EVALUATING THE PERFORMANCE OF MATERIAL HANDLING SYSTEM USING SIMULATION

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ABSTRACT

This thesis discusses about the performance of material handling system at rice packaging plant. The objectives of this thesis are to model the rice packaging processes, evaluate the performance of the process which include throughput and resource utilization and improve the process. Arena, is the simulation software applied to model and examine the performance of the system in this study. Resource allocation and machine layout are important factors that affect to the efficiency of the process. After modeling the processes in Arena, "what if analysis" strategy is implemented to enhance the whole system by doing model experimentation. Integrating of simulation and "what if analysis" provided a better model, achieved all the objectives of this study. We can see improvements in term of the processing time, work in progress, resource utilization and efficiency of the system at the end of the project. By using simulation, we can solve the industrial problems without elevate production cost.

ABSTRAK

Kajian ini membincangkan tentang prestasi sistem pengendalian bahan di kilang beras. Objektif kajian ini adalah untuk memodelkan proses-proses pembungkusan beras, menilai pencapaian proses termasuk daya pemprosesan dan penggunaan sumber serta menambah baik proses tersebut. Arena ialah perisian simulasi yang digunakan untuk mengkaji model dan sistem dalam kajian ini. Pengagihan sumber dan kedudukan mesin adalah faktor-faktor yang akan mempengaruhi kecekapan proses. Selepas memodelkan proses dengan Arena, strategi "What if analysis" telah diaplikasikan untuk meningkatan prestasi keseluruhan sistem dengan cara mengaji model. Integrasi antara simulasi dengan kaedah "What if analysis" akan membentuk satu model yang lebih baik serta mencapai semua objektif kajian ini. Pada akhir projek ini, kami akan melihat peningkatan sistem ini dari segi masa pemprosesan, kerja dalam proses, pengagihan sumber dan kecekapan sistem. Dengan mengguna kaedah simulasi, kami boleh menyelesaikan masalah industri dengan tidak menaikkan kos pengeluarannya.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Material handling system is an integrated system involving controlling, handling storing and transporting of materials ('Automated material Handling System' n.d.). Material handling system comprises of material requirement planning, scheduling, control of transportation resource, material handling equipment, delivery of materials, buffering and optimization of material. Effective material handling improves the efficiency of storing, controlling and utilizing of the materials along the production process whereas ineffective material handling can leads to profit loss which is caused by idle part of the system, long queuing time and excessive WIP inventory in buffers. Performance of production process of a company is tightly related to the efficiency of material handling system. Hence, this research is proposed to analyse the movement of materials and make improvements to the production process.

"The food industry is a complex global collective of diverse businesses that supply much of the food energy consumed by the world population" ('Food producers' 2012). The global food industry comprises farming, food production, distribution, retail and catering. In this research, I am choosing JS Jasmine Sdn Bhd, a Selangor rice packaging industry as my study target because competitiveness of rice market in Selangor is high due to the highest rate of population. Increasingly competitive environment and market have forced food industries to seek improvements in their production process to reduce operational costs.

Simulation is an indispensible problem-solving methodology for many real-world problems. "Simulation is a process of creating a model of existing or proposed system in order to understand those factors which control the system or to predict the future behaviour of the system"(GoldSim Technology Group 2013). There are several types of simulation models. Simulation model is classified to static simulation model, dynamic simulation model, deterministic simulation model, stochastic simulation model, continuous simulation model, and discrete simulation model (Anun.d.). Among above simulation models, combination of discrete and continuous simulation model is preferred to use in the study. "Discrete event simulation utilizes logical model of a physical system that portrays state changes at precise points in simulated time"(Mike 2010). Discrete event simulation helps in checking for bottleneck, queue location and sizes and machine breakdown interval. Simulation is one of the methodologies to improve and solve material handling issues in industries.

Through observation and information given by manager of rice packaging factory, Mr Tee Jin Han, packaging line consists of workstations that perform the processes of destoning, polishing, colour sorting and packaging. There are four core machines, destoner, polisher, colour sorter and packaging machine work as leverages in production process of the plant. Design, layout and performance of the machines and material handling equipments are affected to the productivity, production cost and efficiency of the process. However, performance of the machines is influenced by the amount and speed of material flow. Packaging line is complex processes. "If the line is set up correctly, using the correct profiles of accumulation in conjunction with machine speeds, then any downtime experienced should be purely attributable to labour issues"(Saker Solution n.d.). Conversely, if the design is incorrect, performance of the overall system may be significantly degraded.

Performance of material handling is important for industries. Therefore, I proposed a research to evaluate the performance of material handling at packaging line and find out alternative way for improving the process.

1.2 STATEMENT OF THE PROBLEM

Normally, machines used in industries are set up by supplier's company at standard size, pattern and design. The rice packaging plant sometimes faces problem of machines jammed due to big bulk of rice block the machine. In addition, they do not have experts or engineers to take care of the machines. Currently, they depend on a trainee who sent from supplier to clean machines and doing maintenance once a week basis. Through information I received, when machines go to rebellious, the plant have to stop the process and use a lot of time to find out the sources of the problem. This issue may incur higher operational cost. Therefore, I recommended simulation method to be used to enhance the system. Simulation modeling can let researcher look details to each part of the material handling equipment layout and performance of the process. Simulation provides easier way for us to find the sources of industrial problems which caused by mistakes on resource allocation.

Today's world, companies are often face with increased requirements for productivity, accuracy and reliability, while at the same time contending with increase labor expenses and stuff reduction. This issue is confronting every company. Resource allocation is affected to company financial management. In this research, I will use simulation methodology to evaluate the performance of the processes including throughput and resource utilization to help in improving processes without high resource expenses.

Quantity demanded to every product is not the same. Quantity demanded depends on the price of good or service in the marketplace, regardless of whether that market is in equilibrium. Quantity demanded of rice alters sometimes due to changes of market price. In this case, rice packaging plant must ensure its productivity can achieve customer's demand to prevent stock out. Productivity of the industry is depends on the efficiency of the machines. For improving the process, what if analysis can help out. What if analysis is sensitivity analysis which used to compare different scenarios and their potential outcomes based on changing condition. We can know what will happen if we do amendment on some parts of the material handling equipment or system.

1.3 OBJECTIVES OF THE STUDY

The objectives of this study are:

i.   To model the rice packaging processes using simulation.

ii. To evaluate performance of the process which include throughput and resource utilization.

iii. To experiment different strategy for improving the process.

1.4 RESEARCH QUESTION

I.   What are the problems of material handling in the rice packaging plant?

II. How does simulation method improves the process and solves the problems?

III. How does what if analysis improves the process?

1.5 METHOD OF ANALYSIS

Simulation is a flexible methodology we can use to analyse the behaviour of a present or proposed production line, business activities, packaging line or plant expansion. In a simulation, we perform experiments on model of the real system with faster, cheaper and safer way.

Simulation steps are shown as follow:

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                    │  1. Problem Formulation  │
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        ┌───────────────────────────────────────────────┐
        │ 2. Setting of objectives and overall project plan │
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          No    ◇ 6.Verified? ◇
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No                   Yes                              No
              ◇ 7.Validated? ◇
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          ┌──────────────────────┐
          │ 8. Experimental design │
          └──────────────────────┘
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        ┌───────────────────────────────┐
        │ 9. Production runs and analysis │
        └───────────────────────────────┘
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     Yes    ◇ 10.More runs? ◇    Yes
                      │
                     No
      ┌─────────────────────────────────────┐
      │ 11. Document program and report results │
      └─────────────────────────────────────┘
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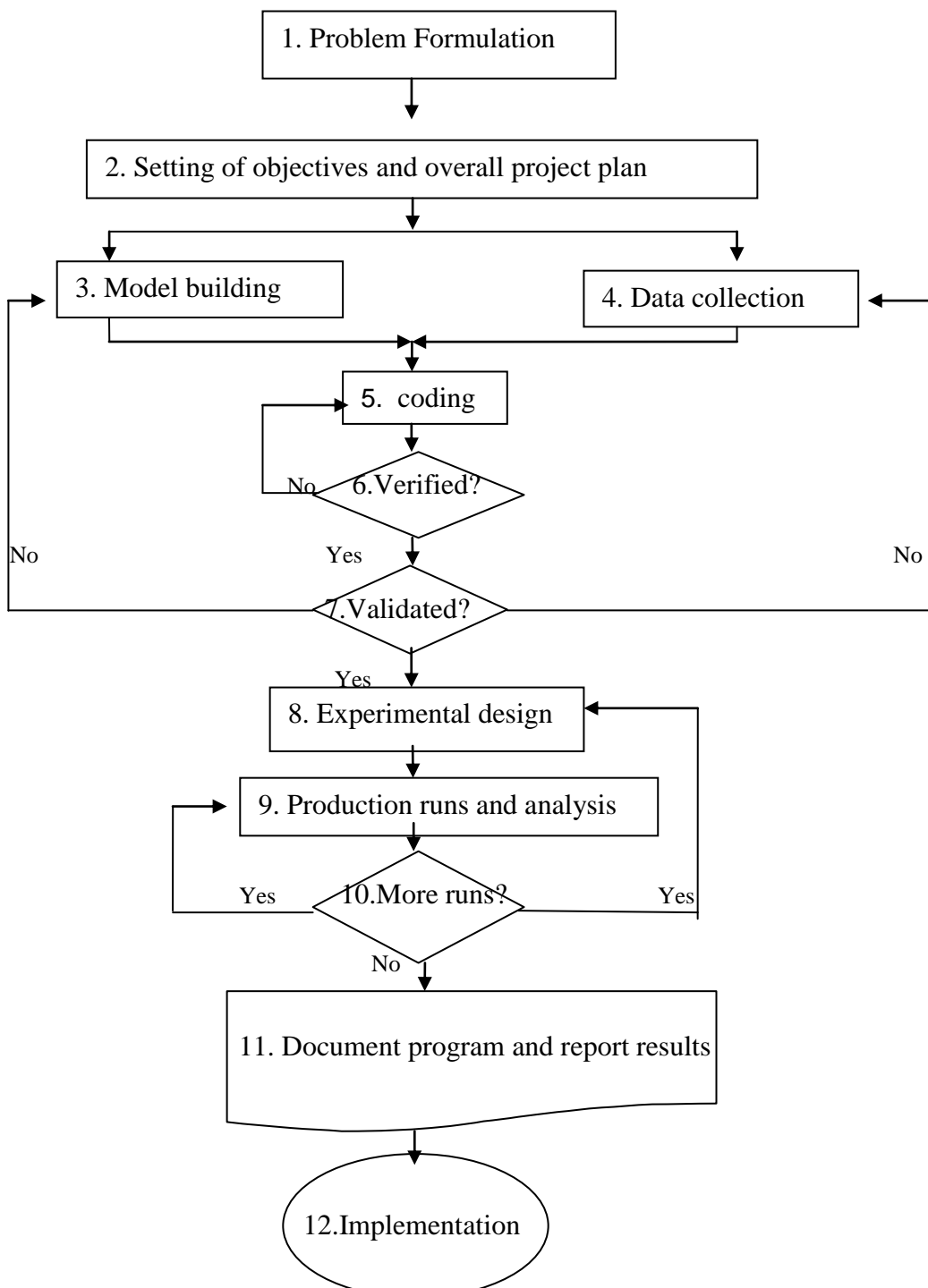
1. Problem formulation: Problem must be identified with a set of assumptions by simulation analyst as simulation study progresses.

2. Setting of objectives and overall project plan: Prepared a proposal which comprised of clear and achievable objectives. Project plan must included scenarios that will be investigated and elements used to solve the problems. Elements consist of hardware, software and time.

3. Model building: Built and developed model in this stage. Begin with draw a simple model and grow it until an accurate complexity model form. For instance, consider a model of material handling system, construct a basic model with arrivals, queues, and servers then add material handling capabilities and special features afterward.

4. Data collection: Data can collect from company after proposal is accepted. Data can be anticipated if they found data are quite different. Simulation analyst can readily construct model when data is collected at the same time.

5. Model translation: The conceptual model is coded into an operational model.

6. Verified?: Check whether it is perform correctly with an interactive run controller.

7. Validated?: Validation is a determination to the accuracy of the model in representing of the real system. Compared output of the model to the base system, existing system is the best way in doing validation.

8. Experimental Design: Considered length of simulation run, number of runs and manner of initialization.

9. Production runs and analysis: It is used to estimate performance of the scenarios that are being simulated.

10. More Runs?: Can add any simulation scenarios and runs based on analysis.

11. Documentation and reporting: Documentation is important for analyst to understand the simulation model operates. The result of all analysis should be reported clearly and concisely. This will enable the company to review the final formulation by comparing alternative systems, results of experiments and analyst recommendation.

12. Implementation: Report prepared at step 11 as information to company for making decision. Manager can choose to run or not to run the plan at the real place.

1.6 SIGNIFICANCE OF STUDY

The main aim of this particular study is to analyse the implementation of material handling system at packaging line of food industry.

This research is to improve the efficiency of the processes. Every part of production process is important to rice packaging line. Simulation method can help in solving problems which faced at the packaging line. Besides, manager can manage and control the process easily through running simulation model. The industry can save cost and time to find out sources when problems happen.

Besides, this study will significantly shows how the material handling layout effects to the performance of whole process. Material handling plays an important role in supply chain. In supply chain, material handling functions to handle a bulk of materials over short distance. Material handling also functions at lifting the storage to another place during order picking, moving material for checking and packing, loading the packaging carton on to the transport vehicles, unloading incoming material from transport vehicles and shifting the unloaded material to arrange storage place in warehouse(Scople 2007). Hence, developing of material handling can enhances the performance of supply chain management in industries.

Moreover, this study also helps to test the real situation of rice packaging processes at rice packaging plant with computer software. By using Arena and what if analysis, we can know the productivity that company achieved via testing with collective data. These data include amount of labour in every station and processing time of every process. Production cost is a main issue that concerns by every industry. Improving the processes with simulation can help company to increase its efficiency of the production without elevate production cost.

Lastly, this research can aids manager to enhance the speed of the production and reduce the rice processing time.

1.7 SCOPE OF STUDY

In this research, we focus on rice packaging industry in Selangor, Malaysia. Material handling System that used in that rice packaging company is my research target. Proper implementation of material handling will contribute profits whereas improper material handling design will cause loss.

Today competitive business world forced industries struggling to find ways for improving their material handling system including equipment, design and layout. Simulation will use in this research to evaluate and improve the performance of material handling system. First, layout of the machine will model out with Arena, then identify problems through simulation model and redesign a new model which is more effective. Finally, test the result and compare the outcomes with real system. We will look over the machine utilization, worker utilization, productivity and processing time of the system after modify the model. We can also evaluate performance of the processes including throughput and resource utilization by analyzing simulation result. On the other hand, different strategy, what if analysis will use to improve productivity by testing on different scenarios.

Thus, rice packaging plant will be the context here, I will analyse material handling and performance of the process at packaging line via simulation modeling and what if analysis methods.

1.8 OPERATINAL DEFINITION

Key Terms	Definition
Material handling	Short distance movement of goods or materials within a storage area, involving loading, unloading, palletizing, de-palletizing and so on.
Material handling system	It refers to activities, equipment and procedures related to the moving, storing, protecting and controlling of materials in a system.
Material handling Equipment	They are mechanical devices for handling of supplies with greater ease and economy.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A material handling system is an integrated system involving activities such as handling, storing and controlling materials. "The primary objective of using a material handling system is to ensure that the material in the right amount is safety delivered to the desired destination at the right time and at minimum cost"('Automated Material Handling and Storage Systems' n.d.). Implementing incorrect design of material handling system can incur problem to the packaging line. Simulation will use in this research to study and enhance the processes of rice packaging line.

2.2 MATERIAL HANDLING SYSTEM

Material flow is a significance factor of food packaging processes. Good material handling system is able to supply components with raw materials, tools and consumables at desired rate and time. Material handling works along each individual part of packaging line to form a whole. Advantages of material handling system are increase productivity, save time and cost, reduce materials inventory, provide better working condition, make improvement in quality and reduce damage to materials. Proper material handling can allocate manpower well and increase system flexibility(Chan 2002).

Cliff Holste, a Supply Chain Digest's Material Handling Editor(Cliff 2013) said that improved system throughput capacity and system reliability was brought to 10% to 25% of benefits. It is rather update or improve Material handling system than replace the breakdown machine. Manufacturer can save overall cost of production by enhancing material handling system instead of buying new machine.

On the other hand, W and H systems designed and implemented a material handling system that incorporated warehouse control system, voice picking technology, conveyor systems, a high speed unit sortation picking and shipping sortation has achieved a 45% increased in productivity and a 60% reduction in pick errors. Better material handling system make the process run smoother(Carlstadt, N.J 2012).

Furthermore, delivery service to the customers can also improve through enhancing the material handling system. Tesco is one of the companies that possessed this kind of benefit by implemented new material handling system called automated material packing and handling. Tesco practiced new system on January 2012 and it succeeds to increase volume of order picking while retained high service level at the same time. Tesco fulfilled an increase number of home delivery grocery orders from one location with lower running costs (Bowling 2013). Automated material handling system also increased the efficiency of dedicating a warehouse to home-delivering orders made online.

Enhancing material handling system is one of the best ways to significantly lower company's operating costs. Good material handling systems help in accelerate the operation of the production and increase the efficiency of production process. Material handling system has positive effects on almost everything run in food industry. Historical cases showed that improve material handling system can help managers in handling the materials of the production processes better. In Industrial field, simulation is one of the efficient tools to study, improve and solve material handling problems.

2.3 SIMULATION

Simulation is favourite technology that used by researchers in solving scenarios and doing material handling design. "In recent year, there has been a tremendous growth of material handling technologies and equipment types such as robots,

automated guided vehicle(AGV), electrified monorail system(EMS), high-rise storage retrieval system, computerized picking, systems and computer controlled conveyor systems"(Ulgen&Upendramn.d.). Material handling projects are often costly with potential risk. To implement it well in industry, simulation technology can be used as a test-bed to better understanding the system. Simulation can help to address complex design, operational, business and scheduling problems. Simulation can classify into four phase, the conceptual phase, detailed design phase, launching phase and full operation phase.

Simulation was known and used by people to solve industrial problems long time ago. In the year 1968, a second conference on the application of simulation was held in New York Hotel, Roosevelt with seven hundred attendees. The conference was the first one to issue many aspects of discrete event simulation. Topics related discrete event simulation that discussed in the conference were sessions covered transportation, computer systems, manufacturing applications, reliability and maintainability, graphics and GPSS modification, job shops, material handling, facility planning model and so on. After that, in year 1970 and 1971, third conference, fourth conference and fifth conference were held in western countries to discuss simulation method. Many schools were offered continuous and discrete event simulation course at that time.(Simulation and Modeling Teamn.d, 'Introduction to modeling and simulation systems', para. 16).

Simulation was studied by many manufacturing designers, engineers, researchers and scientists. Today, many types of simulation were developed by experts. Now, simulation method is used at many sites including hospital, bank, petrol station, manufacturing plant, aerospace, company and so on. A great man, Jeremy J. S. B., is one the world's leading designer and provider of business simulations for management development and business training. Since 1970, he has developed sixty-five computer simulations comprehensively covering management learning across industry. He provided big contributions to simulation. (Jeremy 2012).

Simulation is a tool to managing change. Simulation can use in business process. Simulation accelerates business people make change of the way they are doing business. Business Process Simulation(BPS) is type of technique which use in making accurate business decisions. It support by several software tools. Software tools that may be applicable for business process simulation are business process modeling tools, business

process management tools, general purpose simulation tools. For evaluation of simulation functionality, we consider Petri Neys(Protos) and Event-driven process chains(ARIS Toolset). Business process management tools supports business design phase, functions to evaluate Flower tool and FileNet. For general purpose simulation tools, we consider Arena and CPN tools.

In this study, Arena is chosen as simulation tool to do simulation modeling. Arena is a general purpose simulation instrument developed by Rockwell Automation. Arena is a discrete event simulation software which developed by Systems Modeling. Arena product family consists of a Basic Edition for uncomplicated process and a Professional Edition for more complex large scale projects in manufacturing, distribution, processes, logistics and so on. "As of June 2012, Arena was in version 14 and it has been suggested to join Rockwell software packages under "Factory Talk" brand(Arena Simulation Software, 2013). This software is suitable used to build simulation models. Arena can solve any industrial problems including complex and intricate cases. When opening Arena, we can see three modules, basic process, advance transfer and advance transport. Arena can make analysis of the data easily and more effective compared to manual calculation.

People started study simulation many years ago and its importance was affirmed by many industries. Even today, some high education institutions are focus on study Arena, simulation modeling. This technology makes manger's tasks easier in managing machine, people, resource, business and time.

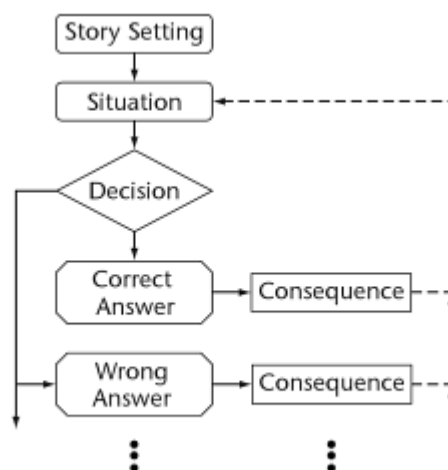## 2.4 APPLICATION OF SIMULATION IN INDUSTRY

As15 February of 2013, there is news of Today's Medical Development claimed that simulation now recognized by FDA as essential to medical device evaluation. Liu C. reported that solid mechanics simulations can help determine proper implant size, evaluate manufacturing tolerances, compare design geometries or consider next-gen devices. Furthermore, simulation-based product can be linked in automated workflows, optimizing large quantities of design data for creating patient-specific medical tools. Simulations with Abaqus finite element analysis(FEA) was solved the toughest challenges of design engineering with increase the accuracy in evaluating device

performance. Recognition of simulation by FDA was proven that simulation not only useful in manufacturing industry but also medical care (Cheryl 2013).

Computer simulation already widely accepted in many industries. For example, the case of Hughes Aircraft succeeds to design automated storeroom system through simulation application in the year 1990. He was combine six storeroom into single, automated facility using simulation method. The simulation modeling product which Hughes chosen for this project is WITNESS. Hughes integrated powered conveyor, double stacked horizontal carousel, robotic inserters and tote pans and many other components into one operation system using WITNESS on a standard IBM PC/AT or PS/2 system. (Thomas & Charles 2013).Through simulation, objectives of this project which to receive store and issue material in an efficient and economical manner and ensure inventory accountability ware achieved. Hughes Aircraft achievements was proven that simulation is pretty suitable used for researcher in solving material handling problems.

There are many types of simulations were developed by experts. Computer-based scenario simulation is one of them. "Computer-Based scenario simulation sometimes called "best-practice" simulations, are used to build leadership, project management, and sale capabilities"(BTS n.d.).This simulation supports decision tree structures in realistic story lines, enhance with text audio, still photography, and video. Simulation imitates the realistic of real situation.Users are given chance to observe real-world business situation then they react to the issue presented. Upon choosing course of action, the simulation will present the effects of the participant's decisions immediatelyon the goals.Scenario core structure at below will make reader more understand to the functions of computer-based simulation.

Scenario core structure:

Simulation was used in many applications. Study of Brazilaian petroleum industry applied human modeling and simulation tools to assist in the ergonomics designs of new petrol chemical industry facility is the example of using simulation in chemical industry. In this case study, that industry employed 3D modeling software and digital 3D human mannequins. Digital human simulation helped in doing decision making about the technical systems and workplace conception. According to Danieal, Nilton, Joao &Michel(2009), simulation has three steps:

- Analysis of reference situation
- Identification of situation characteristics
- Future activity simulation

Simulation characteristics in situation accurately reflected the future implementations of floorplans, prototype and simulation software.

Queuing systems can improved through simulation method. Based on paper, "An Integrate Artificial Neural Network-computer Simulation for Optimization of Complex Tandem Queue System", intelligent simulation environment utilized computer simulation and Artificial Neural Network(ANN) to stimulate and optimize tandem queuing systems. This study is able to solve the states, conditions and operations of the system in manufacturing industry (Azadeh et al. 2011, p.666-678). Simulation can solve many industry problems especially issues at production line.

On the other hand, simulation was used in service industry. An article linked simulation to service industry, use clinical simulation among Chinese nursing students

for developing their communication skills, critical thinking and teamwork. The way they did simulation was dividing students into 6 groups then brought them into a simulation room. In the room, a 3 minutes video was played to give students information and help them adapt to the simulation environment. The simulation environment was made like a real condition in respiratory department. After the video, students can started discuss and assessed symptoms and patient's problems. Students more understand to the real situation of their working condition and improved their service performance to patients through simulation. Simulation is an effective teaching strategy(Wang, Joyce & Marcia 2012).

Filippo, Isabella and Andrea were doing a research on the case study of applied discrete event simulation to the design of a service delivery system in the aerospace industry at ALFA Company. This case study is about how discrete event simulation can be used at the point of signing a long-term service contract to assess whether a service delivery system will be able to comply with the contractual terms over time. The researchers collected data from leading global supplier of human to machine electronic then modelled and tested with simulation model. In addition, this study also suggested a methodology based on Monte Carlo Simulation to estimate the service demand. Data like number of aircrafts, numbers of flight cycle, number of failures and number of requests were recorded to do experiment. The study finally concluded that simulation can be powerful tool to support the design of service delivery system and to reduce the risks that suppliers faced when they sign long term service contracts. (Fillipino, Isabella, & Andrea 2013).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In methodology part of the study, some instruments and methods will use to conduct the investigation on the study of the material handling system. After this research, we can increase the efficiency of production process. Research methodology used in this study consists of simulation modeling and what if analysis.
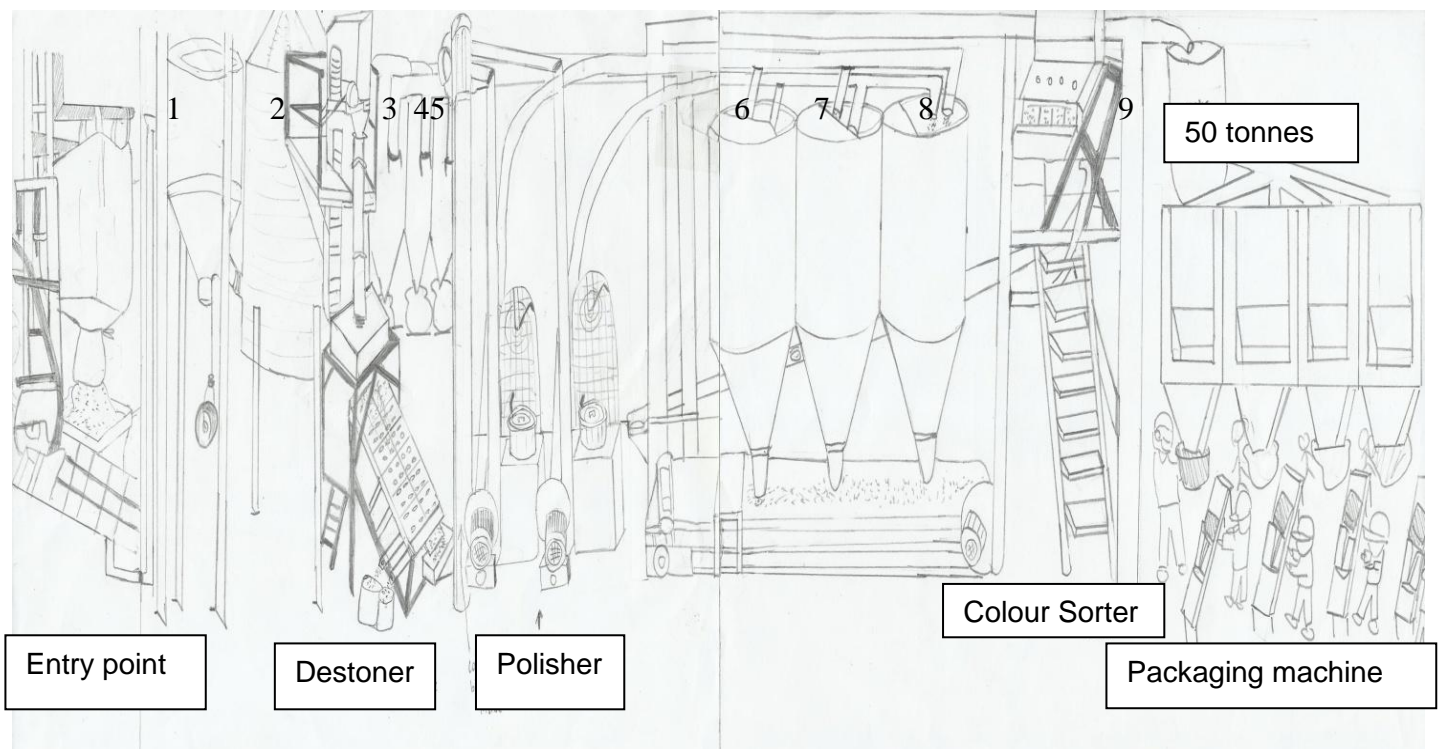
3.2 SYSTEM DESRIPTION

1   2   3 45   6   7   8   9

50 tonnes

Colour Sorter

Entry point   Destoner   Polisher   Packaging machine

Figure 3.1 System layout