PRODUCTIVITY IMPROVEMENT THROUGH LINE BALANCING

HAZMIL BIN HAPAZ

Report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2008
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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

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](http://www.smidec.gov.my))

<table>
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<td>Manufacturing and Agro-based Industries</td>
<td>Sales turnover between RM250, 000 and less than RM10 million OR full time employees between 5 and 50.</td>
</tr>
<tr>
<td>Services</td>
<td>Sales turnover between RM200, 000 and less than RM1 million OR full time employees between 5 and 19.</td>
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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].](image)

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 number of workers, w and manning level, M

\[ n = \frac{w}{M} \]

A workstation has length dimensions, \( L_{st} \), where I denotes station i. Total length assembly line, L is summation of each workstations length

\[ L = \sum_{i=1}^{n} L_{st} \]

If the length assembly line (m, ft), \( L \) and \( L_{st} \) = length of station I (m, ft) are equal

\[ L = nL_{st} \]

If using conveyor we have to determine the feed rate, \( f_{cp} \) and assume time cycle, \( T_c \) is constant throughout the line

\[ f_{cp} = \frac{1}{T_c} \]
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 provide 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 be 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.
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:

\[
\text{Line efficiency} = \frac{\sum \text{task times}}{\text{Number of workstation} \times \text{Desired cycle time}} \times 100
\]

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