocked. As compared to queuing conveyor allow parts to be compact together even if the conveyor is stopped. The time queuing conveyor stopped when there are no gaps left, completely full where no part is being removed from it. Some other discrete elements include tracks and vehicles, labor, shifts, variables, part attributes.

Continuous elements are used when the movement of parts is represented as a flow rate and not as an individual. The material that is used in a continuous simulation model might be powder, fluids, gases or high volume fast-moving part. A good example of high rate production that suitable for continuous simulation modelling might be small individual candies, nail, screws, bottle caps, etc. Other scenarios that suitable for continuous modeling might include the processing of large rolls of sheet metal, wire, adhesive tapes, paper, etc.

WITNESS continuous flow modeling elements comprise by Fluids, Tanks, Processors, and Pipes. As already described, fluid can be liquids but they also are powders, gases, grains or high production rate part. It's usually measured in volume or weights the fluid and the resulting flow rates. Exact units can be chosen by the user. Gallons, liters, or even towns are common to be used. As long as their usage is consistent throughout the simulation it does not matter what units are used.

The tank analogous to the Buffer element in discrete processing, the function was storing fluid. A user indicates tank capacity and input and output flow rates. Flow rate is expressed in user determined unit over the simulation time unit (such as gallons per hour, liters per minute, cubic centimeters per second, etc.). On rising or falling the warning level can be set, allow the user to take action under certain conditions. Just as

machines can be repaired and retooled, the tank will also configure for a cleaning cycle if it is required.

The pipe element moves the fluid from one location to another and it is analogous the conveyor element in discrete processing Pipes have input and output flow rates. As it is defined in the input and output rule attached to them. It also has a maximum volume specification, it determines how long it took for a given fluid to go from one end of pipe to another end. It can have breaks down associated with, for modeling in an event such as burst, leaks, clogs, and other periodic downtimes. Pipes also are scheduled for purging or cleaning, and it is independent from the breakdown. When pipe break down, any fluid from pipe can be sent to waste area and recorded in simulation statistics. It also can be configured to have fluid flow of it even at the end no fluid come out. This allows the convenient modeling of gravity fed material handling systems for fluids, powder or small object. The operation of the valve (on, off, partially off) can simply modeled by toggling the flow rate offs the tanks, pipes and processors from the positive flow to zero. The processor is the element same as machines in the discrete processing. It fills the capacity in specified level, then process the fluid with given times then empties completely.

The processor can be configured for cleaning cycles as well as a breakdown like a case of mixing drive motor may fail. It also can set to trigger warning level alarms like a tank. Finally it is possible to mix fluid with parts in the discrete machine element. It is commonly used when filling the vessel with fluid like paint cans with paint, bottle with soft drink and etc.. And it also commonly used when the typed of fluid being consumed in the machined which processing the discrete parts. There may be coolant or detergent or other cleaning agent being consumed in cleanup part. The Witness graphical user interface is Window compliant. The operation of simulation model controls at the bottom of the screen from the toolbar, which starts, stops, and reset the model. Once basic model is set up; the more detailed is added to the element. Then in the detailed dialog is where the logic of element entered. The detailed dialog can be invoked by double clicking on any element on the screen.

The detailed dialog control logic on element, the display dialog control how it looks. From display dialog it can change the icon be used, text color, assortment of other item can be attached to the display of each modeling element. The display dialog can be invoked by double right clicking on any element on the screen.

The WITNESS report can view on screen in tabular or graphic format. Several graphical elements are available for summarizing statistics from a model Pie chart, time series and histograms provide a meaningful, easily-read format for data from a simulation model run

WITNESS has associated with it up to 500 icons; it can represent elements on the screen. Simulation means to model different scenarios and compare the results. Witness provides a plug-in module which can intelligently test different combinations of changes within a model, and indicate the “best” model based on an objective function provided by the model builder. In addition, the user can provide any constraint information in WITNESS like factors within the model which can vary, and what their range of variation is. Model run-length, as well as number of replications, is also indicated by the user.

Objective function defined as normal WITNESS functions. The example objective function might be: value of throughput, cost of machines, and cost of staff. During the optimization process, different aspects of the model are varied, and the resulting value for the objective function will be compared to previous values to see if any improvement has taken place.

A model optimization dialogue provides a means for users to select from several different objective functions that have specified, and to indicate whether the function should be maximized or minimized. With given optimization run user can set a warm-up period which is a period after which statistics are zeroed out, and a model run continued. The length of a running in simulation time unit, a number of replications or reproduction and information on how random numbers are to be varied for each replication. Several optimization methods is provided like running all possible combinations, Min/Mid/Max value of all value of the variable being run; Hill Climb

which generates random iteration with high quality is accepted otherwise rejected; Which generate random combinations of variable values. Once a WITNESS model has been completed and results emerge, it can create a 3D Virtual Reality version of the model.

## **2.7 A STUDY ON FACILITY LAYOUT IN MANUFACTURING PRODUCTION LINE USING WITNESS**

Using the WITNESS software able developed a specific design of facility layout for a production line, implement a new facility layout is very consuming time and require a huge amount of investment. Today industrial and manufacturing are facing the problem of the competitive environment that affect the facility design and engineering activities. Simply increasing price of product is not an option. Latest advances in manufacturing were rapidly applied by the company in an effort to increase the efficiency of the factory, quality control, enhance manufacturing flexibility.

Facility layout is defined as the physical arrangement of everything needed for product or service including personnel, raw material and finished goods; To put it simply it is the arrangement of area within a facility (Roslin et al. 2008). The efficient design of a facility layout has generally been recognized as one of the most important solution for the facility layout problem (Roslin et al. 2008). Effective layout can utilize space and labor efficiently, facilitate the entry, exit, and placement of material, products, and people, eliminate bottlenecks, reduce manufacturing cycle time, minimize material handling costs, and increase productivity, throughput or profitability (Roslin et al. 2008).

In manufacturing facility layout there are two types of layout, the basic layout and hybrid layout. The three basic layout is the process, product and fixed layout. Whereas the other three types of hybrid layouts are cellular, flexible manufacturing system, and mixed-model assembly lines. Pattern of flow may be viewed from the perspective of flow within the department , between departments and within the workstation. This software also can provide information to predict outcomes, identify bottlenecks, analyze problems, and formulate solutions. It is also able to provide immediate feedback under certain predetermined conditions (Roslin et al. 2008).

WITNESS simulations do not produce exact result compare to real life this is because simulation does not produce optimal solutions. To get the best results, the user must generate all the condition and constraints during the building of model for simulation. Input data in WITNESS more emphasis on time instead of distance. In workstation, such as cycle time need to be key in, and time for parts traveled between two stations, rather than distance.

## **2.8 THE WITNESS TOOLBOX – A TUTORIAL**

WITNESS is a true process simulation and modeling tool, it makes possible obvious for any production bottlenecks, overly-idle resources, storage areas that are too small or too big and any potential issues with respect to labor availability WITNESS capable of modeling a variety of discrete (part based) and continuous element ( fluid or high volume fast moving goods). The most basic discrete modeling elements are parts, Buffers, Machines, and Conveyors. Parts travel from one location to another, it pulls passively into the model by simulation, pushed into the system by an active part arrival schedule.

Buffers are passive storage areas of finite capacity. It can be configured into delay where parts can stay for a minimum amount of time; and dwell states which parts cannot stay at buffer longer than the specified time. Parts can be ejected from buffer if it violates any of these conditions.

Machines are the workhorses of WITNESS. The variety of machine types that available is single, batch, assembly, production, Multiple-Cycle, Multiple-Station. It can be defined with Setup and Breakdown parameter, useful for modeling real time failure, retooling, and preventive maintenance.

Conveyors are defined by length in parts and index time which represent times for parts move from one location to another. It can be fixed and queued. A fixed conveyor maintains the space between parts if the part on the front of the conveyor is blocked; where the queued conveyor allows parts to compact together even if the

conveyor is stopped. Some other discrete element available in WITNESS is the track and vehicle, labor, shifts, variables, part attributes.

Continuous elements are used whenever the movement of the parts is represented by a flow rate, rather than movement of individual parts. Like powder, nails, screws, bottle caps. Another scenario appropriate for continuous modeling might be large rolls of sheet metal, wire, adhesive tapes, paper. Fluids, Tanks, Processors, and Pipes comprise the WITNESS continuous flow modeling elements. Fluid will result in flow rate usually measured in volumes or weight, where the exact unit which is chosen by the user. A Tank stores fluid is analogous to buffer element in discrete processing. The flow rate unit is expressed in user units over simulation (gallons per hour, liters per minute, cubic centimeters per second). Warning level can be set on rising or falling, allowing the action to be taken under these conditions. The machine can be configured to repair and retool, the Tank can be configured for cleaning cycle when required.

The Pipe element move fluid from one location to another is analogous to the conveyor element in discrete processing. And it has input and output rate and maximum specification. The pipe can have breakdowns for modeling event such as leaks, burst or other periodic downtime. It also can be scheduled for cleaning or purging, independent of breakdown. There are ability of a fluid to empty from Pipe even though no arriving fluid, allow the convenient modeling of gravity-fed material handling system for fluids, powder, and small objects by using operation of the valve (on, off , partially closed) simply by toggling the flow rate into and out of tanks, pipes and processors, from positive flow rate to zero.

The processor element is analogous to machine element is discrete processing. The processor first will fill the capacity to specify the processing level, and then processes the fluid for a given amount of time, then empties completely. The common use of it is simulating the agitators and mixing machine, aerators, fluid separators, degaussing equipment, gas injection equipment. Processor as well as a tank can show the proportional of two mix fluids. And it can be configured like Tanks for cleaning cycles, as well as a breakdown, and can also trigger warning level alarms.



Finally, it is possible to mix fluids with the parts in the discrete machine element. This feature is commonly used when filling vessels with fluid like paint can with paint, bottles with soft drinks. WITNESS model associate with it up to 500 icons, can be represented elements on the screen, Bitmap files can be imported into the WITNESS model as an icon, and AUTOCAD dxf files can be imported to provide a shop floor layout to be used as a backdrop or as background drawing from a model. Now is preparing the model for optimization for example the objective function: Values of throughput (quantity or amount of raw material processed at the given time) minus cost of staff and cost of the machine. During the optimization process, different aspect of the model is varied, and the resulting value for the objective function will be compared to previous values to see if any improvement has taken place.

The model optimization dialogue provides means for users to select from the several different objective functions they may have specified, and to indicate whether the function should be maximized or minimized. Any number of variables can be considered during optimization. Optimization variables can be added or removed from the list of those available. To manage constraints which to reduce the total number of possible combinations of value it can expressed as a linear function in two or more of the optimization variables. For example:  $\text{sraff1} + \text{staff2} \leq 10$ . Any number of constraints can be included in an optimization scenario. Several optimization methods are provided like All combinations; Min, Mid, Max (run 3 evaluations based on minimum, midpoint, maximum values of all variables); Hill Climb (generates random iteration which is accepted if of high quality and rejected if not); Random solution (generates random combinations of variable values); Adaptive thermostatically SA (simulated annealing)- it less dependent than the Hill Climb method on “stuck: at a local optimum. The sophisticated users may manually adjust the search parameter.

## 2.9 SIMULATION

Simulation models are used in everyday and it is not alien to us. Taking an example, weather forecasters shows us the simulation weather system, where we can see the movement of weather fronts over the day ahead. Some game consoles that even can simulate the whole variety of activities, enabling us to test our skills as racing drivers, adventurers and city planners. All this is computer based simulations.

Nowadays, many of the operations are subject to variability. The variation might be predictable, for instance changing the number of operators in call centers. It can be unpredictable, for example the arrival rate of patient to hospital.



**Figure 2.1** Operation Diagram

Source : Robinson 2003

Operating systems are also interconnected. The components of the system do not work alone, it affects one another. A change in one part lead change in another part of the system, especially when variability is present. Taking example the Figure 2.1 above each stage take 9 minutes. If one of the machines set to run faster, it is likely to cause a reduction on work-in-progress in up-stream and down-stream. In general terms simulation, it is used for modeling queuing systems. Many systems can be conceived as queuing system, whether it is physical items or people.

## 2.10 PREVIOUS STUDIES

The study is conducted in one small medium industry (SMI) organization in Malaysia, Dinamika Pelumas Sdn. Bhd. A lubricant and solvent manufacturer company which is established in 2007.

The data collection is divided into two main parts: first half and second half process. First half of the process is lubricant manufacturing and preparation, second half is filling and lubricant packaging. The available production area in the company is 1081.5 ft<sup>2</sup>.

<i>Equipments</i>	<i>Types</i>	<i>Quantity</i>	<i>Dimension/Size</i>	<i>Area Requirement</i>	<i>Description</i>
Machine	Blending	1	Ø50mm x L600mm	0.042 ft <sup>2</sup>	-
	Filling	1	H1600mm x L700mm x W700mm	5.27 ft <sup>2</sup>	Filling speed: 20 bottles per minute
	Induction sealing	1	H200 x L350mm x W250 Ø30mm x L300mm	0.94 ft <sup>2</sup>	Production capacity: 60 bottles per minute
Tank	Oil base (90%)	2	Diameter: 10ft Height: 15ft	78.54 ft <sup>2</sup>	Capacity: 16000 litres per tank
	Additives (10%)	12	Diameter: 2ft Height: 3ft	3.14 ft <sup>2</sup>	Capacity: 200 litres per tank
	Waste/Scrap	2	Diameter: 2ft Height: 3ft	3.14 ft <sup>2</sup>	Capacity: 200 litres per tank
Container	Mixture of raw materials	4	H4ft x L4ft x W3.5ft	14 ft <sup>2</sup>	Capacity: 1000 litres per container
Worktable	-	1	H3ft x L8ft x W2ft	16 ft <sup>2</sup>	-

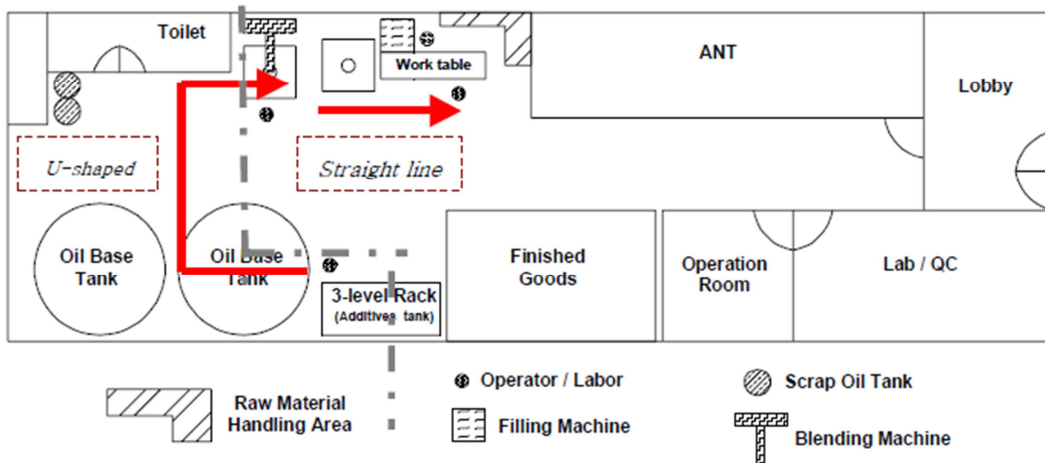
**Figure 2.2** Equipment Data

Source : Roslin et.al 2008

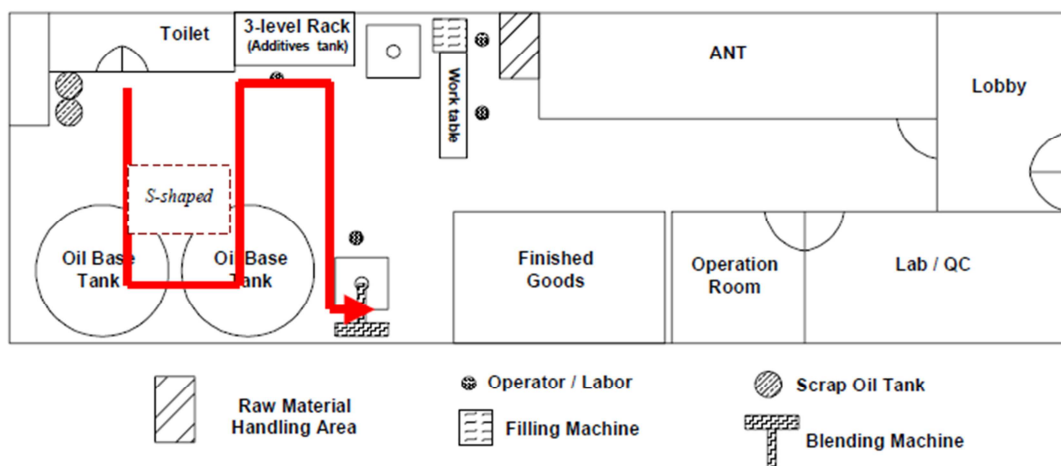
Path	Workstation	No. of Operator	Activity/Process/Work Element	Activity/Cycle Time (sec)	Cumulative Time for Workstations (sec)	Cumulative Time for Path (sec)
1 <sup>st</sup> half	S1	1	Additives input	1980	1980	1980
			Oil base input	1650	3630	3630
	S2	1	Blending	1980	1980	5610
2 <sup>nd</sup> half	S3	1	Load empty bottles	3.3	3.3	3.3
			Filling	6.6	9.9	9.9
	S4	1	Capping	4.4	4.4	14.3
			Induction Sealing	2.2	6.6	16.5
			Packaging	4.4	11	20.9

**Figure 2.3** Workstation Cycles Time Data

The new proposed layout design for the manufacturing production line is the product layout type. Selecting the types of layout design also depend on the product types manufactured by the company. The production line is set for one type of the product (lubricant), and special machines (blending machine, filling machine, and induction sealing machine) are arranged in a fixed location to match the product specific processing requirements.

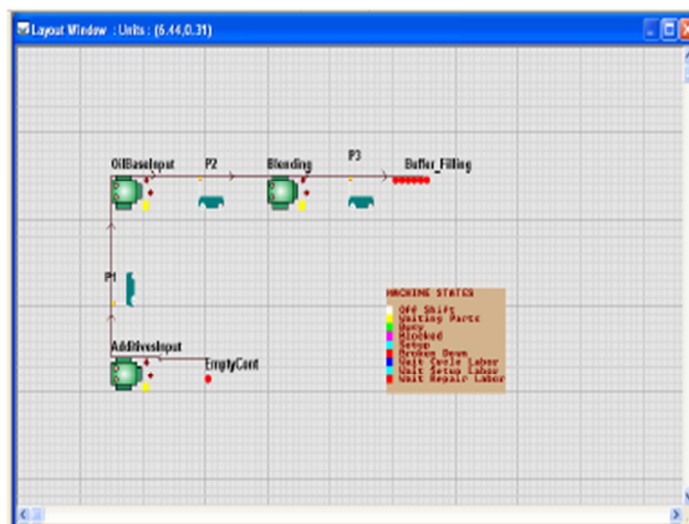


**Figure 2.4** U-shaped Flow Pattern Design



**Figure 2.5** S-shaped Flow Pattern Design

Model building in the first half process in the U-shaped is shown in Figure 2.2. And second design in S-shaped is shown in figure 2.3. As a model for the second half of the process for both alternatives is same. In this study, Witness simulation software is used, the simulation has based one new layout design to illustrate the efficiency of both alternative new layout designs to get an idea which layout is best to pick and implement.



**Figure 2.6** U-shape Witness Model Building

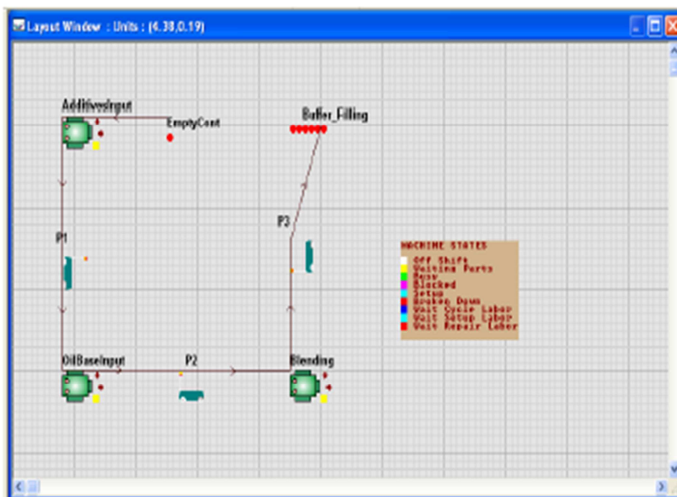


Figure 2.7 S-shape Witness Model Building

Figure 2.4 and Figure 2.5 show the U-shape and S-shape model build in Witness software

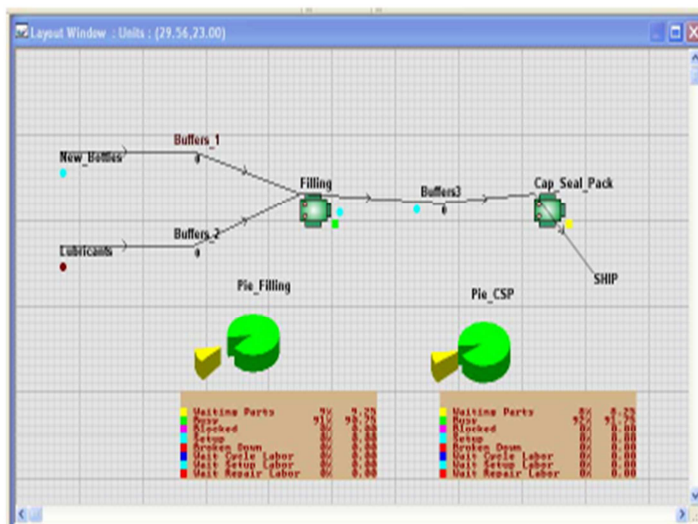


Figure 2.8 Second half model Witness Model

Figure 2.6 shown the second of the process in Witness software model, where it is identical for both layout designs.

<i>Workstations/ Machine</i>	<i>Additives Input</i>		<i>Oil Base Input</i>		<i>Blending</i>	
	<i>% Idle</i>	<i>% Busy</i>	<i>% Idle</i>	<i>% Busy</i>	<i>% Idle</i>	<i>% Busy</i>
<i>U-shaped flow pattern design</i>	25.31	74.69	37.76	62.24	25.31	74.69
<i>S-shaped flow pattern design</i>	28.81	74.19	38.18	61.82	25.81	74.19

**Figure 2.9** Layout Performance

Using the Witness interactive simulation software, analysis of layout model will be generated in statistical reports. The result included efficiency (percentage of working and idle), number of parts produced, buffer capacity and so on. It also shows that U-shape flow pattern is a more preferred option. This is because U-shaped flow pattern design have better line efficiency as compared to S-shaped flow pattern design. Where the S-shape flow pattern design show a higher percentage of idle time comparison to U-shaped flow pattern design. U-shaped flow pattern design the efficiency of utilization of space, where space is well allocated for equipment. U-shaped flow pattern design have higher a percentage of busy / working time compared to S-shaped flow pattern design. By implementing of U-shaped flow pattern design, it reduces the idle time of workstations in a production line.

## 2.11 CONCLUSION

In conclusion, it is important to have a proper layout of the manufacturing operation, and using the WITNESS software simulation analysis can save many times in analyses and determining whether the old or new proposed layout efficient or not, and will the productivity increase or not, saving time or not. This entire factor is important in improving layout efficiency.

## **CHAPTER III**

### **METHODOLOGY**

#### **3.1 INTRODUCTION**

This chapter covers the scope of the study in methodology, selected company and sampling procedure, as well as the method and instrument used. Each of this topic will be followed by a brief explanation of data collection and data analysis procedures and the concluding section that summarizes the entire research process.

#### **3.2 SELECTED COMPANY**

The selected company for this study is MAMA BAKE. This company located at Gambang behind University Malaysia Pahang (UMP) Gambang . The company starts operating in 2009, the main product produce is bread. Among the bread produce is sandwich bread, bun, cream bread, Arab bread. The worker including the manager is 7 of them. The Bread Factory starts operating at 8 a.m. and stop at 6 p.m. per day. Basically they will start machine setup, dough and cream preparing around 30 to 40 minutes before start bread making process. Depend on the order from the customer, they may have to work overtime, sometimes the worker has to work until 8 p.m. to 9 p.m.



### 3.3 METHOD AND INSTRUMENT

The method used in this study is that, first of all choose a day and observed in MAMA BAKE factory, observed the process line of bread production. Take note on how many machines and type of the machine usable. Then use the stopwatch software in smart phone the record every cycle time of the machines. In area determine use the Smart Measure software which is able to measure distances 1 place to another in 1, then the size a machine need and size of the factory is able to determine.



**Figure 3.1** Smart Phone Motorola ME865

The usage the smart phone is use as a medium to use the Smart Measure software and Stopwatch & Timer software to collect data for simulation parameter input.



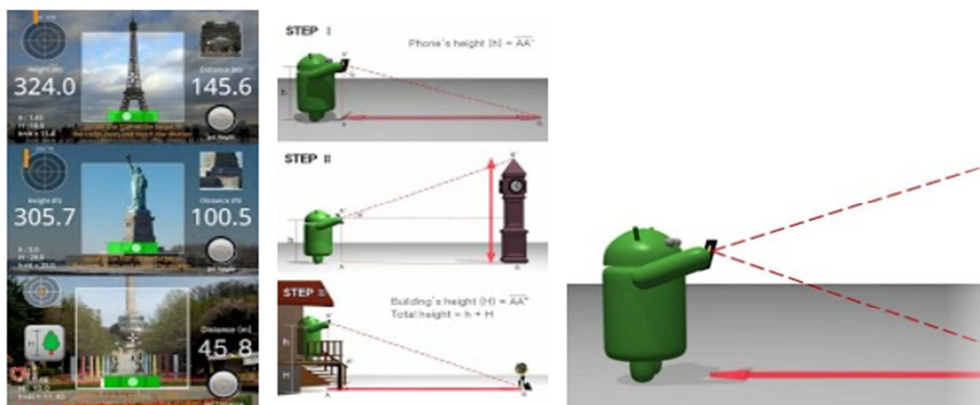
**Figure 3.2** Stopwatch & Timer Software

The Stopwatch & Timer software use in the smart phone have the same function as a stopwatch, it is used to record cycle time of the workstation of machines.



**Figure 3.3** Smart Measure Software

Smart Measure Software requires a Smartphone with android running program inside and camera function.



**Figure 3.4** Smart Measure Software Guide

The function of it is measure the distance of the user to the place where the camera shooting in meter unit. Since the factory is quite large, using other measurement tool will quite impossible. It can see from Figure 3.4.

## 3.4 DATA COLLECTION AND DATA ANALYSIS

### 3.4.1 Data Collection

Information about process, delays, maintenance time gathering for a model is likely to fall into one of the categories;

1. Available – data is readily available and it is in an appropriate format that the model can use immediately.
2. Not available but collectable – data is either in an incorrect format or it has not been collected before. It might need to perform a small work study in order to collect this type of data (for example, timing certain processes manually)
3. Neither available nor collectable – data is not currently available and it is not easily collectable (for example, for a model of a new factory on a greenfield site with new machinery). If the data is neither available nor collectable, what can be done here is use estimates. Whenever the data we use an estimate, assumption upon the model have to be declared. If later the model later proves inadequate as a representation of the real world situation, then it is possible to examine again the assumption upon which it was based.

As for the area and length I will use it based on the walking path observe from the worker for measure travel distance, as for area of machine I measure by assuming a rectangular shape around a machine.

### 3.4.2 Data Analysis

The data collected will be analyzed and simulated by using WITNESS software, then the analysis result is used as a basis for further improvement through layout improvement. At first the current plant layout, from the simulation, the machine status will be shown. The average value of overall workstation, it can use to calculate the efficiency of the each machine or workstations, it is shown in equation (3.1) and (3.2).

$$\text{Idleness} = \text{Waiting parts} + \text{Blocked} \dots \dots \dots (3.1)$$

$$\text{Efficiency} = 100\% - \text{Idleness} \dots \dots \dots (3.2)$$

In calculating the productivity of the plant layout the formula used is as below , equation (3.3), in here the labors use is 10 people and 10 hours, because to calculate maximum output units of product, both shifts is combine only one type bread is choosing to run in the simulation, thus labors or workers have to increase so that they will be labor operating second half the process.

$$\text{Productivity} = \text{Unit produced/ labor hour per day} \dots \dots \dots (3.3)$$

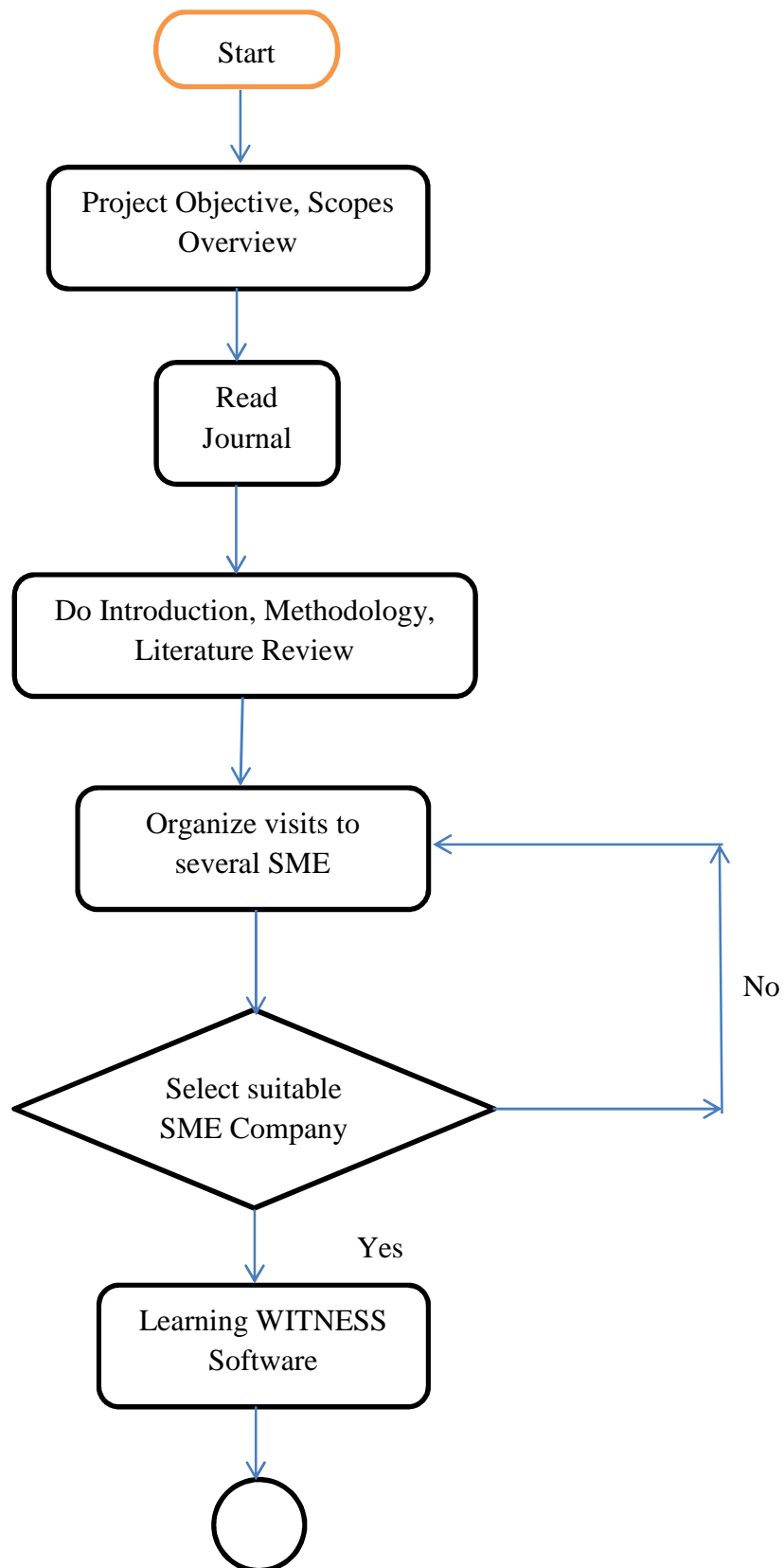
$$= \text{Unit produced/ (10 labor x 10 hours)}$$

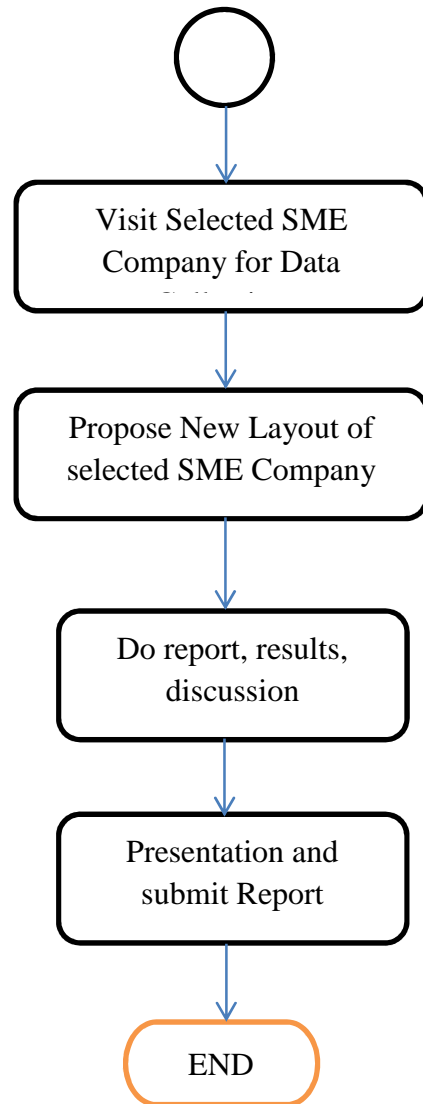
In calculating the productivity and efficiency improvement, the formula use as shown below equation (3.4) and (3.5)

$$\begin{aligned} & \textit{Productivity Percentage Improvement} \\ & = \frac{[\textit{Productivity(New)} - \textit{Productivity(Old)}]}{\textit{Productivity (Old)}} \times 100\% \\ & \dots\dots\dots(3.4) \end{aligned}$$

$$\begin{aligned} & \textit{Efficiency Percentage Improvement} \\ & = \frac{[\textit{Efficiency(New)} - \textit{Efficiency(Old)}]}{\textit{Efficiency (Old)}} \times 100\% \\ & \dots\dots\dots(3.5) \end{aligned}$$

## 3.5 Flow Chart





## **CHAPTER 4**

### **RESULTS AND DISCUSSION**

#### **4.1 INTRODUCTION**

This chapter discusses about the finding of the analysis the project based on the project objectives. By using the WITNESS software, in trial and error on design new layout , 4 new layout is being designed, data is recorded in the table . Follow by the calculation on the efficiency and productivity of 4 new plant layout is then compared to the current layout. Then the discussion will made to discuss the change that improves the efficiency and the productivity of the layout.



## 4.2 RAW DATA

### 4.2.1 Cycle Time for each Process of Different Bread

Below are the tables of cycle times in each workstation for different breads produce in one day, in every 30 minutes the dough which is the raw input will be sent to 1<sup>st</sup> workstation.

**Table 4.1** Cycle Time of breads on each station

Bread\Process	Mixing & Weighing (min)	Stirring & Softening (min)	Dough Shaping (min)	Heating (min)	Baking (min)	Cooling (min)	Bread Cutting (min)	Packaging (min)	Sealing (min)
Sandwich-Bread	15	15	20	60	40	30	0.5	0.25	0.25
Arab-Bread	15	15	32	40	11	30	-	0.25	0.25
Bread	15	15	29	40	15	30	-	0.25	0.25
Bun	15	15	60	40	14	30	-	0.25	0.25
Cream-Bread	15	15	24	40	14	30	-	0.25	0.25

Following by the table of breads in the package, a data required to determine which type of machine element use in Packaging workstation, station 8. After that, the shift time of the workers.

**Table 4.2** Breads Packaging Number

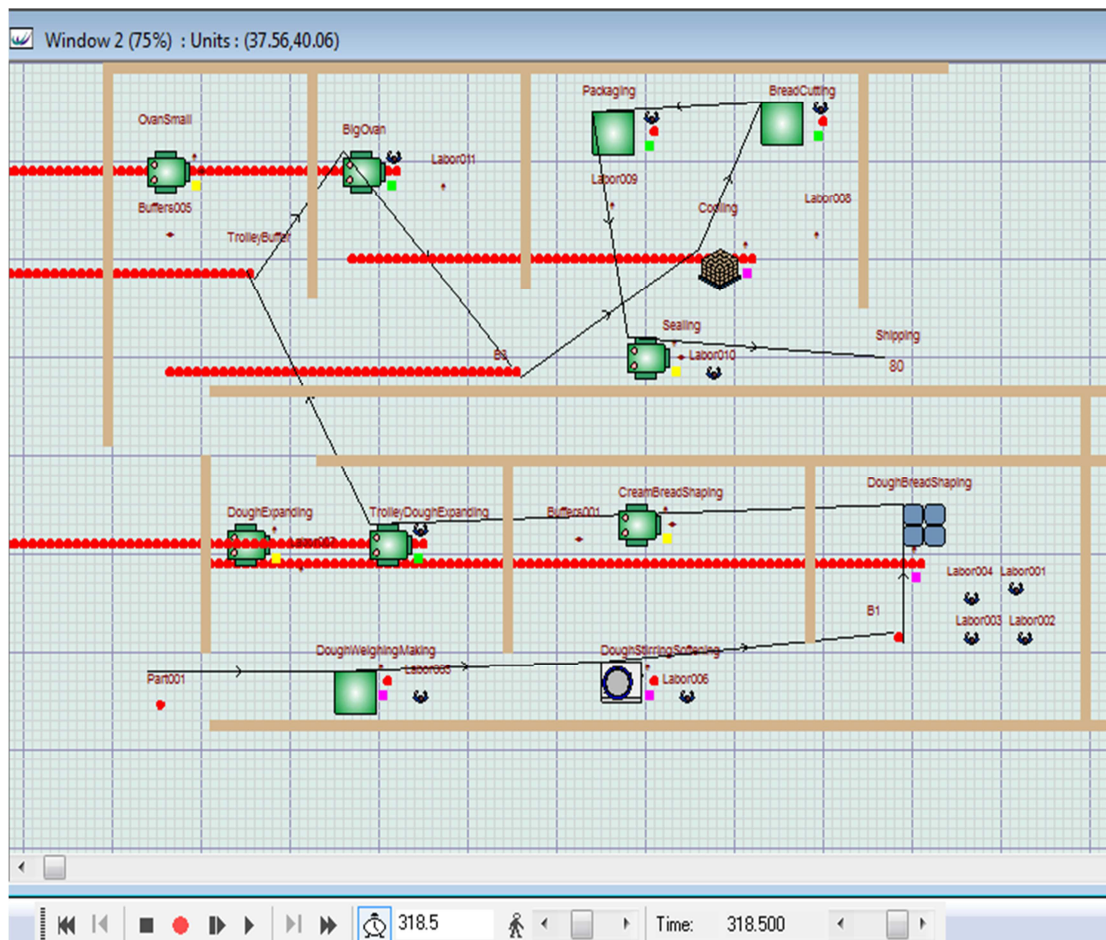
Bread's Type	Sequence	Number of Bread per pack	Number of Bread Produce (demand)	Number of Packs
Sandwich Bread	1	1 per pack	80	80
Arab Bread	2	4 per pack	240	60
Bread	3	10 per pack	240	24
Bun	4	4 per pack	360	90
Cream Bread	6	1 per pack	35	35

There are 2 shift one mainly in dough shaping before go into the oven for baking, second shift is focused on baking and packaging; in between the shift there is a one hour break, it was that time the 1 hour is used for dough expanding period , so in simulation we can treat it as a 1 hour cycle time for bread simulation. From shift time data, we are able to determine the standard working hours per day so that in simulation we able to calculate the output of the product made.

**Table 4.3** Working Shift

Time	Activities
8.00 a.m. ~ 12.00 a.m.	Machine setup, ingredient preparing, preparing Bread until it expand
12.01 p.m. ~ 1.00 p.m.	Rest
1.01 p.m. ~ 5.00 p.m.	Baking, packing, delivery
5.01 p.m. ~ 6.00 p.m.	Cleaning

## 4.2.2 Accuracy of Witness Simulation Layout



**Figure 4.1** Simulation Lead Times for 80 Units Breads Produced

Figure 4.1 shows the simulation run 318.5 minutes to produce 80 units of sandwich breads.

**Table 4.4** Real Lead Times for 80 units Breads Produced

Workstations	Cycle Time (min)	Capacity	Output produces per cycle time (min)	Total Time (min)
Dough Weighing	15.00	1	1	1x15 = 15
Making				
Dough Stirring Mixing	15.00	1	1	1x15 = 15
Dough Bread Shaping	20.00	1	80	1x20 = 20
Trolley Dough	60.00	64-192	64-192	1x60 = 60
Expanding				
Big Oven	40.00	56	56	2x40 = 80
Cooling	30.00	64	64	1x30 = 30
Bread Cutting	0.50	1	1	80x0.5 = 40
Packaging	0.25	1	1	80x0.25 =20
Sealing	0.25	1	1	80x0.25 =20
			Lead Time	300

The actual production lead time to produce 80 units of bread is 300 minutes as shown in Table 4.4. The different of real and simulation time can be considered as a simulation error since in this simulation do not include any travel time, or the worker slack off, or take a minute rest. The data collected is cycle times on each machine, so the simulation takes more time, like machine waiting, transferring from 1 station to another, take more time than in real.

Error percentage is calculated using formula as below:

$$\begin{aligned} \text{Error percentage of time} &= [\text{Time}_{\text{simulation}} - \text{Time}_{\text{real}}] / \text{Time}_{\text{real}} \times 100\% \\ &= (318.5 - 300) / 300 \times 100\% \\ &= 6.17\% \text{ (error increment in real time)} \end{aligned}$$

$$\begin{aligned} \text{Real time percentage} &= 100\% - 6.17\% \\ &= 93.83\% \end{aligned}$$

The calculation shows that the simulation time is faster than real time by 6.17% to produce 80 breads per day. The simulation time with 200 mins can produce 50 breads, therefore the real time can be calculated as ;

$$93.83\% \times 200 \text{ mins} = 187.66 \text{ mins}$$

. Since the error percentage is low, so it is acceptable. From the observation at factory start at 8 a.m., before the operation starts it required 30 to 40 minutes to prepared raw material, and machine setup time. So simulation time 600 minutes for 1 working day is about 562.98 minutes in real time. It is acceptable since after deducted, 37.02 minutes extra can be taken as the machines set up and material preparation times.

The error calculation can be calculated on time, since the data above only taking data. The data collected above is cycle time of each station, because whenever one station finish process the half-finish product it will start another process, so only using simulation can calculate the number units of breads produce in time longer than 3 hundred minutes.

### 4.2.3 Current Layout

To analyze the productivity of the current plant layout itself, taking 1 type of bread to calculate the maximum output in 1day which is Sandwich Bread. In simulation, the amount of time used is 10 hours (600 minute) as standard working time per day.

**Table 4.5** Current Layout Station Data

Workstations	Cycle Time	Machine Type	Input(u nit)	Output(u nit)	Buffer (after this station)	Buffer Capacity (approximate)
Dough Weighing	15.00	Single	1	1	No	
Making						
Dough Stirring	15.00	Single	1	1	Yes	1
Mixing						
Dough Bread Shaping	20.00	Producti on	1	80	No	-
Trolley Dough Expanding	60.00	Batch	64 -192	64-192	Yes	128
Big Oven	40.00	Batch	56	56	Yes	128
Cooling	30.00	Batch	64	64	No	-
Bread Cutting	0.50	Single	1	1	No	-
Packaging	0.25	Single	1	1	No	-
Sealing	0.25	Single	1	1	No	-

From Table 4.5 Current Layout Station Data, we able to access the insight on the station cycle time, capacity of producing the half finish product and the buffer provide after each station and its capacity.

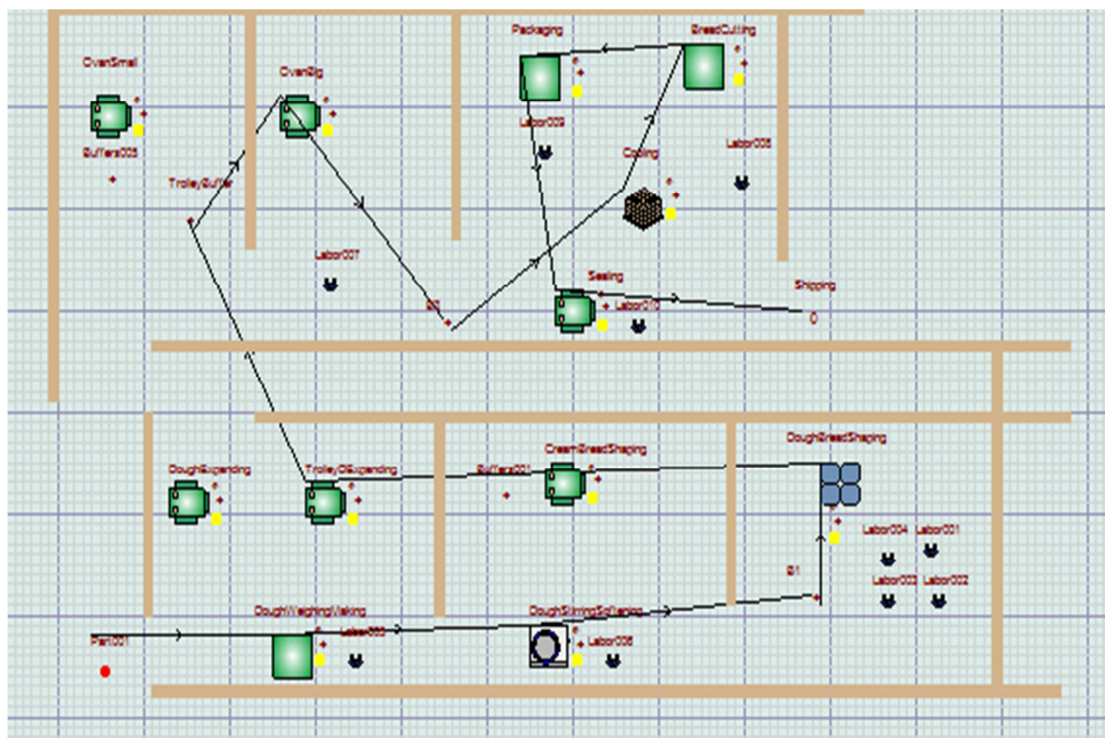


Figure 4.2 Process Flow before the Simulation

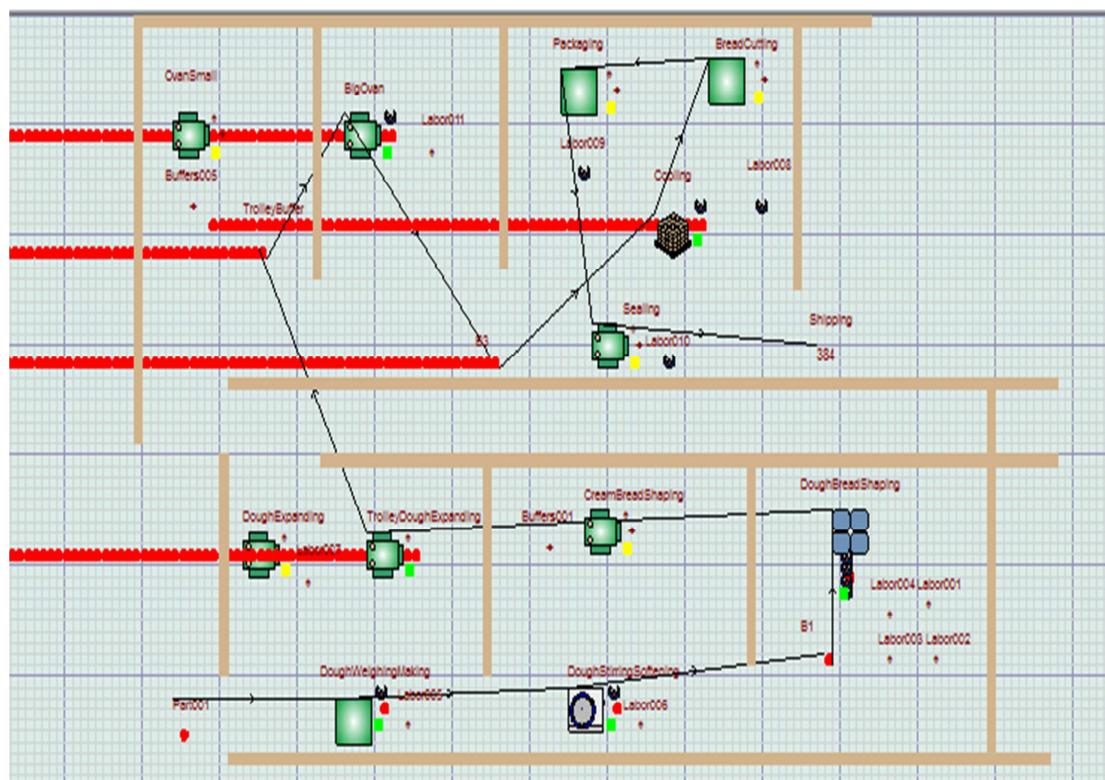


Figure 4.3 Process Flow after Simulation



Figure 4.2 and Figure 4.3 are shown before and after the Witness software running the simulation on the plant layout. From the process flow simulation, the bottle neck such as the red color part (half-finished product) is fully filled in the buffer or the machine can be seen.

Using the formula (3.3)

$$\begin{aligned} \text{Productivity} &= \text{Unit produced/ labor hour per day} \\ &= 384/(10 \times 10) = 3.84 \text{ units/ labor hour per day} \end{aligned}$$

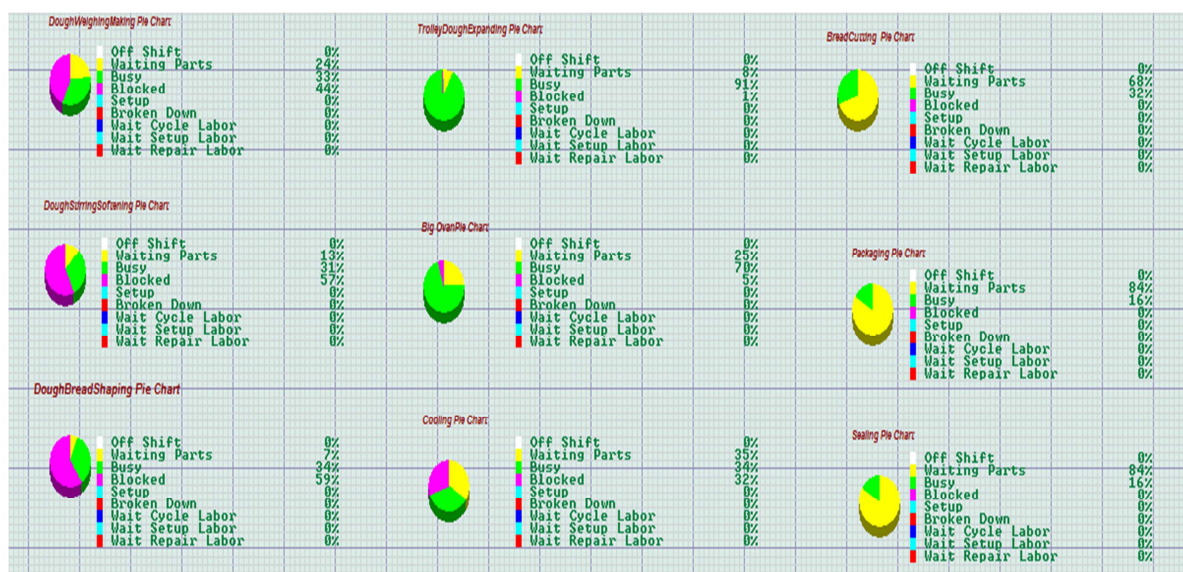


Figure 4.4 Performance Pie Charts of Workstations

From Figure 4.4 it represents the performance or status of machine for current plant layout the status of machines or workstations are known in percentage within the time limit of 600 minutes from pie chart and the list shown above. Purple color represents status block which occurs when the buffer before the machine is full and the machine is finished process the half-finish products but have no way to send. The green color represents machine is busy processing the half-finished products. As for yellow color it represents the machine is currently waiting input to be processed. Then the data is recorded in the table 4.6.



**Table 4.6** Workstations Performance

Process	Waiting Parts (%)	Busy (%)	Blocked (%)
Dough Weighing Making	24	33	44
Dough Stirring Mixing	13	31	57
Dough Bread Shaping	7	24	59
Trolley Dough Expanding	8	91	0
Big Oven	25	70	5
Cooling	35	24	32
Bread Cutting	68	32	0
Packaging	84	16	0
Sealing	84	16	0
Total	348	337	197
Average	38.67	37.44	21.89

From the workstations Performance table we able to calculate the efficiency based on the pie chart data, the busy percentage of the overall plant, and where the idle percentage is a summation of waiting parts and blocked percentage. The unit produced is bread finish baking and packaging which is ready for shipping.

Using the formula (3.1) and (3.2)

$$\text{Idleness} = \text{Waiting parts} + \text{Blocked}$$

$$= 38.67 + 21.89 = 62.56 \%$$

$$\text{Efficiency} = 100\% - \text{Idleness}$$

$$= 100 - 62.56 = 37.44 \%$$

**Table 4.7** Plant Layout Performance

Efficiency (%)	Idleness (%)	Output (Units)	Productivity(units/ labor hour per day)
37.44	62.56	384	3.84

### 4.3 PROPOSED LAYOUT

#### 4.3.1 New Design Layout 1

The modification here is All 4 walls are removed, buffer capacity increase for Dough Stirring Mixing to 3, Trolley Dough Expanding to 192 units(3 trolleys), cooling provided 64 units (1 trolley) afterward., data shown on Table 4.17.

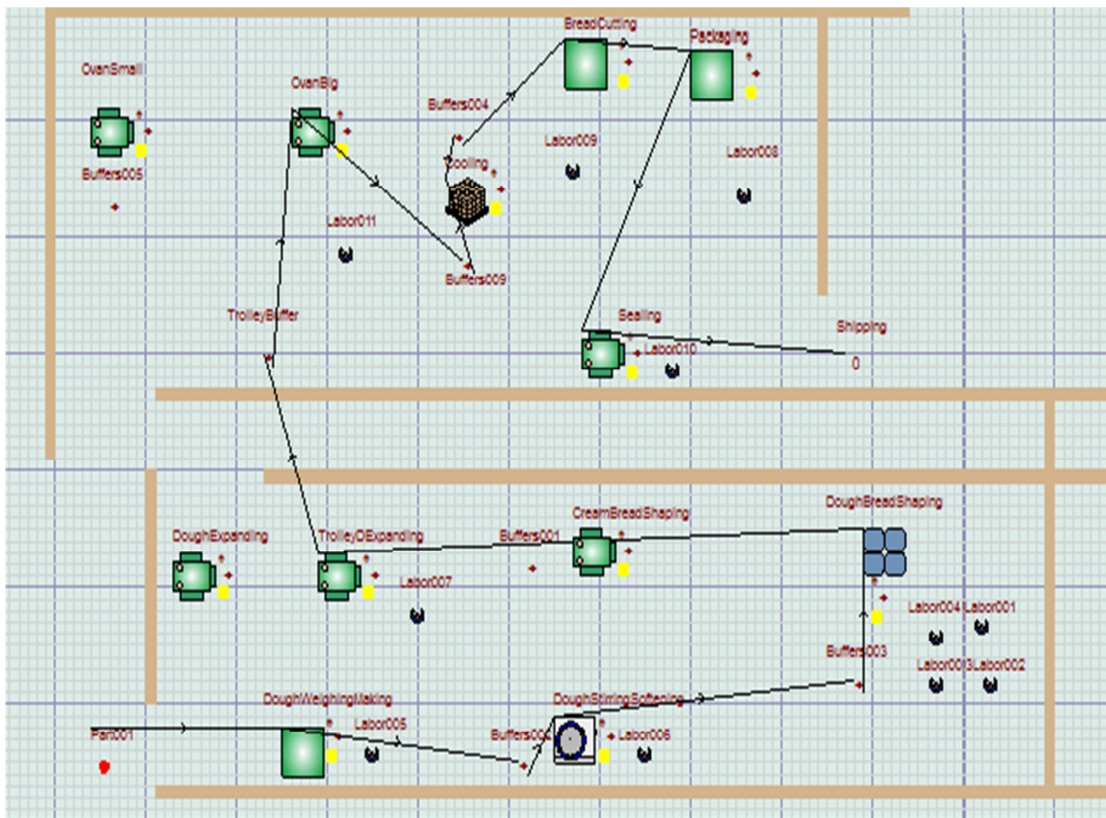


Figure 4.5 Process Flow before the Simulation 1

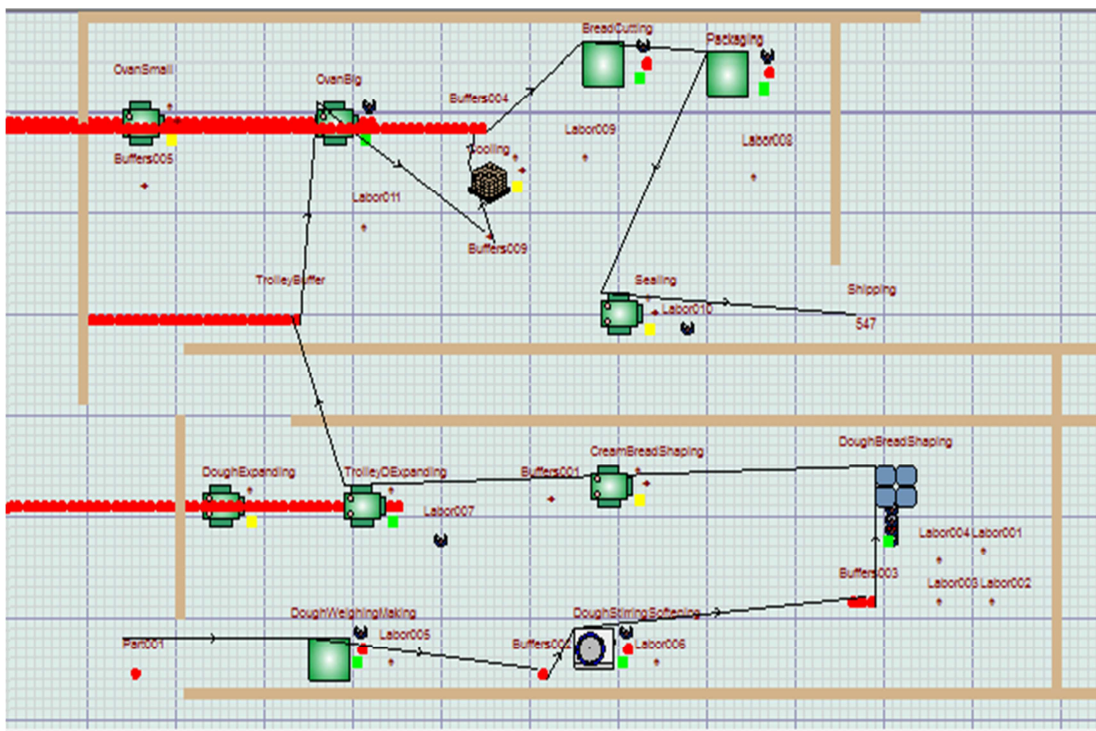
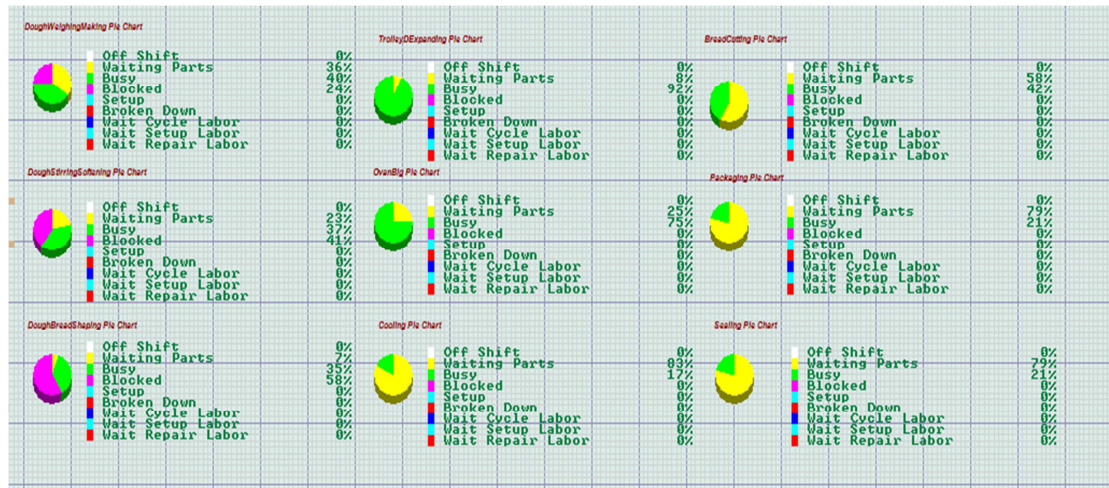


Figure 4.6 Process Flow after Simulation 1

Figure 4.5 and Figure 4.6 are shown before and after the Witness software running the simulation on the plant layout. From the process flow simulation, the bottle neck such as the red color part(half-finished product) is fully filled in the buffer or the machine can be seen.



**Figure 4.7** Performance Pie Charts of Workstations 1

From Figure 4.7 it represents the performance or status of machine for 1<sup>st</sup> new plant layout the status of machines or workstations are known in percentage within the time limit of 600 minutes from pie chart and the list shown above. Purple color represents status block which occurs when the buffer before the machine is full and the machine is finished process the half-finish products but have no way to send. The green color represents machine is busy processing the half-finished products. As for yellow color it represents the machine is currently waiting input to be processed. Then the data is recorded in the table 4.9.

**Table 4.8** New Layout Station Data 1

Process	Cycle Time	Machine Type	Input(unit)	Output(unit)	Buffer (after this station)	Buffer Capacity (approximate)
Dough Weighing	15.00	Single	1	1	Yes	1
Making						
Dough Stirring	15.00	Single	1	1	Yes	1
Mixing						
Dough Bread Shaping	20.00	Production	1	80	No	-
Trolley Dough Expanding	60.00	Batch	64 -384	64-384	Yes	192
Big Oven	40.00	Batch	56	56	Yes	128
Cooling	30.00	Batch	64-128	64-128	Yes	64
Bread Cutting	0.50	Single	1	1	No	-
Packaging	0.25	Single	1	1	No	-
Sealing	0.25	Single	1	1	No	-

**Table 4.9** Workstations Performance 1

Process	Waiting Parts (%)	Busy (%)	Blocked (%)
Dough Weighing	36	40	24
Making			
Dough Stirring Mixing	23	37	41
Dough Bread Shaping	7	35	58
Trolley Dough	8	92	0
Expanding			
Big Oven	25	75	0
Cooling	83	17	0
Bread Cutting	58	42	0
Packaging	79	21	0
Sealing	79	21	0
Total	398	380	123
Average	44.22	42.22	13.67

Using the formula (3.3)

Productivity = Unit produced/ labor hour per day

$$= 547 / 100 = 5.47 \text{ units/labor hours per day}$$

Using the formula (3.4) and (3.5) in calculating productivity and efficiency improvement in layout.

*Productivity Percentage Improvement*

$$= \frac{[5.47 \text{ (New)} - 3.84 \text{ (Old)}]}{3.84 \text{ (Old)}} \times 100\%$$

$$= 42.45\%$$

*Efficiency Percentage Improvement*

$$= \frac{[42.11 \text{ (New)} - 37.44 \text{ (Old)}]}{37.44 \text{ (Old)}} \times 100\%$$

$$= 12.47\%$$

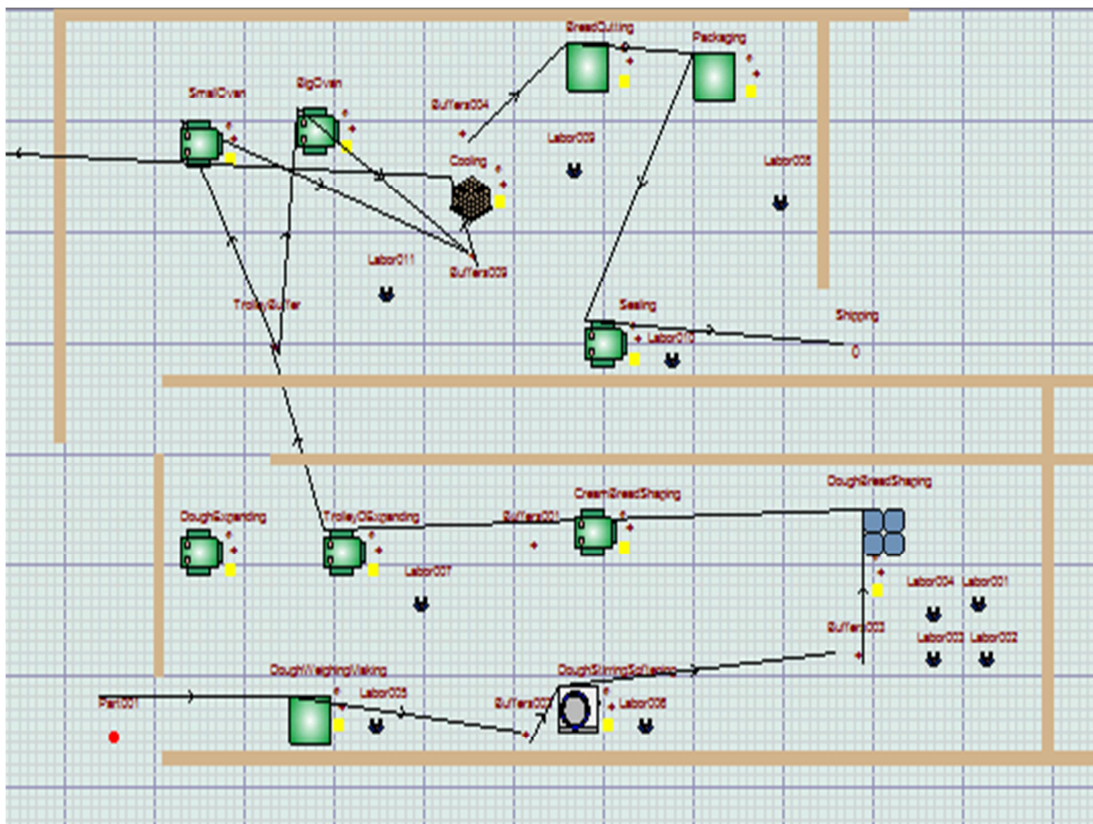


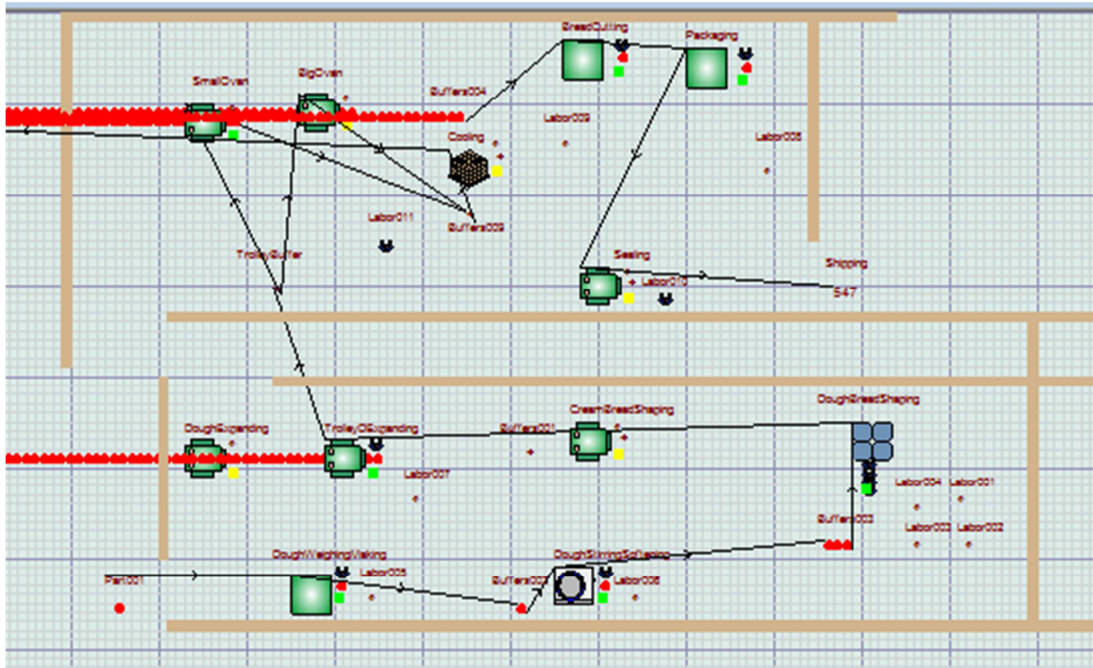
**Table 4.10** Plant Layout Performance

Efficiency (%)	Idleness (%)	Output (Units Produced)	Productivity	Productivity Improvement (%)	Efficiency Improvement (%)
42.11	57.89	547	5.47	42.45	12.47

### 4.3.2 New Design Layout 2

The modification here is removing 1 gate, installed one buffer after cooling station, rearrange bread cutting station and packaging station (cooling place capacity increase), increase capacity of the buffer after dough weighing and making workstation, it is shown in Table 4.11.

**Figure 4.8** Process Flow before the Simulation 2



**Figure 4.9** Process Flow Chart after Simulation 2

Figure 4.8 and Figure 4.9 is showing before and after the Witness software running the simulation on the plant layout. From the process flow simulation, the bottle neck such as the red color part(half-finished product) is fully filled in the buffer or the machine can be seen.



**Figure 4.10** Performance Pie Charts of Workstations 2



From Figure 4.10 it represents the performance or status of the machine for 2<sup>rd</sup> plant layout the status of machines or workstations are known in percentage within the time limit of 600 minutes from pie chart and the list shown above. Purple color represents status block which occurs when the buffer before the machine is full and the machine is finished process the half-finish products but have no way to send. The green color represents machine is busy processing the half-finished products. As for yellow color it represents the machine is currently waiting input to be processed. Then the data is recorded in the table 4.12.

**Table 4.11** New Layout Station Data 2

Process	Cycle Time	Machine Type	Input(unit)	Output(unit)	Buffer (after this station)	Buffer Capacity (approximate)
DoughWeighing Making	15.00	Single	1	1	Yes	1
DoughStirringMixing	15.00	Single	1	1	Yes	1
DoughBreadShaping	20.00	Production	1	80	No	-
TrolleyDoughExpanding	60.00	Batch	64-384	64-384	Yes	192
Big Oven	40.00	Batch	56	56	Yes	128
Cooling	40.00	Batch	32	32	-	-
Bread Cutting	30.00	Batch	64-128	64-128	Yes	64
Packaging	0.50	Single	1	1	No	-
Sealing	0.25	Single	1	1	No	-
Small Oven	0.25	Single	1	1	No	-

**Table 4.12** Workstations Performance 2

Process	Waiting Parts (%)	Busy (%)	Blocked (%)
Dough Weighing	36	40	24
Making			
Dough Stirring Mixing	23	37	41
Dough Bread Shaping	7	35	58
Trolley Dough	8	92	0
Expanding			
Big Oven	53	47	0
Cooling	83	17	0
Bread Cutting	58	42	0
Packaging	79	21	0
Sealing	79	21	0
Small Oven	45	55	0
Total	471	407	123
Average	47.1	40.7	12.3

Using the formula (3.3)

$$\begin{aligned} \text{Productivity} &= \text{Unit produced/ labor hour per day} \\ &= 547/ 100 = 5.47 \text{ units/labor hours per day} \end{aligned}$$

Using the formula (3.4) and (3.5) in calculating productivity and efficiency improvement in layout.

$$\begin{aligned} &\textit{Productivity Percentage Improvement} \\ &= \frac{[ 5.47 \text{ (New)} - 3.84 \text{ (Old)}]}{3.84 \text{ (Old)}} \times 100\% \\ &= 42.45\% \end{aligned}$$

$$\begin{aligned} &\textit{Efficiency Percentage Improvement} \\ &= \frac{[ 40.6 \text{ (New)} - 37.44 \text{ (Old)}]}{37.44 \text{ (Old)}} \times 100\% \\ &= 8.44\% \end{aligned}$$

Table 4.13 Plant Layout Performance 2

Efficiency (%)	Idleness (%)	Output (Units Produced)	Productivity 5.47	Productivity Improvement (%)	Efficiency Improvement (%)
40.6	59.4	547	5.47	42.45	8.44

### 4.3.3 New Design Layout 3

The modification here is removing 1 gate, installed one buffer after cooling station, it is shown on Table 4.17.

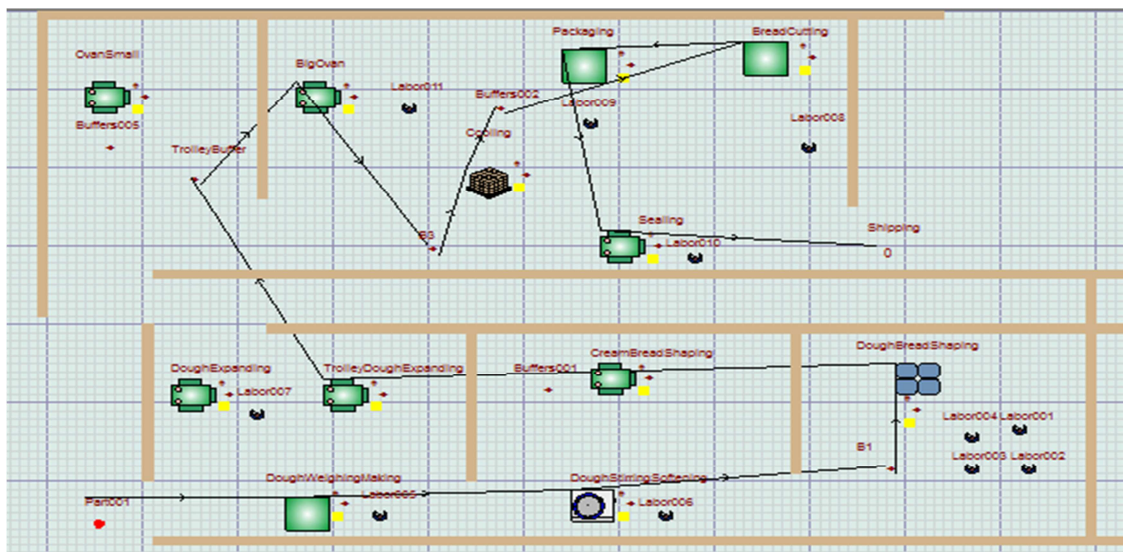


Figure 4.11 Process Flow before the Simulation 3

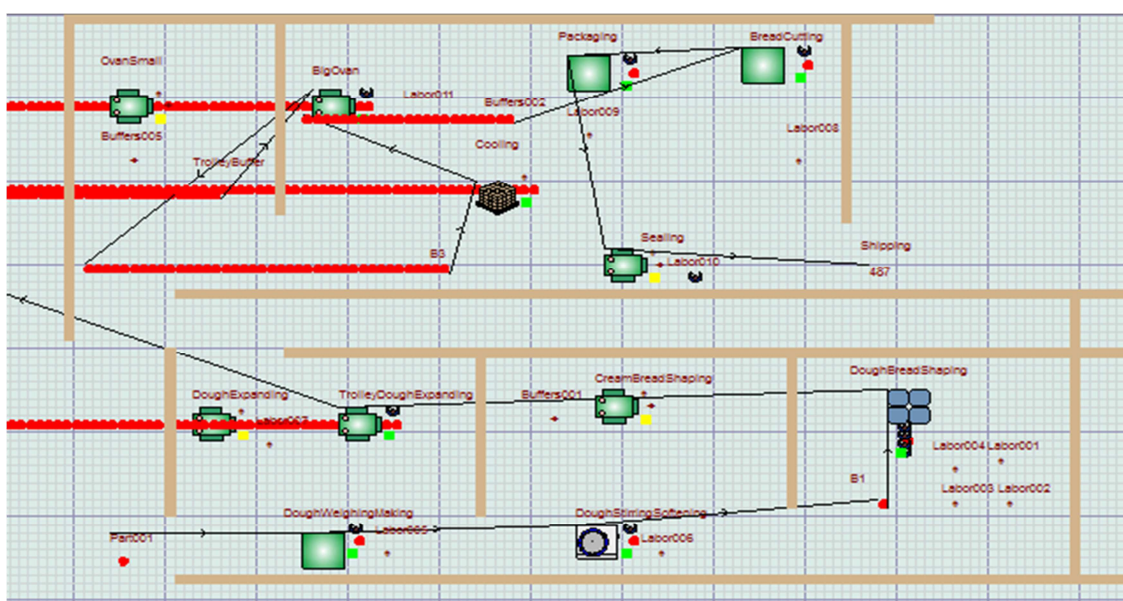
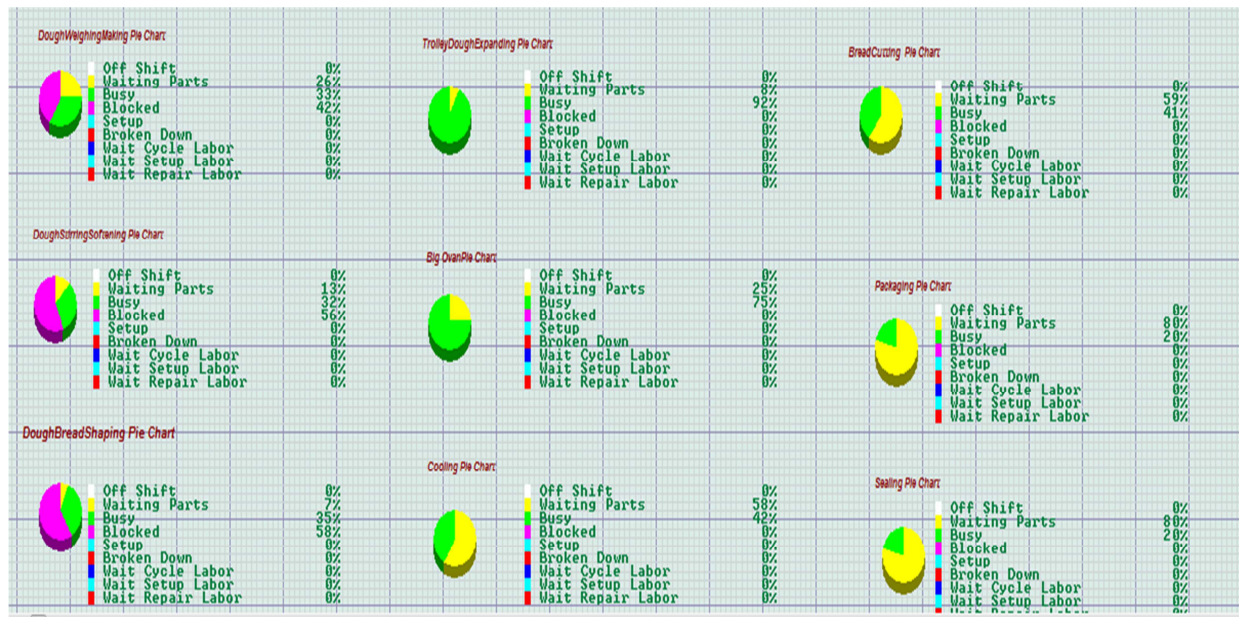


Figure 4.12 Process Flow after Simulation 3

Figure 4.11 and Figure 4.12 is showing before and after the Witness software running the simulation on the plant layout. From the process flow simulation, the bottle neck such as the red color part (half-finished product) is fully filled in the buffer or the machine can be seen.



**Figure 4.13** Performance Pie Charts of Workstations 3

From Figure 4.13 it represents the performance or status of machine for 3<sup>rd</sup> plant layout the status of machines or workstations are known in percentage within the time limit of 600 minutes from pie chart and the list shown above. Purple color represents status block which occurs when the buffer before the machine is full and the machine is finished process the half-finish products but have no way to send. The green color represents machine is busy processing the half-finished products. As for yellow color it represents the machine is currently waiting input to be processed. Then the data is recorded in the table 4.15.

**Table 4.14** New Layout Station Data 3

Process	Cycle Time	Machine Type	Input(unit)	Output(unit)	Buffer (after this station)	Buffer Capacity (approximate)
Dough Weighing	15.00	Single	1	1	No	-
Making						
Dough Stirring	15.00	Single	1	1	Yes	1
Mixing						
Dough Bread Shaping	20.00	Production	1	80	No	-
Trolley Dough Expanding	60.00	Batch	64 -192	64-192	Yes	128
Big Oven	40.00	Batch	56	56	Yes	128
Cooling	30.00	Batch	64	64	Yes	64
Bread Cutting	0.50	Single	1	1	No	-
Packaging	0.25	Single	1	1	No	-
Sealing	0.25	Single	1	1	No	-

**Table 4.15** Workstations Performance 3

Process	Waiting Parts (%)	Busy (%)	Blocked (%)
Dough Weighing	26	33	42
Making			
Dough Stirring Mixing	13	32	56
Dough Bread Shaping	7	35	58
Trolley Dough	8	92	0
Expanding			
Big Oven	25	75	0
Cooling	58	42	0
Bread Cutting	59	41	0
Packaging	80	20	0
Sealing	80	20	0
Total	356	390	156
Average	39.56	43.33	17.33

Using the formula (3.3)

$$\begin{aligned} \text{Productivity} &= \text{Unit produced/ labor hour per day} \\ &= 487/100 = 4.87 \text{ units/ labor hours per day} \end{aligned}$$

Using the formula (3.4) and (3.5) in calculating productivity and efficiency improvement in layout.

$$\begin{aligned} &\textit{Productivity Percentage Improvement} \\ &= \frac{[ 4.87 \text{ (New)} - 3.84 \text{ (Old)}]}{3.84 \text{ (Old)}} \times 100\% \\ &= 26.82\% \end{aligned}$$

$$\begin{aligned} &\textit{Efficiency Percentage Improvement} \\ &= \frac{[ 43.11 \text{ (New)} - 37.44 \text{ (Old)}]}{37.44 \text{ (Old)}} \times 100\% \\ &= 15.11\% \end{aligned}$$

**Table 4.16** Plant Layout Performance 3

Efficiency (%)	Idleness (%)	Output (Units Produced)	Productivity	Productivity Improvement (%)	Efficiency Improvement (%)
43.11	56.89	487	4.87	26.82	15.11



#### 4.3.4 New Design Layout 4

The modification here is removing 1 gate, installed one buffer after cooling station, rearrange bread cutting station and packaging station (cooling place capacity increase), increase capacity of the buffer after dough weighing and making workstation, it is shown in Table 4.17.

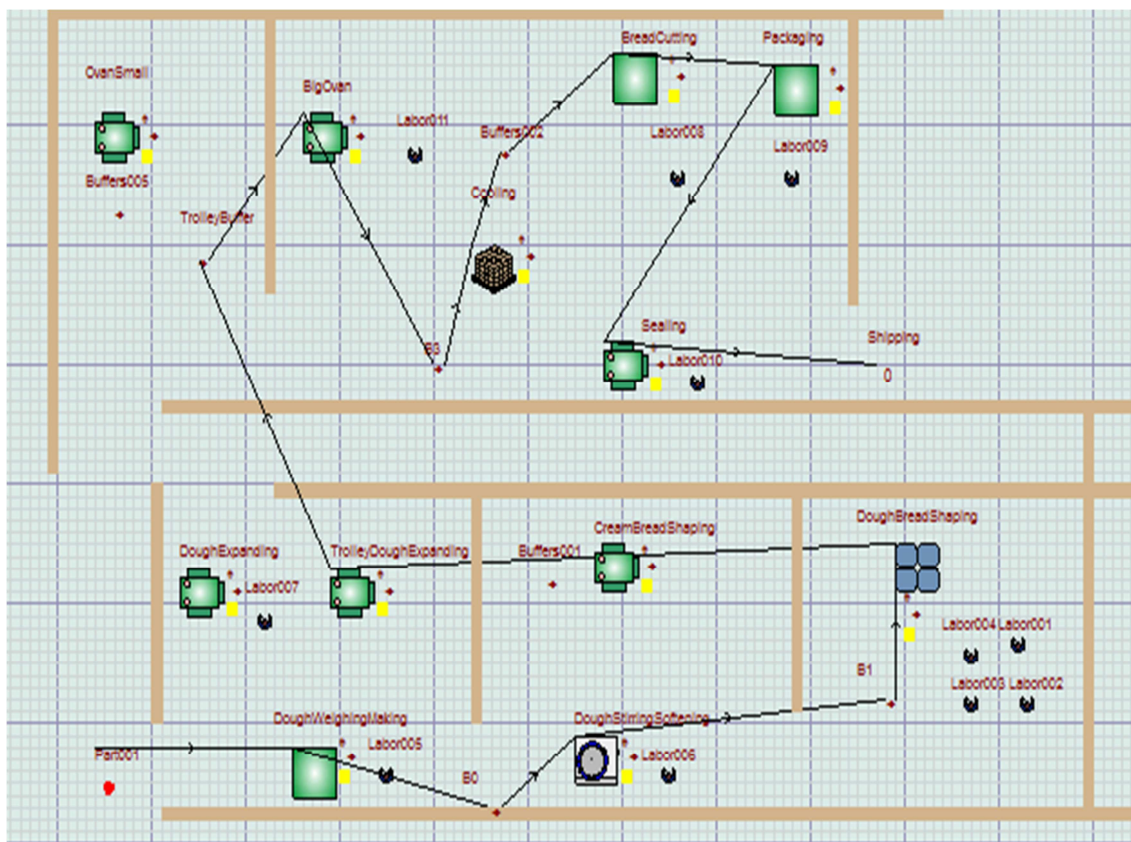


Figure 4.14 Process Flow before the Simulation 4

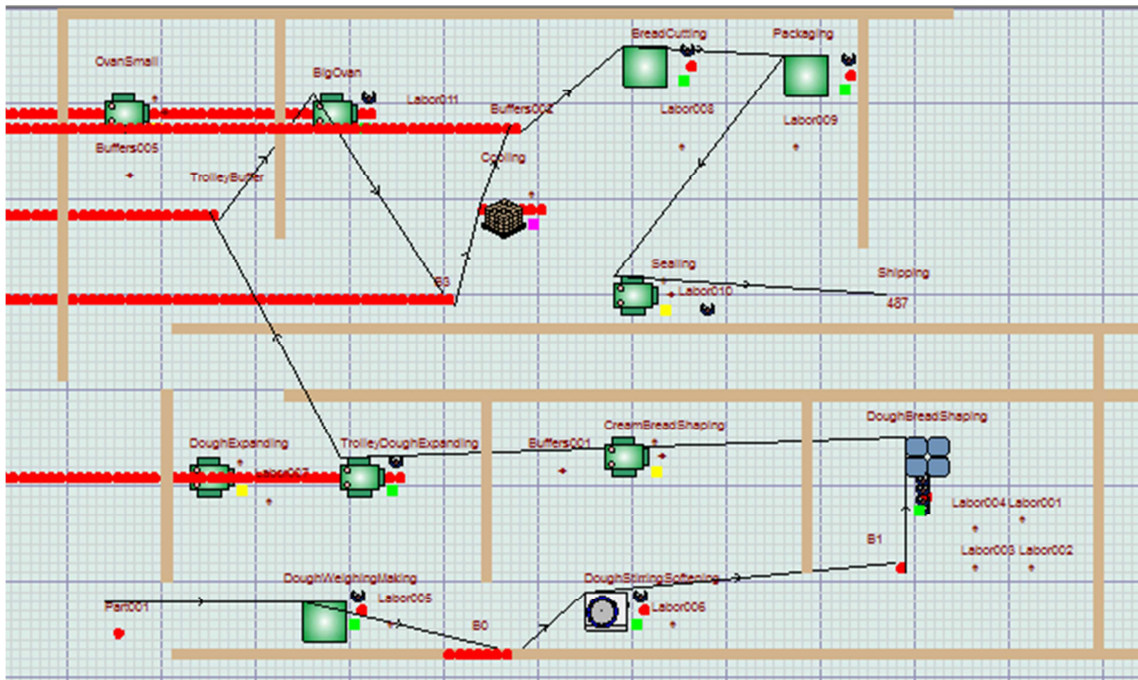


Figure 4.15 Process Flow after Simulation 4

Figure 4.14 and Figure 4.15 are shown before and after the Witness software running the simulation on the 4<sup>th</sup> new plant layout . From the process flow simulation, the bottle neck such as the red color part (half-finished product) is fully filled in the buffer or the machine can be seen.

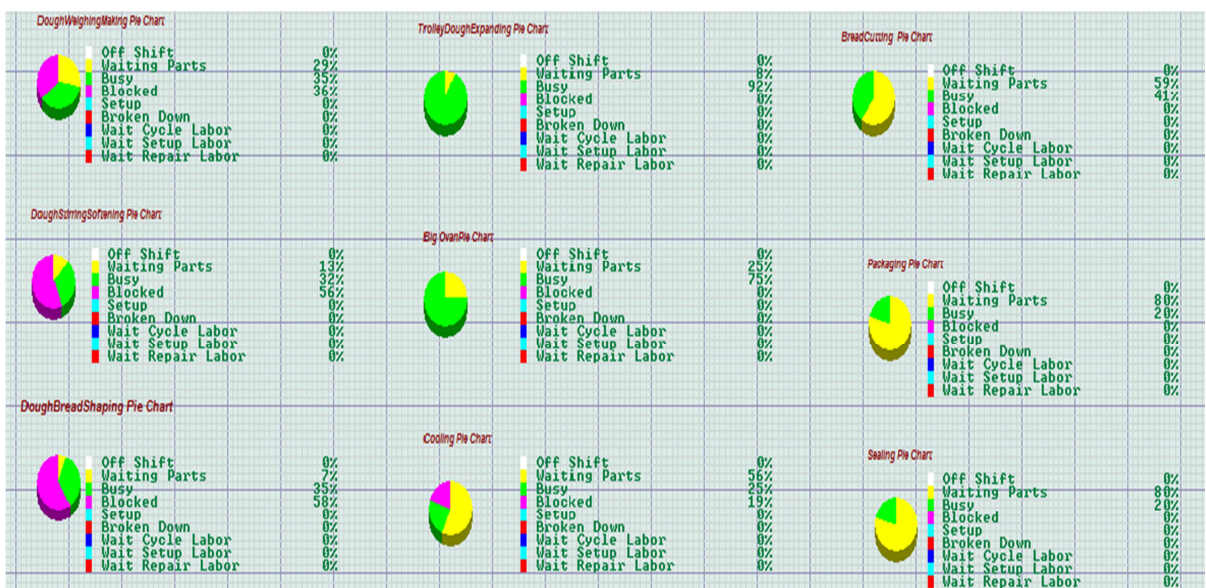


Figure 4.16 Performance Pie Charts of Workstations 4

From Figure 4.16 it represents the performance or status of machine for 4<sup>th</sup> plant layout the status of machines or workstations are known in percentage within the time limit of 600 minutes from pie chart and the list shown above. Purple color represents status block which occurs when the buffer before the machine is full and the machine is finished process the half-finish products but have no way to send. The green color represents machine is busy processing the half-finished products. As for yellow color it represents the machine is currently waiting input to be processed. Then the data is recorded in the table 4.18.

**Table 4.17** New Layout Station Data 4

Process	Cycle Time	Machine Type	Input(unit)	Output(unit)	Buffer (after this station)	Buffer Capacity (approximate)
Dough Weighing Making	15.00	Single	1	1	Yes	8
Dough Stirring Mixing	15.00	Single	1	1	1	1
Dough Bread Shaping	20.00	Production	1	80	No	-
Trolley Dough Expanding	60.00	Batch	64 -192	64-192	Yes	128
Big Oven	40.00	Batch	56	56	Yes	128
Cooling	30.00	Batch	64-128	64-128	Yes	64
Bread Cutting	0.50	Single	1	1	No	-
Packaging	0.25	Single	1	1	No	-
Sealing	0.25	Single	1	1	No	-

**Table 4.18** Workstations Performance 4

Process	Waiting Parts (%)	Busy (%)	Blocked (%)
Dough Weighing Making	29	35	36
Dough Stirring Mixing	13	32	56
Dough Bread Shaping	7	35	58
Trolley Dough Expanding	8	92	0
Big Oven	25	75	0
Cooling	56	25	19
Bread Cutting	59	41	0
Packaging	80	20	0
Sealing	80	20	0
Total	357	375	169
Average	39.67	41.67	18.78

Using the formula (3.3)

$$\begin{aligned} \text{Productivity} &= \text{Unit produced/ labor hour per day} \\ &= 487/100 = 4.87 \text{ units/labor hours per day} \end{aligned}$$

Using the formula (3.4) and (3.5) in calculating productivity and efficiency improvement in layout.

$$\begin{aligned} &\textit{Productivity Percentage Improvement} \\ &= \frac{[4.87 \text{ (New)} - 3.84 \text{ (Old)}]}{3.84 \text{ (Old)}} \times 100\% \\ &= 26.82\% \end{aligned}$$

$$\begin{aligned} &\textit{Efficiency Percentage Improvement} \\ &= \frac{[41.55 \text{ (New)} - 37.44 \text{ (Old)}]}{37.44 \text{ (Old)}} \times 100\% \\ &= 10.98\% \end{aligned}$$

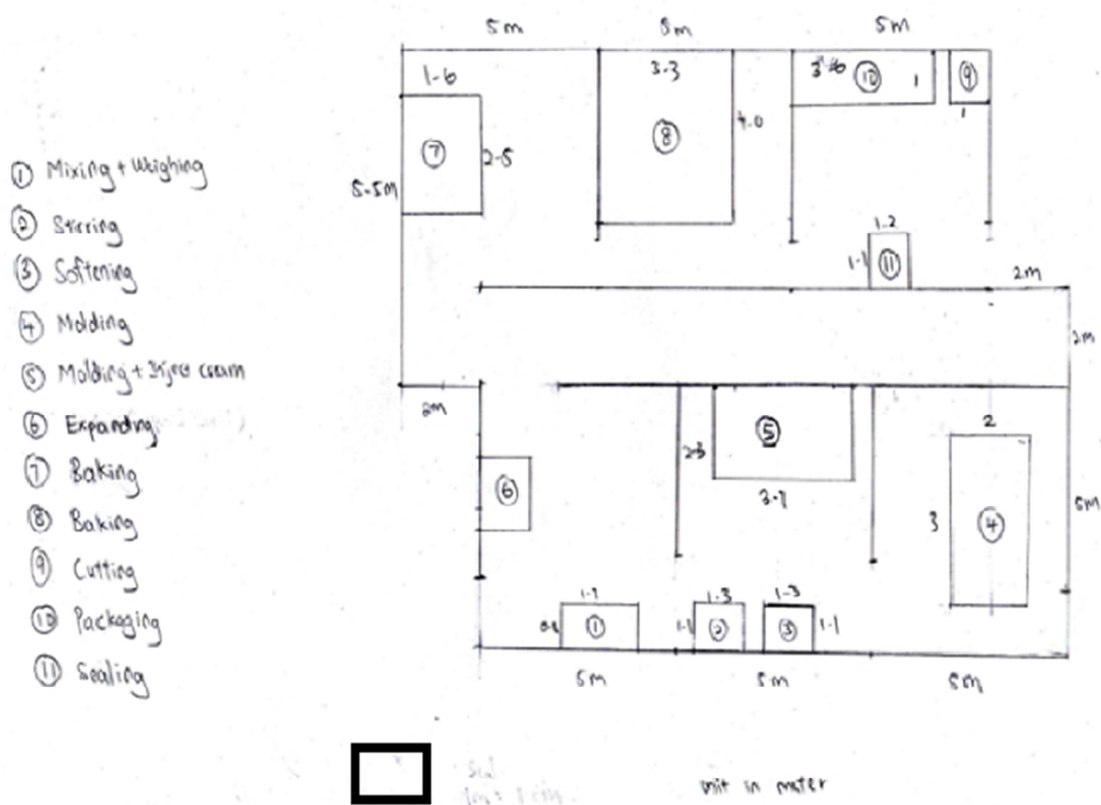
**Table 4.19** Plant Layout Performance 4

Efficiency (%)	Idleness (%)	Output (Units Produced)	Productivity	Productivity Improvement (%)	Efficiency Improvement (%)
41.55	58.45	487	4.87	26.82	10.98

#### 4.4 LAYOUTS ANALYSIS

##### 4.4.1 Workstations Capacity

In the simulation the units of the sandwich bread are moved by a trolley, the trolley has around 8 levels of place to put tray, 1 level can put 8 units of sandwich breads so total number of bread in one trolley is 64 units. 128 units mean 2 trolleys, and 192 units mean 3 trolleys, lastly 384 unit mean 6 trolleys in a place. As shown below the original layout with a scale of 1 cm: 1meter. The bold color rectangular below represent a size of trolley with approximate 1 x 2 m<sup>2</sup> surface area, during the simulation by removing the wall we can estimate the capacity of the buffer and workstations like the cooling part which is located at the top right in the center of the workstation of number 9, 10 ,11. And 1 trolley approximates 64 units of sandwich breads.



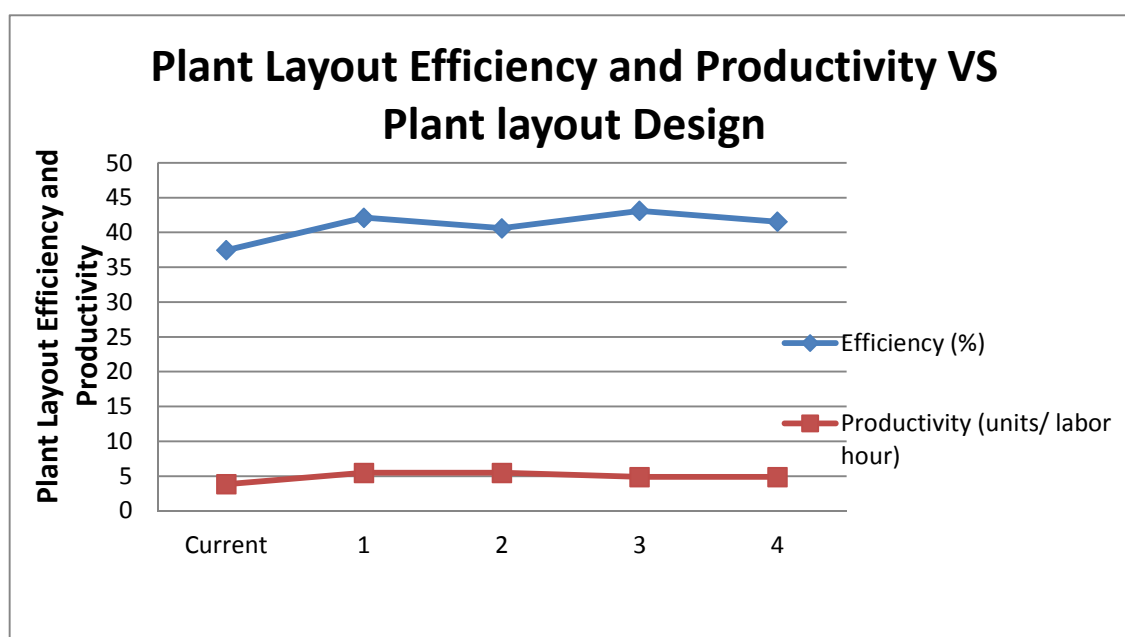
**Figure 4.17** Hand Drawing's Original Layout

Figure 4.17 is the hand drawing from the collected data on size, length of the machine and the size of the factory, which is used in estimating the size of the buffer and workstation when building plant layout model to be run simulation in Witness Software.

#### 4.4.2 Results Comparison

**Table 4.20** Results Comparison

Layout	Layout Efficiency (%)	Layout Idleness (%)	Productivity (Units/ labor hours)	Productivity Improvement (%)	Efficiency Improvement (%)
Current	37.44	62.56	3.84	-	-
1	42.11	57.89	5.47	42.45	12.47
2	40.60	59.40	5.47	42.45	8.44
3	43.11	56.89	4.87	26.82	15.11
4	41.55	58.45	4.87	26.82	10.98

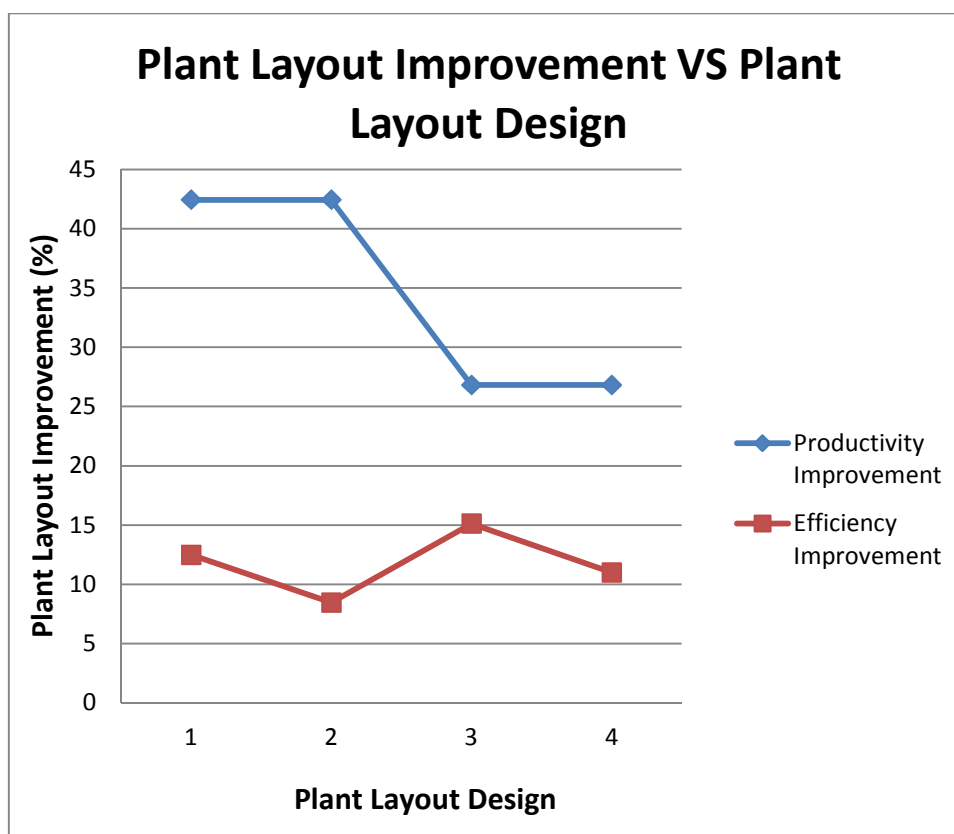


**Figure 4.18** Comparisons of Plant Layout Efficiency and Productivity

The Figure 4.18 shows the efficiency and productivity of the design layout for current layout and 4 new proposed layout. For current layout the efficiency and productivity are 37.44% and 3.84 units/labor hours respectively. For 1<sup>st</sup> proposed layout the efficiency and productivity are 42.11% and 5.47 units/labor hours respectively. For



2<sup>nd</sup> proposed layout the efficiency and productivity are 40.60% and 5.47 units/labor hours respectively. For 3<sup>rd</sup> proposed layout the efficiency and productivity are 43.11% and 4.87 units/labor hours respectively. For 4<sup>th</sup> proposed layout the efficiency and productivity are 41.55% and 4.87 units/labor hours respectively.



**Figure 4.19** Comparisons of Plant Layout Efficiency Improvement and Productivity Improvement

The Figure 4.19 shows the improvement in efficiency and productivity based on the Table 4.20. Among all the higher Productivity improvement is design 1 and design 2 plant layout which is 42.45% and for design 3 and 4 the productivity improvement is 26.82 %.

As in the efficiency improvement design 3 is the highest with 15.11%, second go to design 1 which is a 12.47 % improvement, follow by design 4 which is 10.98% and lastly design 4 with 8.44 %.



**Table 4.21** Workstation and Buffer Capacity Comparison

Layout	Workstation Name	Capacity	Buffer	Buffer Capacity
Current	Dough Weighing	1	Yes	1
	Making			
	Dough Stirring	1	No	-
	Softening			
	Trolley Dough	64-192	Yes	128
	Expanding			
	Big Oven	56	Yes	128
1	Cooling	64	No	-
	Dough Weighing	1	Yes	1
	Making			
	Dough Stirring	1	Yes	1
	Softening			
	Trolley Dough	64-384	Yes	192
	Expanding			
2	Big Oven	56	Yes	128
	Cooling	64-128	Yes	64
	Dough Weighing	1	Yes	1
	Making			
	Dough Stirring	1	Yes	1
	Softening			
	Trolley Dough	64-384	Yes	192
3	Expanding			
	Big Oven & Small Oven	56 + 32	Yes	128
	Cooling	64-128	Yes	64
	Dough Weighing	1	Yes	1
	Making			
	Trolley Dough	64-192	Yes	128
	Expanding			
	Big Oven	56	Yes	128

	Cooling	64	Yes	64
4	Dough Weighing	1	Yes	1
	Making			
	Dough Stirring	1	Yes	1
	Softening			
	Trolley Dough	64-192	Yes	128
	Expanding			
	Big Oven	56	Yes	128
	Cooling	64-128	Yes	64

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#### 4.4.3 Design 1

The improvement made for the first design layout is two walls in the 1<sup>st</sup> half of the process and 2<sup>nd</sup> half of the process. In doing so the, Capacity of trolley dough expanding station increase, in which the place for dough to stay and left for expanding is increased from maximum 192 units to 384 units. Then the removal of wall in the second half together with the rearrangement of bread cutting stations and packaging station have increased the capacity of the cooling station from 64 to 128 units of loaf . And at the same time able to provide a buffer after cooling with 64 units of bread.

From the simulation and calculation, we get an efficiency of plant layout is 42.11 %, Idleness 57.89%, producing 5.47 units per labor hour per day, maximum output 547 units. Improvement in productivity is 42.45%, and in efficiency improvement is 12.47% shown in Table 4.20.

The improvement made have increased the capacity of Dough Expanding Station from 192 to 384 units and the buffer capacity 128 to 192 units, and also increase the capacity of cooling workstation 64 to 128 units and buffer capacity provide after cooling workstation with 64 units capacity which have eliminated most of the bottleneck, thus lead to increase in productivity by 42.45% and Plant layout performance efficiency 12.47%.

#### 4.4.4 Design 2

The improvement made for the first design layout is 2 walls in the 1<sup>st</sup> half of the process and 2<sup>nd</sup> half of the process. And with extra using of one more ovens with capacity input and output of 32 sandwiches bread maximum. Capacity of trolley dough expanding station increases. In which the place for dough to stay and left for expanding is increased from maximum 192 units to 384 units. Then the remove of wall in the second half and the rearrangement of bread cutting stations and packaging station have increased the capacity (area) of the cooling workstation from 64 to 128 units . And at the same time able to provide a buffer after cooling with 64 units of bread.

From the simulation and calculation, we get an efficiency of plant layout with 40.6 %, Idleness 59.4%, Producing 5.47 units per labor hour per day, maximum output 547 units. Improvement in productivity is 42.45%, and in Efficiency improvement is 8.44% shown in Table 4.20.

The improvement made have increased the capacity of Dough Expanding Station from 192 to 384 units and the buffer capacity 128 to 192 units, and also increase the breads cooling workstation 64 to 128 units and more place provide for capacity after cooling workstation with 64 units capacity which have eliminated most of the bottleneck, thus lead to increase in productivity by 42.45% and Plant layout performance efficiency 8.44%.

From the use of one more oven it is seen that the maximum output of the units produced does not increase. But the efficiency of layout is improved compared to current layout but lower relatively compared the 1<sup>st</sup> design layout. The bottleneck will occur here because as the capacity of the oven is increased but the buffer provides for half finished product is still the same and thus causing the oven have to stop the operation as waiting for buffer the clear place as the half finish product made its way to the following work station.

#### **4.4.5 Design 3**

The improvement made for the fourth design layout is remove 1 wall of 2nd half of the process.

From the simulation and calculation, we get an efficiency of plant layout with 43.11%, Idleness 56.89%, Producing 4.87 units per labor hour per day, maximum output 487 units. Improvement in productivity is 26.82%, and in efficiency improvement is 15.11%. shown in Table 4.20.

The improvement made have increased buffer after cooling workstation with 64 units capacity which have eliminated most of the bottleneck, it is important that always provide enough buffer place so that bottle neck or the machine operation won't block due to not enough space to store half-finished product after finish processing. From the simulation and calculation get the results in increasing in productivity by 26.82% and Plant layout performance efficiency 15.11% shown in Table 4.20.

#### **4.4.6 Design 4**

The improvement made for the fourth design layout is remove 1 wall of 2nd half of the process. And also rearrangement of the bread cutting station and packaging station, the process flow goes on smoothly and increase the capacity of the cooling workstation.

From the simulation and calculation, we get an efficiency of plant layout with 43.66 %, Idleness 56.34%, producing 4.87 units per labor hour per day, maximum Output 487 units. Improvement in productivity is 26.82%, and in efficiency improvement is 16.61% shown in Table 4.20.

The improvement made had increase the cooling workstation capacity from 64 units to 128 units of loaf and provide place for buffer after cooling workstation with 64 units capacity which have eliminate most of the bottleneck, from this layout design the

is in reducing cost in wall removing, so change is made in the most important place which is operation after and before the oven (with cycle time 40 min) which make they are always enough buffer place so that bottle neck won't occur at oven workstation or station after this. From the simulation and calculation get the results increase in productivity in 26.82% and Plant layout performance efficiency 16.11%.

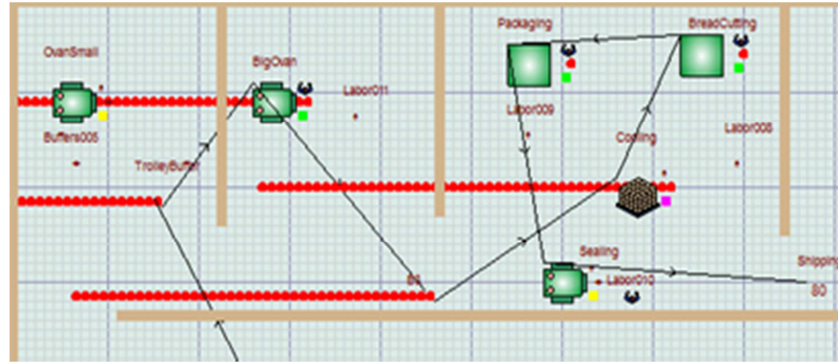
## **4.5 DISCUSSION**

### **4.5.1 Balanced Process**

Bottleneck problem is caused when there is a gap between the capacity of the machine. For example taking Oven workstation with a capacity of 56 units and the next Breads cooling 40 units, the bottleneck here occurs in which the oven station has to wait before the 64 units finish 2 processes repeatedly at a cooling station unless there are buffer provide is enough to store the half finish product and the cooling workstation together finish process all the units before oven workstation finish process the input. If there was no buffer provided, a system is balanced when the output of each step supplies the exact volume of input required by following step or the process cycle time of the following station is longer and is able finish the inputs before next input arrive. Otherwise, there will appear bottlenecks.

### **4.5.2 Factor Affecting Plant Layout Productivity**

In Breads Factory that few factors have observed which have affected the productivity is the waiting time of a machine for input to arrive. And another factor is the building where the space area is constraint the capacity of the buffer can provide, and thus indirectly increase the waiting time and machine in blocked status which have to wait the buffer space to empty before starting operating again..



**Figure 4.20** Bottleneck in the Process

In the analysis of all the design layout and the current layout and from simulation, the cause of bottleneck come from an insufficient place to store half-finish product for workstation like an oven with a cycle time of 40 minutes, capacity of processing in 56 units of loaf; and cooling workstation with a cycle time of 30 min, and capacity of processing in 64 units of loaf. So bottle neck has not occurred since every 30 minutes cooling station finish processing all product, it will have an extra 10 min waiting input from oven workstation, and have extra 8 units space to spare.

But the station following is the bread cutting workstation with 0.5 minutes of cycle time, each time process 1 loaf. From Figure 4.18, if no buffer place provided, the cooling workstation will have to stop operating before buffer place clear out, it can be seen in the figure icon with Cooling is full of red dot, the machine is currently in blocked status. Thus indirectly causing the oven station to be blocked and stop operation if the buffer in between the oven and cooling workstation full as well.

### 4.5.3 Suitable Layout

From the all design has been proposed, the first 2 design is focused on removing all the walls from 1<sup>st</sup> half and 2<sup>rd</sup> half of the shift. From this 2 design the buffer is provided and increasing the capacity, but the 2<sup>rd</sup> design using 2 oven which is available but the effect is not as good as it then, since the space area is very limited so are the

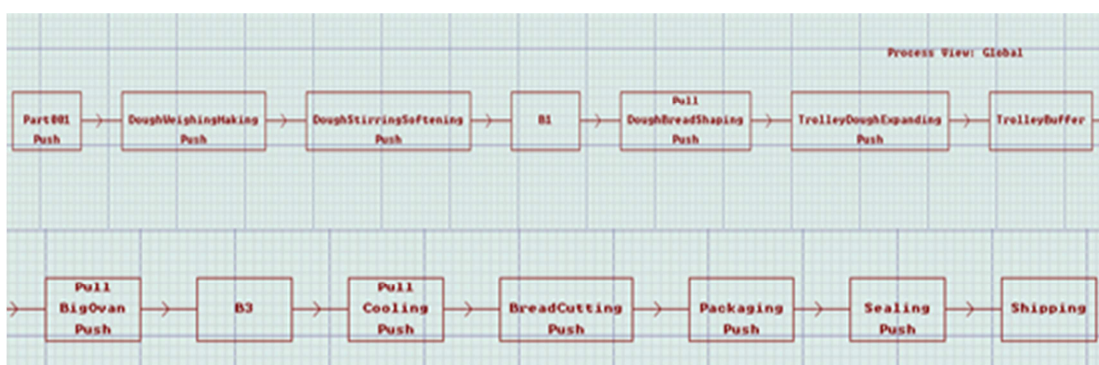
buffer provider, the process will be delayed when the buffer provide is full and the next station is not finished processing the input units. Thus, the bottleneck will occur, process have to be waiting.

As for 3<sup>rd</sup> and 4<sup>th</sup> design layout, it is focused on removing the wall of the second half of the shift. In 3<sup>rd</sup> design layout buffer has been provided at the station after oven, cooling station capacity is increased as well. But since the walls at the 1<sup>st</sup> half of the shift is not removed so the capacity at the Dough Expanding workstation is remaining the same, so productivity improvement not as good 1<sup>st</sup> and 2<sup>rd</sup> design layout, but still lead to productivity and efficiency improvement. As for the 4<sup>th</sup> design layout, they are rearranged for the cutting bread station and packaging station in which more area is providing increased the capacity of the cooling station and smoothen the process flow, thus efficiency improvement is slightly higher than 3<sup>rd</sup> design layout.

So at long term prospect, the best layout design is the 1<sup>st</sup> design layout which has the highest improvement in productivity and plant layout efficiency.

## 4.6 PROCESS FLOW AND BUFFER CAPACITY OVERVIEW

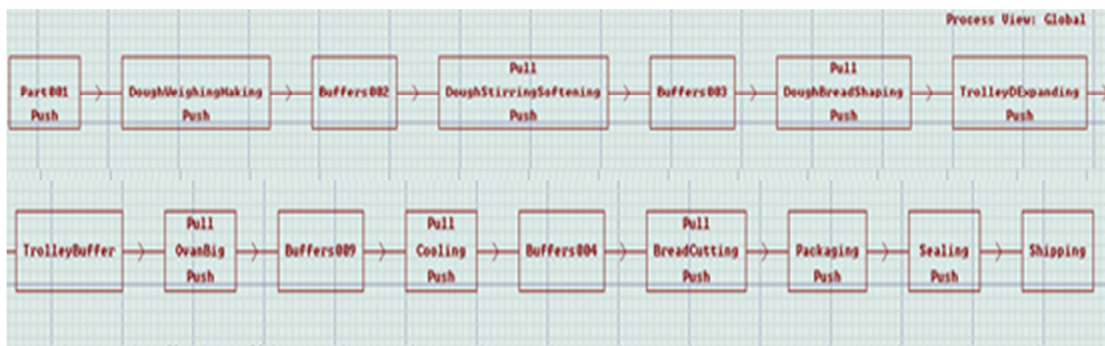
### 4.6.1 Current Layout



**Figure 4.21** Process Flow of Original Layout

Figure 4.18, B1, Trolley Buffer, B3 is buffer with a capacity of 1, 128, 128 respectively with 64 units breads for 1 trolley, and 2 trolleys for 128 numbers. B1 is a buffer for placing the finish mixing and weighing dough. Trolley buffer is provided to place before put into baking. And B3 is place for finish baked bread preparing to be cool down by fans before pack up.

#### 4.6.2 First Proposed Layout

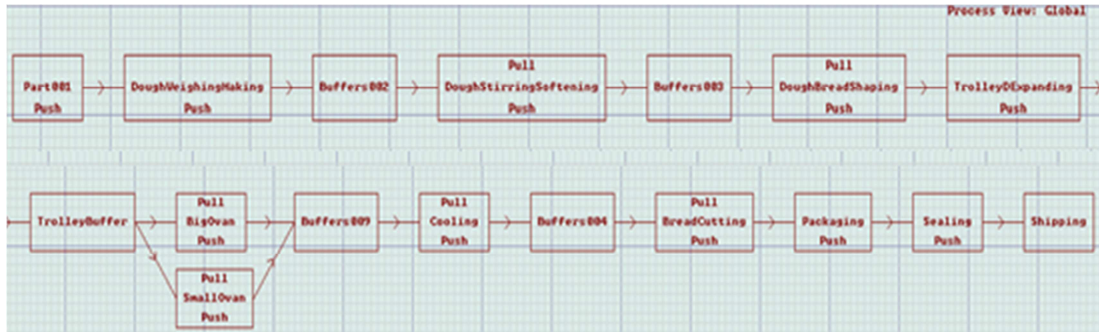


**Figure 4.22** Process Flow of New Layout Design 1

Figure 4.19, Buffer002, Buffer003, Trolley Buffer, Buffer009, Buffers004 is a buffer with a capacity of 1, 1, 192, 128, 64. By removing the wall of lower side and upper side of the layout the buffer capacity after trolley expanding is increasing from 128 to 192, 3 trolleys; and 1 trolley 64 unit's buffer after cooling workstation.



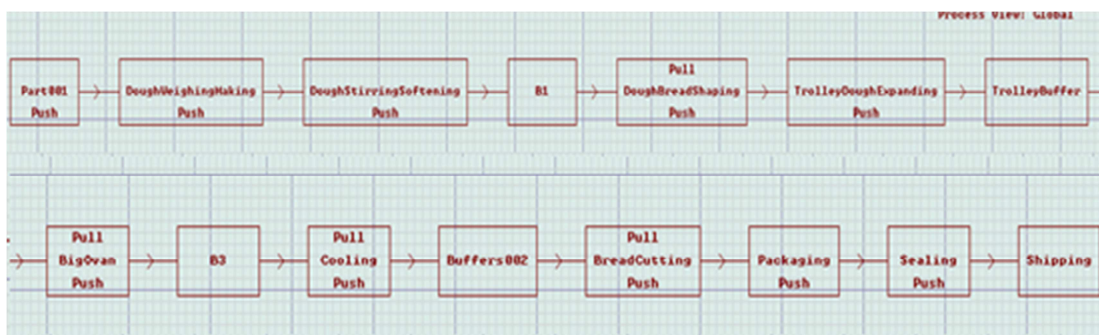
### 4.6.3 Second Proposed Layout



**Figure 4.23** Process Flow of New Layout Design 2

Figure 4.20, Buffer002, Buffer003, Trolley Buffer, Buffer009, Buffer004 is a buffer with a capacity of 1, 1, 192, 128, 64. The process modifies with one more oven is and the rest is same as above.

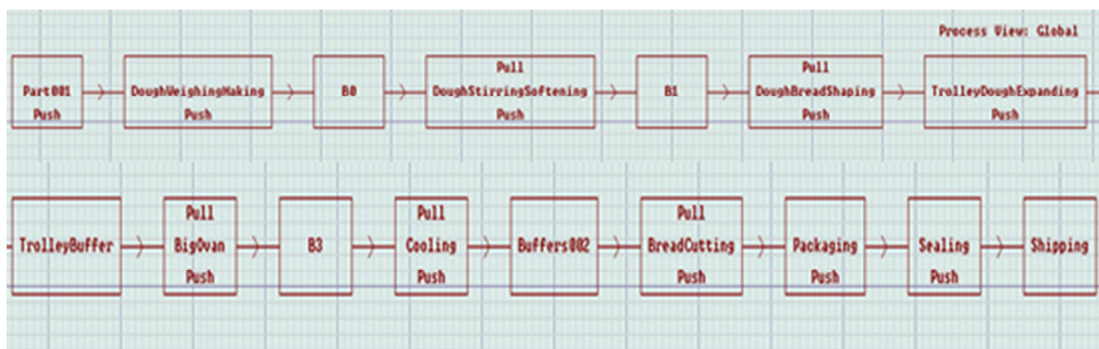
### 4.6.4 Third Proposed Layout



**Figure 4.24** Process Flow of New Layout Design 3

Figure 4.21, B1, Trolley Buffer, B3, Buffer004 is a buffer with capacity 1, 128, 128, 64. With only the upper layout's wall is removed, providing the buffer after the cooling workstation with a capacity of 64 units.

#### 4.6.5 Fourth Proposed Layout



**Figure 4.25** Process Flow of New Layout Design 4

Figure 4.22, B0, B1, Trolley Buffer, B3, Buffer004 is a buffer with capacity 8, 1, 128, 128, 64. In this layout rearrange the workstation of Packaging and sealing which provide more capacity for cooling workstation 128 units from the 3<sup>rd</sup> proposed layout design.

## **CHAPTER V**

### **CONCLUSIONS**

#### **5.1 INTRODUCTION**

In this chapter, conclusions in the current layout, 4 other proposed layout, major finding in bottleneck, and the recommendations which could be applied in this company will be made.

## 5.2 DISCUSSION OF MAJOR FINDING

From the design the efficiency improvement from 1st to 4th new layout design is 12.47%, 8.44%, 15.11%, 16.11% respectively. As for productivity improvement 42.45%, 42.45%, 26.82%, 26.82% respectively shown in Table 4.20.

From the all of the new layout design, the productivity increase with 2 major factors. First is providing buffer place before increasing the capacity of the workstation in processing the half-finish product; second one is balancing the workstation based on the process flow with U-shape instead of zigzag lines like the cutting and the sealing workstation, indirectly provide more space (buffer capacity increase) to store half-finished product, so bottleneck will occur less.

The bottle neck occurs when they are no buffer provide in between the successive workstation with capacity and cycle times are different. The bottleneck will occur slowly if buffer provides in between.. Taking example oven workstation with a capacity of 56 units and the buffer capacity before the workstation is 64 units, the bottleneck here occurs when the 8 units accumulated repeatedly until 64 units of the buffer capacity is full fill every time oven finish processing the bread.

By increasing the capacity of the of workstation doesn't necessarily increase the productivity, in design 1 and design 2. The productivity is the same based on the units of load produced which is 42.45%. Where efficiency improvement for design 1 is 12.47% and design 2 is 8.44%. The decreasing in efficiency of 2rd design due to waiting time increase since 2 oven is using process take place by turn. With the buffer capacity is 64 units and total capacity of 2 ovens uses 88 units, after the 64 units capacity buffer is fully filled. Process on oven have to stop to wait for buffer clear before starting another process.

In the 4th, increasing the capacity to 128 units of cooling workstation causing the blocked status of the machine. Since the buffer capacity is 64 units, after finish processing half-finished product in cooling workstation, it will have to wait the buffer space to clear the before it can operate again since no space to store for another output. For 3rd design the capacity of cooling workstation and buffer capacity is same, and the workstation afterwards able finish processing all 64 units of loaf before the buffer space is filling up, so no blockage or bottleneck occur. And this lead to higher efficiency improvement 15.11% for 3rd design, and 10.98% improvement due to blocked status at cooling machine.

### **5.3 RECOMMENDATION**

From the analysis of the original plant layout and the new design layout, to increase the productivity and efficiency of the plant layout, it is important to provide the buffer place for every each of the workstations before increase the capacity of the machine. Otherwise, the workstation will be staying in status of blocked since they will be not enough place to store the half-finish product. Waiting is required before the following workstation is finished processing the product, only then the buffer space in between the workstations will be clear, and then the process can start again. So delay will occur more often, lead to a more bottleneck in the overall process.

Providing more space (buffer) to store half-finished product by removing the wall, and balancing the process with relocating the workstations will also produce space for the buffer. So that the process will go on more smoothly.

## 5.4 CONCLUSION

By increasing the productivity mean producing more output with the same amount of input such as labors, electricity cost and so on. Increasing efficiency means decreasing the time required to produce the products, the workstation will be busy processing the half-finish product instead of staying in idle or waiting status. It is important that increasing efficiency and productivity of plant layout in order to be more competent and delivering the units of product on time. From the all new layout designs proposed it is recommended that the 1st proposed design with efficiency improvement of 12.47% and productivity improvement of 42.45%, the highest among 4 proposed layout designs is recommended to implement and replace the old plant layout.

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## APPENDICES

### A1 Gantt chart Final Years Project 1

Project Activities	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13
Read Journal													
Do Literature Review													
Do Report Introduction													
Do Report Methodology													
Visit SME Companies													
Learning WITNESS Software													
Final Report Compiling													
Preparing Presentation Slide													
Presentation													



**CHUA YEE LEONG MA09070 BACHELOR OF MECHANICAL ENGINEERING 2013**

PRODUCTIVITY IMPROVEMENT IN SME INDUSTRY THROUGH NEW PLANT  
LAYOUT DESIGN BY USING WITNESS  
SOFTWARE

CHUA YEE LEONG

Thesis submitted in fulfillment of the requirements  
for the award of the degree of  
Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering  
UNIVERSITI MALAYSIA PAHANG

JUNE 2013

## **EXAMINERS APPROVAL DOCUMENT**

UNIVERSITI MALAYSIA PAHANG  
FACULTY OF MECHANICAL ENGINEERING

I certify that the report entitled 'Productivity Improvement in SME Industry Through New Plant Layout Design by Using Witness Software' is written by Chua Yee Leong. I have examined the final copy of this report and in my opinion, it is fully adequate in terms of the language standard, and report formatting requirement for the award of the degree of Bachelor of Mechanical Engineering. I herewith recommend that it be accepted in fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering.

Examiner

Signature