PRODUCTIVITY IMPROVEMENT THROUGH LINE BALANCING

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Report submitted in partial fulfilment of the requirements
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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing

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

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ABSTRACT

Poor layout design is determine as a major problem contribution in small and medium industry. These particular problems thus affect the productivity and the line efficiency as well. Throughout the study, the aim is to proposed new layout to the related company to increase their productivity. The major step is to identify a bottleneck workstation in current layout. After identify related problems, the current layout is redesign by computing the standard time and processing time in each workstations. In each workstation the processing time is different and the longest time consumption is workstation will be identified as a bottleneck workstation. This related line is studied by time study techniques. The time is taken by stopwatch. In this study, application of Computer Aided tools is introduced which in this study is WITNESS SOFTWARE. The related inputs are going to be simulated with this software. The manual calculation also included especially in line balancing algorithm. The goal of the thesis is to seek the best layout in terms of line efficiency and productivity rate hence proposed to the company. Through out the study, 3 layouts have been achieved. Among 3 layouts only one will be propose to the company. This layout has better line efficiency and rate of productivity.

ABSTRAK

Pelan kerja yang lemah dikenal pasti sebagai penyumbang masalah utama di industri kecil dan sederhana. Masalah ini juga menyebabkan kesan pada segi pengeluaran dan juga keberkesanan sesuatu barisan. Sepanjang kajian ini dijalankan, tujuan utama adalah untuk mengutarakan satu pelan kerja yang baru dan terbaik untuk meningkatkan daya pengeluaran kilang itu. Untuk melaksanakannya, langkah utama adalah mengenal pasti tempat kerja ”*bottleneck*”pelan tempat kerja yang sedia ada. Kajian di barisan ini menggunakan teknik kajian masa dengan menggunakan jam randik sebagai medium untuk mengira masa standard dan kerja. Ini adalah input penting kerana didalam kajian ini aplikasi penggunaan terbantu komputer diperkenalkan iaitu WITNESS SOFTWARE. Turut serta adalah pengiraan manual terutama sekali algoritma “*line balancing*”. Dapatan akhir kajian ini adalah mengutarakan pelan kerja terbaik untuk kilang yang berkenaan.Sepanjang kajian ini dijalankan, 3 pelan kerja telah dihasilkan dan hanya satu pelan kerja yang terbaik akan diutarakan pada kilang terbabit. Pelan kerja ini dikenalpasti kerana mempunyai kadar pengeluaran yang tinggi serta kecekapan lini yang bagus.

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LIST OF SYMBOLS

T_C	Cycle Time
ω	Number of Worker
L_{s_i}	Length at i
f_p	Feed rate
R_p	Required Product
D_a	Required Demand
S	Number of Shift Per week
H	Number of Hours in Shift
E	Efficiency

LIST OF ABBREVIATIONS

SMI	Small and Medium Industry
ICT	Information & Communication Technology
M	Manning Level
L	Length

CHAPTER 1

INTRODUCTION

1.1 Introduction

Quality product and capable to cope with customers demands are important aspects that should be take an account especially for small and medium industry. Management systems are also contributes in order to planning, controlling and measuring parameters related to the performance of the sectors. Companies should realize that the performance is depending on how well the production line in term of output.

Process layout, product layout and fixed-position layout are 3 basics types of layout [M.Davis.M, Heineke J, 2005].This project are interested on product layout. Product layout is defined as flow-shop layout where number of machine and work processes are arranged so that the products will pass through several workstation. Due to high demand the resources was rearranged from process layout to product layout. This required a sequence steps to make product. Industries often called as a assembly lines.

Assembly lines are general described as progressive assembly linked by some type of material handling. This can be found especially for industries that assembles

product such as electronics part, food and etc. An example of product layout is cafeteria, where customer trays are moving through series of workstations. However bottlenecks are often occurred in assembly line. This will cause delay in term of time and decreasing in line efficiency.

The aims of the study are improving the productivity and compute efficiency of an assembly line in small and medium industry. The objective are redesign the layout for purposing to improve line performance. Computer aided simulation are implemented in this project in order to analyze and investigate the problems occurring in assembly line.

The model will select and using time study techniques it will be analyzed. The line balancing method is use to solve the problem. Comparison of the current layout and new layout are done. Simulation is done by WITNESS software to accomplish this study.

1.2 Project Background

"Manual assembly lines technology has made a significant contribution to the development of American industry in twentieth century" [Groover, 2001]. This phrase emphasizes the importance of assembly line especially in several sectors such as automobiles, consumer appliances and those sectors that produced large quantities product. This indicates the success factors are depending on the efficiency of assembly line. Along assembly lines various operations can be done either manually, automatically or integrated. For manual operations, the workers will perform jobs like brazing, assemblers, welding and so on. Normally for manual process the station will equipped with aided stationary depends on type of tasks. Automation operations are done for high volume quantities with addition features on the workstation. However, assembly line suffered one major problem, bottleneck. This phenomenon is defined as stage where causes the entire process to slow down or stop [Taj,2006]. This can be due to improper scheduling, improper line balancing and machine breakdown or equipment repairing.

Improper line balancing for example is defined on distribution of workloads and workers are not equal along the assembly line. The workers are not assigning equally in each workstation. Machine breakdown sometimes contribute to bottlenecks problem since the products are moving and suddenly had to stop and it start accumulate at certain workstation. Due to this problem, there will one station that has maximum time to perform a task. This station is called bottle neck station [Groover, 2001]. Analysis will be performing to identify the location of bottlenecks. Furthermore the product will start to accumulate hence slow down the process yet reduce the line efficiency

The production rate is depending on how well the line is running. In order to fixed or overcoming bottle necks problems, manual calculation has a limitation. Fact that to analyze every stations are impossible due to time consumption. Simulation is often used to determine the root of bottlenecks. The results are valid for engineers to predict the causes and effectiveness of current layout. New layout is proposed to overcoming this problem. Simulation is tools for conducting experiments without damaging and interfering the real systems.

1.3 Project Motivation

Bottle necking and excessive workers are common problems rose in assembly line. These are the major problems that encounter and yet need to be overcome as soon as possible. Assemblers are often encounters this problems and if this happen it will be decreased the line efficiency and the targeted run rate. In preventing these problems, engineers should come out with a solution in order to fix these problems. One way to do so is using line balancing method. This aim is to minimizing work loads and workers on the assembly line while meeting a required output.

“Small and medium industries are covered 90 percent of enterprises in the world”.[Taj,2006]. Due to competitiveness, meeting a required demand and provide continuous product are become important matters. In order to achieve this objective, assembly line should be design to make sure the flow is smoothly. Workers on assembly line are specialized person in particular area. Most of them have been exposed to various tasks and skilled have been developed.

A new layout is proposed to make sure the assembly line achieved required run rate. The layout will include the number of workers, the workloads and the flow of the products. Normally any changes of the layout depend on type of product, environment and company policies. Layout will be design based on the regulation provided by company. Software application also involve in the design since any changes will affect the productivity. Simulation become necessary tool in designing layout based on it capability to evaluate and improving current layout.

Analysis on assembly is important in order to achieve targeted productivity. Assembly line should be design smoothly and simulation should be done to predict the line efficiency and productivity difference between new layout and current layout.

1.4 Problem Statements

1. Reducing line efficiency.

In flow line production the product moves to one workstation due to time restriction. Once its get stuck due to accumulation in certain workstation, it exceeds the cycle time in that station. Faster station is limited by slowest station. Thus, decreasing the rate of productivity .

2. Unbalance workloads

Due to starving, the workers need to wait the products to come.

1.5 Project Objectives.

Two objectives are expected in the end of the project:

1. To improve productivity and efficiency of existing layout and new layout

2. To meet unpredictable demand

1.6 Project Scopes

The research will be conducted at manufacturing based company in Kuantan specifically in electronics company.

1. Software application, WITNESS is used to simulate data.
2. Comparison between existing and new layout.
3. Proposing new layout (3 layout and the best is chosen).
4. Stopwatch is used to take the time

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is to explore and gathered all information’s in order to understand clearly about line balancing. The information’s is come from reference books, journals and thesis. The structure of this chapter is shown in Figure 2.1. These sections are mainly concern about related knowledge about Line Balancing. Small and Medium Industries becoming the selected area then the scope is narrow down from manually assembly line through down until last part is productivity. In the middle part of the Literature Reviews, detailed explanation regarding types of assembly line, workstation, material handling system, line balancing and simulation. This particular area is discussed to give better understanding on what is purpose of this research.

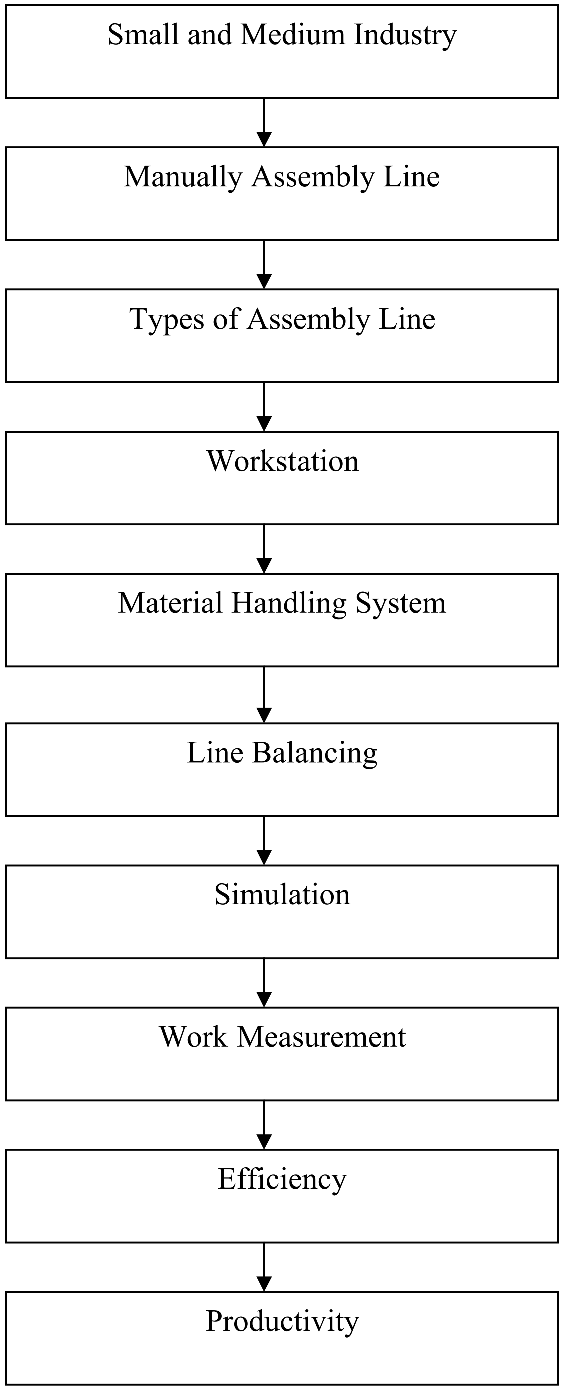

Figure 2.1: Literature Structure

2.2 Small and Medium Industry (SMI)

In Malaysia, the official definition since September 1986 includes enterprises of less than $500,000 ringgit in shareholders' funds or net assets as small, and those with more than $500,000 ringgit but below $2.5 million ringgit as medium. The Table below shows the summarization of SMI definition in different perspective.

Table 2.1: Table of SMI definition (www.smidec.gov.my)

	Definitions	
Sectors	Small	Medium
Manufacturing and Agro based Industries	Sales turnover between RM250, 000 and less than RM10 million OR full time employees between 5 and 50.	Sales turnover between RM10 million and RM25 million OR full time employees between 51 and 150.
Services	Sales turnover between RM200, 000 and less than RM1 million OR full time employees between 5 and 19.	Sales turnover between RM1 million and RM5 million OR full time employees between 20 and 50.

Generally SMI can be classified into two categories which are [Taj,2006]:

i) Manufacturing, Agro and Manufacturing-Related Services industries
ii) Service, Primary Agriculture and Information & Communication Technology (ICT)

In this research the investigation will carried out in manufacturing industry and more specifically in manufacturing electronics components.

2.3 Manually Assembly Line

Manually assembly line is refers to production line that have several workstations arranged in sequence order where task was performed by workers[Driscoll,2001].

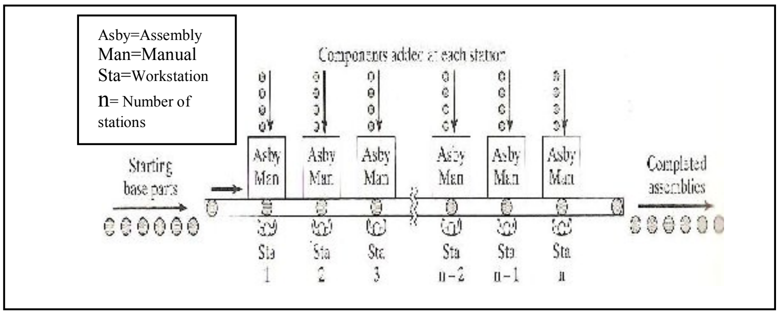

Figure 2.2: Configuration of production line [Groover, 2001].

As the product moves along the line the products are assembled. Every workstation has different task, since the product was moving we can see an addition as the part passing through every workstation and the end the complete product was made. Electrical appliance, audio equipments, furniture and etc are usually made on manual assembly line. There using manual assembly line due to several reasons:

i) High or medium demanding
ii) Similar products.
iii) Total work to assemble can be divided
iv) Cost Estimation (possible to automate the operations).

The movements of products along manual assembly line can be accomplish by two ways manually and mechanized system. Noted that even different method but all units facing same sequence of stations.

2.3.3 The Advantages of Manual Assembly Line

The advantages of manual assembly line are [Taj, 2006]

i) Specialization of Labor

Known as "division of labor" this principle mentioned that when a large job is divided into small portion and assigned to one worker this develop an expertise on that particular area

ii) Interchangeable Parts

Components with sufficiently close tolerances that any part of certain type can be selected for assembly with its matting components, without interchangeable parts, assembly will require filling and fitting.

iii) Work Principle

Products should travel in minimum distances between the stations.

iv) Line Pacing.

Workers should complete the task within a certain cycle time, paces the line to maintain a required rate. Pacing usually found by means of mechanized conveyor.

2.4 Types of Assembly Line

An assembly line can be classed into three categories based on numbers of models assembled on the line and according to the line pace [Groover, 2000] which are:

i) Single - model line
ii) Mixed – model line
iii) Batch model line

2.4.1 Single Model Line

A single – model line can be described as a line that assembles a single model. This line produces many units of one product with no variation. The tasks performed at each station are same for all units. Products with high demand are intended to this line [Groover, 2001]

2.4.2 Mixed – Model Line

Mixed – model line is producing more than one model. They are made simultaneously on the same line[Bhaba and Sarker, 1997]. Once one model is worked at one stations, the other product are made at the other stations. Thus, every station is equipped to perform various tasks needed to produce any model that moves through it. Many consumers product are assembled on mixed – model line.

2.4.3 Batch Model Line

This line produces each model in batches. Usually workstations are set up to produce required quantity of the first model then the stations are reconstructed to produce other model. Products are often assembled in batches when medium demand. It's more economical to use one assembly line to produce several products in batches than build a separate line for each model. The research will be carried out in industry which applied a mixed model line.

2.4.4 Advantages and disadvantages of a Mixed Model Line

Mixed – model line are pioneered by Toyota and is actually figured out to produce several model without any changeover [D.Daizura, 2006] Proper sequencing of the product assures the demand go smoothly on upstream suppliers. There are several benefits using mixed – model line which are:

i) No lost production time switching between models.
ii) High inventories typical of batch production are avoided.
iii) Production rates of different models can be adjusted as product demand changes.

Even though mixed – model line offered several advantages thus its have its own disadvantages. The disadvantages that found out here are:

i) Assigning tasks to workstations to equally the workload is complex.
ii) Determining the sequence models.
iii) Getting the right parts to each workstation for model currently at the station

2.5 Workstation

On manually assembly line workstation is designed along the work flow path so does one or more workers can perform the task. The work elements represent small portion of work that must be accomplished to assemble product. Workstations designed should conclude productivity, operator comfort, operator variety and safety. The number of operator may be different and one operator might monitor several workstations. Certain workstations are equipped with hand tools or powered tools to perform the task assigned in that station. The design is depending on how the workers perform the task. There are several processes to designs the workstations which are [William and Lee, 2005]:

i) Examining tasks, operators and tools.
ii) Allocating tasks between operators and machines
iii) Selecting or designing tools and fixtures
iv) Physical arrangements optimization.

Commonly for assembly large products such as cars, trucks and major appliances the workers need to stand so that they can move about the station to perform tasks. Operator comfort is important.

Comfortableness assures that operators perform better. Most of workstation rarely equipped operators as individuals. Assembling small parts required the workers to sit so that they feel much comfortable to reduce fatigue risks[Lund and Kenneth,200]. This will help them to work on more conducive and more accurate while performing tasks. The workers start to assemble near upstream and product continuously moving through several workstations until task is completed. This was quoted from (Nelson and Lee, 2005)

These are typically operations done on manual assembly line which are:

i) Application of Adhesive
ii) Brazing
iii) Riveting
iv) Soldering
v) Cotter Pin Application
vi) Application of Sealants

2.5.1 Workstation Design

In general, the number of workstations, n is equal to the numbers of workers, w and manning level, M

$$n = \frac{w}{M}$$

A workstation has length dimensions, Lsi, where I denotes station i. Total length assembly line, L is summation of each workstations length

$$L = \sum_{i=1}^{n} Lsi$$

If the length assembly line (m,ft) , L and Lsi=length of station I (m,ft) are equal

$$L = nL_s$$

If using conveyor we have to determine the feed rate, f_p and assume time cycle, T_c is constant through out the line

$$f_p = \frac{1}{T_c}$$

2.6 Material Handling System

Material Handling Industry of America defined material handling as the movement, storage, protection, and control of materials throughout the manufacturing and distribution process including their consumption and disposal. This fact can be summarized that material handling serves two functions which are storage and transport. Meyers denoted that average 50 percent of company’s production costs are made up of material handling [Meyers, 2003]. Material handling systems provides function to facilitate assembly jobs hence it should be integrated into line design [We-min, 1990]. Material handling plays several roles in assembly line. First, material handling systems should compatible with products in terms of size, weight and others factors. The manual deliveries are not suitable for bulky product. In semiconductors industry, product qualities are defined in cleanliness thus they need clean room environment as their material handling systems. Secondly interface between material handling and the workstations. Certain cases where there are additional devices needed. Thirdly , material handling frequency and the duration handling time. A line with shorter time needs less material handling and vice versa. Lastly, material handling should be kept at proper levels so that the line can be operated smoothly.

2.6.1 Goals of Material handling

Here are some goals that expected when using materials handling

i) Maintains or improve product quality, reduce damage and provide protection for materials
ii) Promote safety and improve working conditions
iii) Promote productivity.
iv) Control inventory by decreasing storage requirement.
v) To give efficient flow of materials.

2.7 Line Balancing

Line balancing is commonly technique to solve problems occurred in assembly line. Line balancing is a technique to minimize imbalance between workers and workloads in order to achieve required run rate[H.Jay and R.Barry, 2006]. This can be done by equalizing the amount of work in each station and assign the smallest number of workers in the particular workstation. Here the job is divided into small portion called "job element" .The aim is to maintain production at an equal rate [G. Andrew, 2006].Line balancing operates under two conditions:

i) Precedence Constraint.

Products can't move to other station if it doesn't fulfill required task at that station. It shouldn't across other station because certain part needs to be done before others.

ii) Cycle time Restriction

Cycle time is maximum time for products spend in every workstation. Different workstation has different cycle time.

2.7.1 Objective of Line Balancing

Line balancing technique is used to:

i) To manage the workloads among assemblers.
ii) To identify the location of bottleneck.
iii) To determine number of workstation.

iv) To reduce production cost.

2.7.2 Terms in Line Balancing Technique

In assembly line balancing system, there is various term normally used. Each of them has their meaning and purposes. Below are several common terms found in assembly line balancing system:

i) Cycle Time

Maximum amount of time allowed at each station. This can be found by dividing required units to production time available per day.

ii) Lead Time

Summation of production times along the assembly line.

iii) Bottleneck

Delay in transmission that slow down the production rate. This can be overcome by balancing the line.

iv) Precedence

It can be represented by nodes or graph. In assembly line the products have to obey this rule. The product can't be move to the next station if it doesn't complete at the previous station. Figure 2.8 shows the precedence graph. The products flow from one station to the other station.

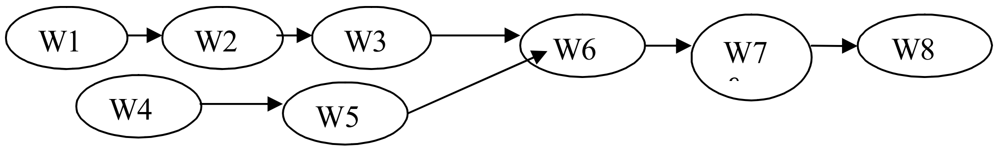

Figure 2.3: Example of Precedence Diagram.

v) Idle time

A period when system is not in used but is available.

vi) Productivity

Define as ratio of output over input. Productivity is depends on several factors such as workers skills, jobs method and machine used.

2.7.3 Steps in Solving Line Balancing

Here are the steps in solving line balancing according to [G. Andrew, 2006]:

i) Drawing Precedence Diagram

Precedence diagram needs to be drawn to show a connection between a workstation. Certain process begins when previous process was done.

ii) Determining Cycle Time

Cycle time is longest time allowed at each station. This can be expressed by this formula:

$$\text{Cycle time} = \frac{\text{Available Time}}{\text{Desired Output}}$$

This means the products needs to leave the workstations before its reach its cycle time.

iii) Assigning tasks to workstation

The tasks allocations should be take after competing a time cycle. It's good to allocate tasks to workstation in the order of longest task times

$$\text{Number of workstation} = \frac{\sum \text{Task Time}}{\text{Desired Actual time}}$$

iv) Calculating an Efficiency Line

This will carried out to find how effectiveness the line. The formula is given by:

$$\text{Line efficiency} = \frac{\text{Sum of task times}}{\text{Number of workstation} \times \text{Desired cycle time}} \times 100$$

2.8 Simulation

Simulation is defined as an attempt by duplicating the features, appearance and characteristics in real life. This simulation usually has three pronged [H.Jay and R.Barry, 2006, 766] which are:

i) To imitate a real world situation mathematically.
ii) To Study its properties and operating characteristics.
iii) To Draw a conclusions and make action decisions based on the results of simulation

These are the common activities that applied simulation which are:

i) Assembly Line Balancing

ii) Scheduling Aircraft
iii) Labor-Hiring Decisions
iv) Bus Scheduling
v) Personnel Scheduling

2.8.1 Importance of Simulation

In industry simulation is a tool for engineers to develop a model and run a test to predict certain result. Therefore simulations becoming popular choice because:

i) Simulations models can be conducted without damaging and interfering real systems.
ii) Estimations of operating characteristics or objective functions values in analyzing problems.
iii) It's analyzes the utilization of fixed resources and variable resources.
iv) Simulation can identify areas which needed to be improved.
v) It's helps identify bottlenecks problems in system
vi) Helps in investigate product flow, resources and routing.
vii) The scientist can model complex and dynamic phenomena that others could not.

2.8.2 Disadvantages of simulation:

Even though simulation provides advantages in certain cases, it also suffered with these main disadvantages:

i) Time consumption to develop good models. Longer times to take to produce good simulation.
ii) Its does not generate optimal solution to problems because this is a trial and error approach.

iii) Constraints and other parameters should be stated earlier since simulation can't run if lack of information.
iv) Each simulation model is unique. Its can be transferable to others problems.

2.8.3 Simulation Tools

There are various packages of simulation tools offered in market nowadays.The selections are depending on the type of analysis. The selections of many packages available now are shown below.

i) WITNESS
ii) Arena
iii) DELMIA

2.9 Work Measurement

Determination of the amount of time required to perform a unit work is work measurement mainly concerned. Work measurement sometimes refers to time study [Taj,2006]. Work measurement is to determine the amount of time requirement by a qualified worker by using standard method at a standard workpace to perform task. There are various techniques to collect data for work measurement such as Predetermined Time Standard Systems (PTSS), stopwatch time study, work sampling, standard data and many more. In this section, stopwatch time study is choose to collect data. [Meyers and Stephens, 2005]

2.9.1 Stopwatch Time Study

A time-study has been proposed by Frederick W. Taylor in 1881 and until now it becomes a selection in a time-study method [Heizer and Render, 2006]. Time-study can be defined as procedures or techniques involving timing sample of workers performance and used as a standard time [Heizer and Render, 2006,]. Meyers and Stephens defined time study as a process to determine the time by required skilled, well trained and normal pace in performing tasks areas.

2.9.2 Standard Time

Meyer and Stephens defined standard time as adjustment to the total normal time. The adjustments provide allowances in term of personnel needs, work delays and fatigue.

The calculation of standard time is given by this formula:

Total allowance (%) = Rest allowance (%)

Normal time (s) = Observed time (%) X Performance rating factor

Standard time(s) = Normal time (s)/ 1- total allowance.

2.10 Efficiency

[G,Andrew , 2006] total tasks time can't be exactly match to the cycle time. A measure of how close these two values is called line efficiency. Based on the books the formula given is [G,Andrew , 2006]:

$$\text{Line efficiency} = \frac{\text{Sum of task times}}{\text{Number of workstation} \times \text{Desired cycle time}} \times 100$$

Other way to calculate efficiency is taking an average cycle time for 100 percent station is the fastest speed at which any operator on this line can work. This time will multiply by total number of operators on line. The formula given is:

$$\text{Line efficiency} = \frac{\text{Sum of 1 cycle time}}{\text{Total cycle time}} \times 100$$

2.11 Productivity

Productivity can be defined as measuring of technical and engineering efficiency of production [H.Jay and R.Barry, 2006]. In simple words it's a ratio of outputs divided by inputs. Outputs here means goods or services while inputs are capital or labor. Improving productivity is usually improving the efficiency. There are two ways on how to improve productivity. First is reducing inputs and keeps output constant and secondly is increasing outputs and keep inputs constant. Basically there are two ways on measuring productivity either single factor or multifactor productivity.

i) Single factor productivity

It's defined as measuring the productivity by ratio of outputs and one input factors. Example is measuring labor productivity. This is often expressed as "output per hour" or "units per labor hour" [H.Jay and R.Barry, 2006].

$$\text{Productivity} = \frac{\text{Units produced}}{\text{Inputs used}}$$

ii) Multifactor productivity

Multifactor productivity is defined as combination of inputs. It's also known as total factor productivity.

$$\text{Productivity} = \frac{\text{Units produced}}{\text{Inputs used}}$$

Inputs used are summation of inputs such as labor, material, energy, capital and miscellaneous. These terms can be summarized in dollars [H.Jay and R.Barry, 2006].

CHAPTER 3

METHODOLOGY

3.1 Introduction

This flow chart is use as a guideline to accomplish this project. Figure 3.1 shows the summary for the whole activities in this research. This will help to run the project successfully. The research started with a discussion with supervisor regarding the topics, then is visiting the company to conduct the research. In PSM the job scope is done until observation which is taking data for processing time and time standard by calculating the allowances. PSM 2 is continued by data collection and simulation. The data is taken by Time study method were times processing in each workstation is collected by time watch. Later the data is simulating by WITNESS SOFTWARE. The pre-extermination is done by showing the outcome to the supervisor. The correction is done if certain part of the simulation is out of the page. Lastly the result is compared to the manual calculation to get the percentage error, to said the data is valid the percentage error should be less than 5%.

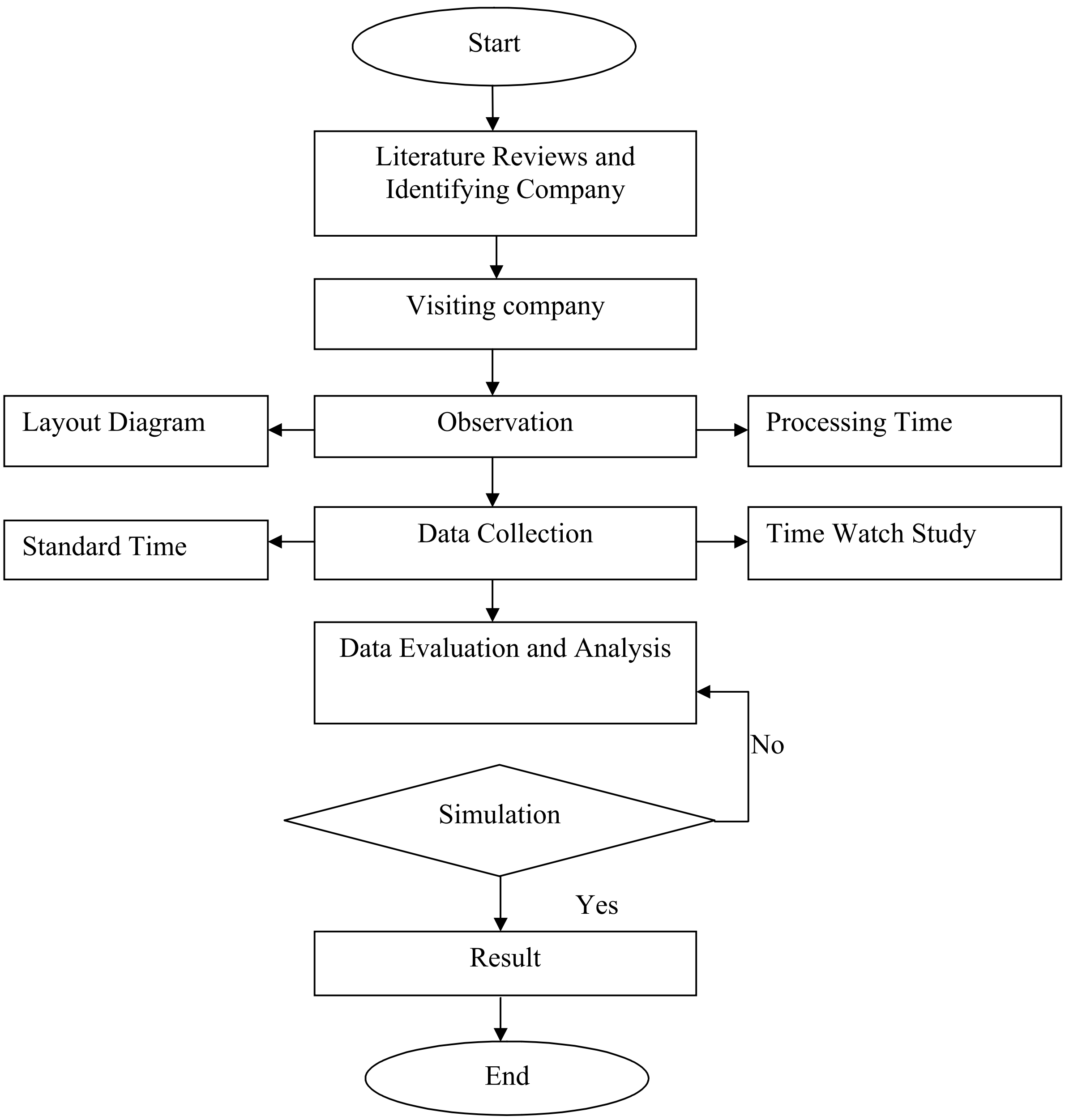

Figure 3.1: Methodology Flow Chart

3.1.2 Literature Review

This section contains about the previous study from existing journals, books and other sources. The information have been gathered and compile in this section. This helps to develop better understanding about the whole project.

3.1.3 Identifying Company

The project will be conducted on the factory which applied assembly line. After discussion with supervisor. Nexus (M) Sdn Bhd which situated at Jaya Gading Kuantan is chosen because they produce an electrical component such as transformer. Nexus become the chosen because this company applied assembly line. Thus improvement needed to fix the current problem.

First, permission is needed to enter this company. All related documents were done by supervisor. After permission is approved, the proposal is done to shows to the company or person in charge so they know well about the project. The approval letter are shown in appendix.

3.1.4 Visiting and Observation

On 2nd April the first visit to the company. After short briefing, Nexus (M) Sdn Bhd assigned one assistant engineer to supervise the visit. The visit was taking an about 8 hours. During that time, a discussion about time standards, material handling system and related topics regarding to the project. This helps the students to get related information.

3.1.5 Data Collection

There is various ways to collect data from existing layout such as:

i) Time study and time collecting

ii) Recognizing the layout and workstations

iii) Identify material handlings system.

These are the time consuming and most importantly related information is gathered. The data may be in form of drawing, time standard and many more.

3.1.6 Data Evaluation and Analysis

All the data will be analysis using witness software. This is because the software is friendly and most importantly established company used it for improving productivity. This software is used to determine efficiency and bottleneck area in order to propose a new layout. The important parameters before analyzing are cycle time, traveling time and numbers of labors used.

3.1.7 Simulation

This project will be carried out by using Witness software to analyze production rate, efficiency and efficiency both current and propose layout. Note that the analysis can't be done if wrong parameters are insert or lack of information's. Thus correction needs to be done. Three layouts are needed to see the change of productivity and other information. This is guideline on how performing simulation.

3.1.8 Result

After analyzing, the software will generate an outcome in terms of productivity and efficiency. The results will be comparing both current and new layout. Three results will be chosen and the best will be proposed to the Nexus (M) Sdn Bhd.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

Through out the research, the scope of study is concentrated on model MDA5057 which is manufactured in daily operations. This model is popular and has higher demand from customers. This model is used widely in electrical compartment such as television.

To determine which line should be studied, those lines that have higher demand from customers are chose to be analyzed. Production of MDA5057 consists of several workstations and numbers of operators are involved. The layout of current production is discussed on next subchapter.

The data is collected and gathered to found up the best solution in order to achieve the research objectives. The time is taken by stopwatch then WITNESS SOFTWARE will do the simulation. The output from WITNESS SOFTWARE is used to compute line efficiency and productivity.

4.2 Task Times

Stopwatch is used to take task time in every workstation. 20 workstations are involved in order to produce MDA5057. The list of workstation is listed below:

Table 4.1: Process of Producing MDA5057

1.Preparation	2.Cutting	3.Tinning	4.Winding 1	5.Winding 2
6.Winding 3	7. Wire Wrap	8.Tinning 2	9.Ratio	10.Touch Up
11.Core Labelling	12.1st Inductance	13.IPQC	14.Prebake+Cooldown	15.2nd Touch Up
16.2nd Inductance	17.Hipot	18.Quality Control	19.2nd Hipot	20.Visual&Packing

4.2.1 Determine Time Standard

Observed time needed to be determined first before computed the time standard. Table 4.1 shows observed time in every workstation. 5 set of reading was taken to get an average time in each workstation. This is done to make sure data is valid.

Table 4.2: Time Study for MDA 5057

Workstation	1 (s)	2 (s)	3 (s)	4 (s)	5 (s)	Average Time (s)	Task Time (s)
1	6.58	7.48	6.24	8.35	9.25	7.58	7.58
2	7.82	8.32	9.58	6.91	13.61	9.28	9.28
3	5.6	4.24	3.01	5.17	3.72	4.35	4.35
4	91.20	101.36	115.30	98.21	98.18	100.9	100.9

5	19.09	21.69	22.45	25.64	26.17	23.00	23.00
6	27.28	24.32	25.03	26.53	26.56	25.94	25.94
7	55.07	43.74	48.79	39.80	54.64	38.41	38.41
8	12.44	14.62	12.56	12.73	15.70	13.61	13.61
9	19.29	13.40	15.58	13.13	16.12	15.50	15.50
10	14.93	13.61	12.84	11.98	14.12	13.50	13.50
11	29.1	23.89	25.19	29.96	26.52	26.93	26.93
12	6.75	4.52	5.89	5.57	4.71	5.49	5.49
13	7.37	5.65	6.70	5.81	5.43	6.19	6.19
14	25.00	25.00	25.00	25.00	25.0	25.00	25.00
15	10.02	10.64	10.45	9.53	11.16	10.36	10.36
16	4.68	2.11	2.61	2.52	2.92	2.97	2.97
17	3.00	3.00	3.00	3.00	3.00	3.00	3.00
18	15.27	14.56	15.65	13.78	14.67	14.79	14.79
19	3.00	3.00	3.00	3.00	3.00	3.00	3.00
20	3.23	3.76	3.78	4.15	3.65	3.71	3.71

To compute normal time, performance rating factor is used to adjust observed time to an operator expect to complete.100% rating is given in determining normal time. After computing normal time, standard time is easily defined however, number of allowances in each operator must be found first. The time standard is shown in Appendix D.

4.3 Current layout

4.3.1 Description of Current layout

The current layouts consist of 20 workstations and operated by 20 operators; means 1 operator operated 1 workstation. On this section, detailed explanation on each workstation is discussed. The model is MDA5057 is a popular demand and it involved in daily operations. It start in Workstation 1 where preparation is begins by checking the master list, number of bobbin required and dotting process is undergo here. Dotting is a process to put a mark in component leg and act as a reference for others operator. Then it goes to Workstation 2 which is cutting process. After put a mark in a component leg, operator start to cutting down the required leg based on master list. Operator 2 pass up to operator 3 whose operates Workstation 3 to do tinning process by dipping component leg into sort of chemical solution to protect the components from broke.

In Workstation 4,5,6,7 are critical areas, where the bobbin is wrapped with wire. In workstation 4 the wire is wrapped on legs number 2 and 5, then in Workstation 5 the wire is wrapped in legs 9 and 11 then continuous to legs number 12 in Workstation 5. After computing the task, the whole bobbin is wrapped to make sure all the wire is fully attached. This area contributing the largest consumption of time.

Tinning process for second time is done is workstation 8, all the legs are dipping in chemical solution for period of time. Ratio is a process by putting the bobbin in a compartment and secures it with layer of masking tape in Workstation 9. Next it goes to workstation 10, the operator will clean up the bobbin from any dirt and operator 11 will continues to put a label on it. The label is attached to the core by putting 2 layers of masking tape around the bobbin. The label is placed between 2 layers.

In workstation 12, the bobbin needs to undergo 1st inductance. Inductance machine is required to check the inductance level of the bobbin. The ranges is between 1.76H-2.64H, if the bobbin exceed the ranges, it considered reject. IPQC process is in Workstation 13. A few sample is took, and the operator start to analyze by measuring the components legs, outer measurement and labeling.

After passing this workstation, the bobbin was soaking in the varnish and placed in the oven to bake it. This process is depending on what type of varnish was used. Thicker the solution, longer the time required. The bobbins have to be cool down first before entering workstation 15. In Workstation 15, the operator has to working out the final touch up. They need to clean up the bobbin from excessive solution that sticks to component legs. Workstation 16 is 2nd Inductance where same steps in previous workstation that had 1st Inductance.

The bobbin entered Workstation 17 to undergo HIPOT process. HIPOT process is to determine ranges of voltage required by putting tools on required leg. The reading stated on the panel boards and the operator need to do it alternately depends on the legs. The time is set to be 3 seconds. The Workstation 18, 19, 20 is basically on checking the bobbin to make sure it fully satisfied by comparing it to master list. Lastly the bobbin was packing and sends to customer. **Table 4.2** shown time study for current layout

Table 4.3: Time Study for Current Layout

Workstation	Task Times (s)	Cycle Times (minute)
W1	8.8	0.147
W2	10.8	0.18
W3	5.1	0.085
W4	100.09	1.668
W5	26.7	0.445
W6	30.0	0.5
W7	44.6	0.7433
W8	16.1	0.2683
W9	18.0	0.3
W10	15.7	0.2617
W11	31.2	0.52
W12	6.4	0.1067
W13	7.2	0.12

W14	30.0	0.5
W15	12.0	0.2
W16	3.4	0.057
W17	3.5	0.0583
W18	17.2	0.2867
W19	3.5	0.583
W20	4.7	0.0783

After gathering all details, the data is been simulated by WITNESS SOFTWARE. Obviously from the outcome from software shown that number of output is 282 units and input is 289 units. This is because due to the process 7 units are involved in work in progress (WIP). The result for current layout is shown on **Table 4.4**

Table 4.4: Result by Simulation with WITNESS SOFTWARE

Matters	Result
Task Times (s)	480
Number of Workstation	20
Number of Input	289
Number of Output	282
Labor	20
Line Efficiency	19.73
Productivity	1.76

4.4 Propose Layout

4.4.1 1st Layout

Looking back the current layout, Workstation 4 has highest cycle time and bottleneck could happen here. Bottleneck can cause the product to be congested at particular workstation thus decreasing the productivity. Current layout could only produce the productivity rate at 1.76 units/hr. The line should be redesign to increase the productivity. One of the solution is to add one more workstation parallel with workstation 4 as Workstation 5.This means that 2 unit is produced at one go since time has been divided half. The time study proposes are shown in **Table 4.5**

Table 4.5: Time Study for 1st Proposed Layout

DESCRIPTION	WORKSTATION	CYCLE TIME (minute)
Preparation	W1	0.146
Cutting	W2	0.18
Tinning	W3	0.085
1st Winding	W4a	0.8433
1st Winding	W4b	0.8433
2nd Winding	W5	0.445
3rd Winding	W6	0.5
Wire Wrap	W7	0.743
Tinning	W8	0.268
Ratio	W9	0.3
Touch Up	W10	0.2616
Core Labeling	W11	0.52
1st Inductance	W12	0.107
IPQC	W13	0.12
Prebake	W14	0.5
2nd Touch up	W15	0.2
2nd Inductance	W16	0.0567
Hipot	W17	0.0583
Quality control	W18	0.2866
2nd Hipot	W19	0.0567
Visual & Packing	W20	0.0783

After computing the data with WITNESS SOFTWARE, the 1st propose layout producing the rate of productivity at 2.88 labor/hr. The detailed is shown on **Table 4.6**

Table 4.6: Result by Simulation with WITNESS SOFTWARE

Matters	Result
Task Times(minute)	480
Number of Workstation	21
Input(pieces)	495
Output(pieces)	485
Number of Operator	21
Line Efficiency (%)	37.28
Productivity	2.88

4.4.2 2nd Propose Layout

This layout has combination of several workstations has been done. This particular workstation is grouped by combine multiple tasking done in single workstation. 1st workstation is consists of preparation, cutting and marking. Workstation that has combination tasking is on 1st, 3rd, 7th; 9th.In workstation 2 we put parallel workstation and this would help in reducing bottle neck. The rest is single workstation with single task. The time study proposes is shown in **Table 4.7.** The simulation results is shown in **Table 4.8**

Table 4.7: Time Study for 2nd Proposed Layout

DESCRIPTION	WORKSTATION	CYCLE TIME (minute)
1) Preparation 2) Cutting 3) Tinning	1	0.4116
1) Winding	2	0.8408
1) Winding	3	0.8408
1) 2nd Winding	4	0.945

2) 3rd Winding		
1) Wire Wrap	5	0.7433
1) Tinning	6	0.2683
1) Ratio 2) Touchup	7	0.5617
1) Core Labeling 2) 1st Induction 3) IPQC	8	0.7467
1) Core Labeling 2) 1st Induction 3) IPQC	9	0.7467
1) Prebake	10	0.5
1) 2nd Touch up 2) 2nd Inductance 3) Hipot 4) Quality Control	11	0.7317

The data from WITNESS SOFTWARE is shown in **Table 4.8**. The data shown an increasing value. Thus its shows the new line is producing a lots of units in one day.

Table 4.8: Result by Simulation with WITNESS SOFTWARE for 2nd Propose Layout

Matters	Result
Task Times(s)	480
Number of Workstation	11
Input(pieces)	510
Output(pieces)	503
Number of Operator	11
Line Efficiency (%)	46
Productivity	5.71

4.4.3 3rd Propose Layout

This layout, 3's new workstation was introduced in workstation 2. This workstation is placed parallel to cut the cycle time. Its mean the time has been cut to 3 thus 3 product are produced at one time. Workstation 14 has a combination of 4 tasking in one workstation. The rest is single workstation with single tasking. The time study proposes and simulation results are shown in **Table 4.9** and **Table 4.10**

Table 4.9: Time Study for 3rd Propose Layout

DESCRIPTION	WORKSTATION	CYCLE TIME (s)
4) Preparation 5) Cutting 6) Tinning	1	0.4117
2) Winding	2	0.8408
2) Winding	3	0.8408
1) Winding	4	0.8408
1) Winding 2	5	0.445
1) Winding 3	6	0.5
1) Wire Wrap	7	0.743
1) Tinning	8	0.268
1) Ratio	9	0.2617
1) Ratio 2) 1st Touchup	10	0.2617
1) Labeling	11	0.52
4) 1st Induction 5) IPQC	12	0.22
1) Prebake	13	0.4167
5) 2nd Touch up 6) 2nd Inductance 7) Hipot&Qua.Control	14	0.7833

The data from WITNESS SOFTWARE is shown in **Table 4.10**. The data shown an increasing value. Thus its shows the new line is producing a lots of units in one day.

Table 4.10: Result by Simulation with WITNESS SOFTWARE for 3rd Propose Layout

Matters	Result
Task Times(s)	480
Number of Workstation	14
Input(pieces)	650
Output(pieces)	639
Number of Operator	14
Line Efficiency (%)	55
Productivity	5.75

4.5 Analysis of Layout (Theoretical)

WITNESS SOFTWARE could calculate the data for single day. To compute the certain parameters such as required output and time cycle, manual calculation is used. Mathematical Equations are use to found the Time Cycle in the line, number of product per year but first we need to define several parameters involve. Computing the number of units produced in a year is given by this formula

$$R_p = \frac{D_a}{50 \times S \times H}$$

S is number of shift per week

H is number of hour in shift

D_a number of units per year produced

R_p is number of required product

In current layout, the number of units produced per day is 282 units. To find number of units per year is determine by this formula

$$D_a = 282\,\frac{\text{Units}}{\text{day}} \times \frac{\text{day}}{0.033\ \text{month}} \times \frac{\text{month}}{0.083\ \text{year}}$$
$$= 102957\,\frac{\text{units}}{\text{year}}$$

Required product per hour is

$$R_p = \frac{D_a}{50 \times S \times H}$$
$$= \frac{102957}{50 \times 5 \times 8}$$
$$= 51.48\,\frac{\text{Units}}{\text{Hour}}$$

Cycle Time, T_c also have to be finding, to see the time is allocating at every workstation

$$T_c = \frac{60E}{R_p}$$
$$= \frac{60 \times 0.95}{51.48}$$
$$= 1.107\,\frac{\text{min}}{\text{Cycle}}$$

In 1st Propose Layout the units produce is 486 units per day. Here the layout is with an additional workstation placed parallel to reduce the bottleneck effect, thus the productivity is increase.

$$R_p = \frac{D_a}{50 \times S \times H}$$

$$D_a = 486\,\frac{\text{Units}}{\text{day}} \times \frac{\text{day}}{0.033\ \text{month}} \times \frac{\text{month}}{0.083\ \text{year}}$$
$$= 177437\,\frac{\text{units}}{\text{year}}$$

Required product per hour is

$$R_p = \frac{D_a}{50 \times S \times H}$$
$$= \frac{177437}{50 \times 5 \times 8}$$
$$= 88.71 \frac{\text{Units}}{\text{Hour}}$$

Cycle Time, T_c also have to be finding, to see the time is allocating at every workstation

$$T_c = \frac{60E}{R_p}$$
$$= \frac{60 \times 0.95}{88.71}$$
$$= 0.6425 \frac{\text{min}}{\text{Cycle}}$$

In 2nd Propose Layout, the line is redesign by adding 2 more workstation parallel to the each related workstation. In this line, combination of tasking is done thus its reduce number of workers that involve.

$$R_p = \frac{D_a}{50 \times S \times H}$$
$$D_a = 503 \frac{\text{Units}}{\text{day}} \times \frac{\text{day}}{0.033 \text{ month}} \times \frac{\text{month}}{0.083 \text{ year}}$$
$$= 202008 \frac{\text{units}}{\text{year}}$$

Required product per hour is

$$R_p = \frac{D_a}{50 \times S \times H}$$
$$= \frac{1202008}{50 \times 5 \times 8}$$
$$= 101.04 \frac{\text{Units}}{\text{Hour}}$$

Cycle Time, T_c also have to be finding, to see the time is allocating at every workstation

$$T_c = \frac{60E}{R_p}$$
$$= \frac{60 \times 0.95}{101.04}$$
$$= 0.564 \frac{\text{min}}{\text{Cycle}}$$

In 3rd Propose Layout, the steps is still the same by combination a few workstation into single workstation. The combination is done by combine workstation that the time process is not exceeds the cycle. The units produce is 639 units per day

$$R_p = \frac{D_a}{50 \times S \times H}$$

$$D_a = 639\,\frac{\text{Units}}{\text{day}} \times \frac{\text{day}}{0.033\ \text{month}} \times \frac{\text{month}}{0.083\ \text{year}}$$
$$= 233296\,\frac{\text{units}}{\text{year}}$$

Required product per hour is

$$R_p = \frac{D_a}{50 \times S \times H}$$
$$= \frac{233296}{50 \times 5 \times 8}$$
$$= 116.648\,\frac{\text{Units}}{\text{Hour}}$$

Cycle Time, T_c also have to be finding, to see the time is allocating at every workstation

$$T_c = \frac{60E}{R_p}$$
$$= \frac{60 \times 0.95}{116.648}$$
$$= 0.564\,\frac{\text{min}}{\text{Cycle}}$$

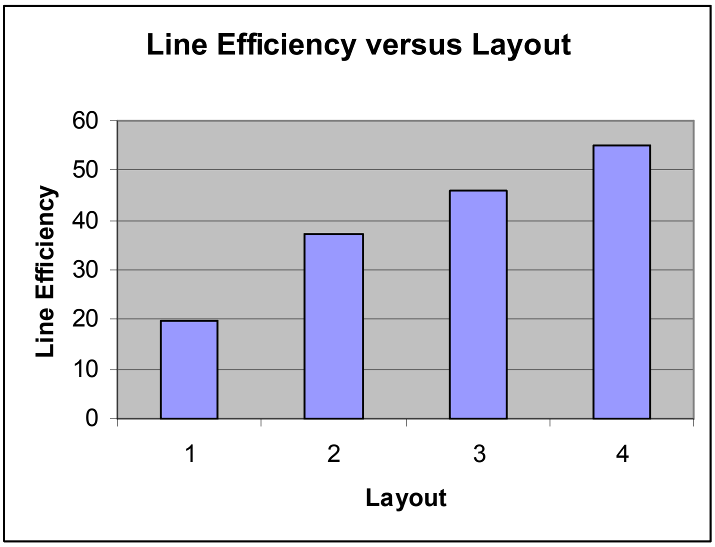

Figure 4.1: Line Efficiency versus Layout Graph

Figure 4.1 resembles the difference between the current layout (1) and other layouts aligned with its line efficiency. First layout indicates the line efficiency at 19.73% followed by second layout at 37.28%. The percentage increasing is about 47%. In reality this situation like this is quit unique. There would be some errors during taking data especially in time processing.

Gradually increasing at the third layout by 46% and finally the last layout produced 55% line efficiency. Obviously the graph explains layout is directly proportional to its productivity. The current layout is not capable to produce number of units by using 20 workstations. The line consumes too much spaces and too much idle time can cause bottlenecking problem. The layout is shown in the Appendix C. Second layout has a line efficiency of 37.28%. This slightly changes where the line has been redesign in order to improve the productivity rate. In this line parallel workstation was established due to bottleneck problems in first layout.

Several tasking are combined to reduce the workstation and number of operators. Therefore, a few workstations for example oven is remaining as single workstation due to its application. Layout three the concept is same as layout two. The layout produces 46% line efficiency. A few tasking are combining in single workstation to reduce the workstation. Layout four was producing the highest line efficiency by 55%. This is because, the line is design based on line balancing technique which the process time in every workstation is balance. Thus this line produce a lots of units compare too the 3 previous layout. In terms of productivity.

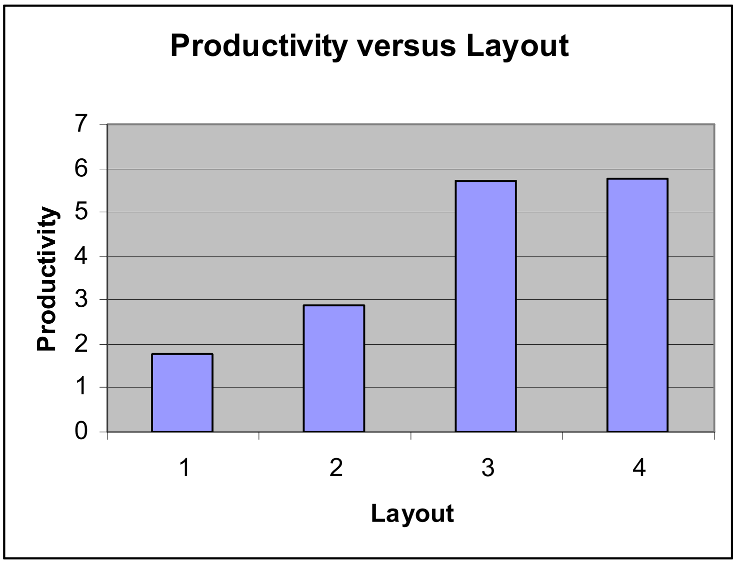

Figure 4.2: Productivity versus Layout Graph

Figure 4.2 first layout produces 1.76 units /labor while second layout contributed about 2.88 units/labor. For third layout the line produce 5.71 units /labor and lastly the layout four give the productivity rate at 5.76 units /labor. The line configuration in first layout is not well balance due to the imbalance workloads in workstations.

After redesign the layout the value changes from 1.76 units/labor to 2.88 units/labor. Next is third layout is gradually increase to 5.71 units/labor. This tells that the line is becoming more balance rather than previous one. This is for the reason that the line configuration is become smaller thus it's reduce the idle time for products to moving from one to others workstation. The fourth layout gave a productivity rate slightly increase from third layout which is 5.76 units/labor. After comparing all the layouts, layout number four is the best layout. Obviously the forth layout give the best line configuration and yet it's producing higher productivity rate.

Obviously the values are start to changing quit big especially in layout 3 and 4. At layout 3 the line efficiency is about 46% and its rise to 55%. Basically in reality the values should be increase but not with wide margin. Its supposed to increase the most is below 50% efficiency. The differences are quit big because there would be several undesirable factors that not included such as automation level in the line, line pacing, workstation and many more.

The automation level is defined as how many automated systems involved in the line to the normal line. Computing this required number of factors such as basic task, subtask, and timing. This required ample time to performing this automation level.

Line pacing is time allocation to workers while performing the tasks. The task times should be minus with the allocation times, thus the times is perfectly for workers doing their jobs.

5.3 RECOMMENDATION

After completing the research, several recommendations are made for further research in future. Below are the recommendations:

a) Performing similar research on mixed model line. It’s becoming a trend for company nowadays to produce multiple products in a single assembly line. This study will encourage students to fully utilize their basic understanding on matters stated before.

b) Using other software to do a simulation. There are numerous tools such as PROMODEL, ARENA, CINMFACTORY. This helps students to achieve better results. Noted that every tool has their limits and this will give a challenge to students to learn and understanding the natures of the software.

c) Enhancing the analysis by using WITNESS Optimizer since its reduce the time spending on the experimenting

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 INTRODUCTION

In this chapter, the main target is to make a summary about overall thesis. This including the expected outcome. The expected outcome basically comes from the previous chapter which is chapter 4. In last chapter, the conclusion is made to emphasizing the results as an addition is going to have some recommendation for further study.

5.2 CONCLUSION

As a conclusion, poor layout will contribute to the problems to production line. In this research, the objectives is achieved by proposing three layout and the best one is being propose to the company. In fact the research also shown that application of computer aided tools is really helping the industry to solve particular problems such as bottleneck station. Therefore the objectives of this research are achieved. In relation to the research, the propose layout is capable of solving the problem arises in the selected assembly line.

5.3 RECOMMENDATION

After completing the research, several recommendations are made for further research in future. Below are the recommendations:

a) Performing similar research on mixed model line. It’s becoming a trend for company nowadays to produce multiple products in a single assembly line. This study will encourage students to fully utilize their basic understanding on matters stated before.
b) Using other software to do a simulation. There are numerous tools such as PROMODEL, ARENA, CINMFACTORY. This helps students to achieve better results. Noted that every tool has their limits and this will give a challenge to students to learn and understanding the natures of the software.
c) Enhancing the analysis by using WITNESS Optimizer since its reduce the time spending on the experimenting

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APPENDIX A

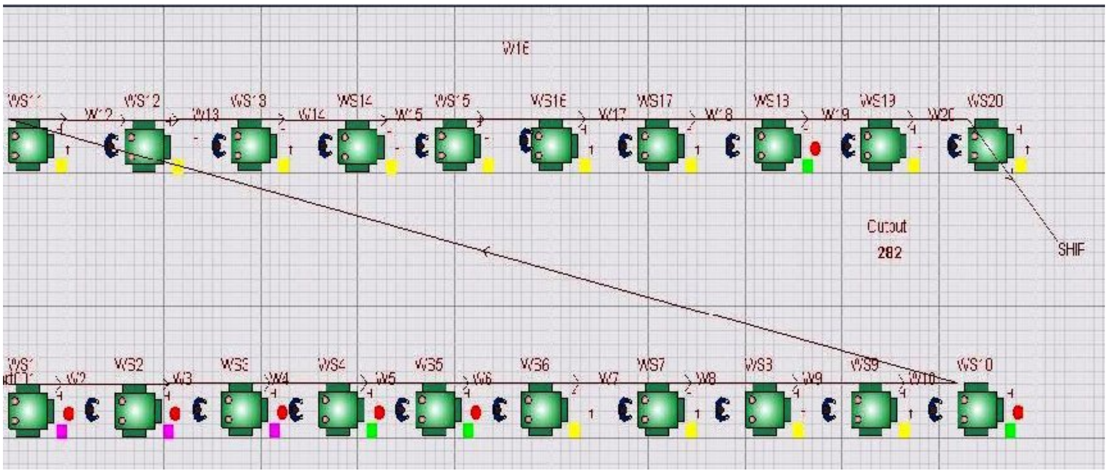

Diagram for Current Layout

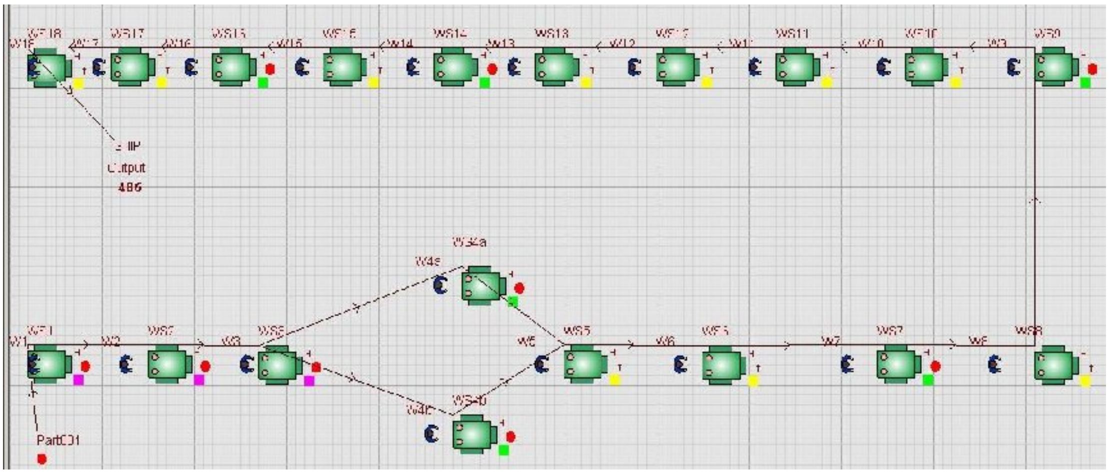

Diagram for 1st Propose Layout

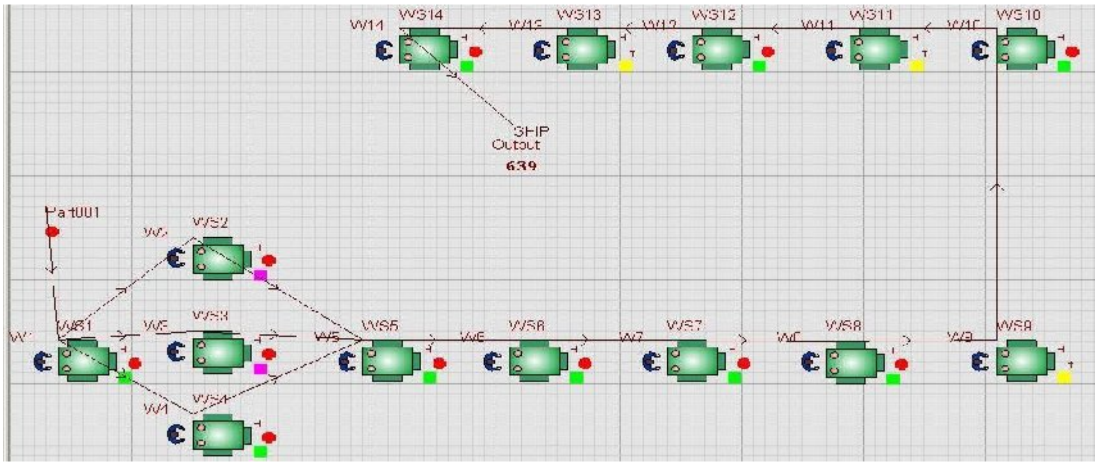

Diagram for 2nd Propose Layout

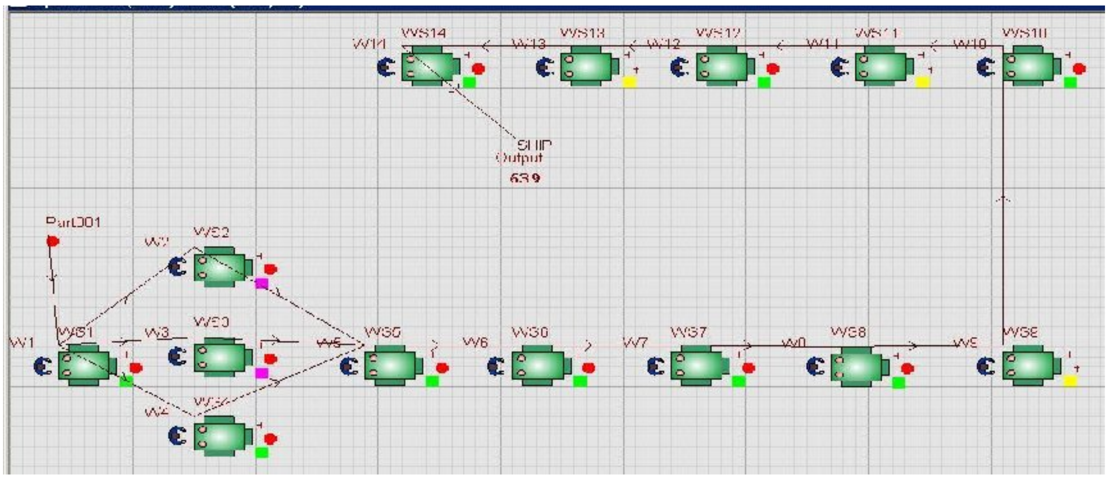

Diagram for 3rd Propose Layout

APPENDIX B

Matters	Observed Time (s)	Relaxation Allowances (%)	Contingency Allowances (%)	Total Contingency (%)	Standard Time (s)
1. Preparation	7.58	11	5	16	8.8
2. Cutting	9.28	11	5	16	10.8
3. Tinning	4.35	13	5	18	5.1
4. Winding 1	100.9	11	5	16	117.1
5. Winding 2	23.00	11	5	16	26.7
6. Winding 3	25.94	11	5	16	30.0
7. Wire wrap	38.41	11	5	16	44.6
8. Tinning	13.61	13	5	18	16.1
9. Ratio	15.50	11	5	16	18.0
10. 1st Touch up	13.50	11	5	16	15.7
11. Core Labeling	26.93	11	5	16	31.2
12. 1st Inductance	5.49	11	5	16	6.4
13. IPQC	6.19	11	5	16	7.2
14. Prebake	25.00	15	5	20	30.0
15. 2nd Touch Up	10.36	11	5	16	12.0
16. 2nd Inductance	2.97	11	5	16	3.4
17. 1st Hipot	3.00	11	5	16	3.5
18. Quality Control	14.79	11	5	16	17.2
19. 2nd Hipot	3.00	11	5	16	3.5
20. Visual	3.71	11	5	16	4.7

Gantt chart for FYP1

Task / Week	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	W16
1. Title Approval	■															
2. Gathered information about research		■	■													
3. Work on project objectives, scopes		■	■													
4. Factory selection for research				■	■											
5. Work on literature reviews				■	■	■	■	■	■							
6. Methodology										■						
7. Learn about software														■		
8. Work on expected result and conclusion												■	■			
9. Submit proposal to panels														■		
10. Compile the report														■	■	
11. FYP 1 presentation																■

Gantt chart for FYP 2

Task/ Week	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1.Research continue														
2.Work on data using Witness														
3.Result discussion														
4.Finalize report														
5.FYP 2 slide preparation														
6.FYP 2 presentation														
7.Final Thesis Submission														