UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Line Balancing and Optimization for Single Model Assembly Line at a Small Medium Industry (SMI)

Thesis submitted in accordance with the partial requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering (Manufacturing Process)

By

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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JUDUL: A Line Balancing and Optimization for Single Model Assembly Line at a Small Medium Industry (SMI)

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I hereby, declare this thesis entitled "Line Balancing and Optimization for Single Model Assembly Line at a Small Medium Industry (SMI) " is the result of my own research except as cited in the references.

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ABSTRACT

In today's competitive manufacturing environment, companies are constantly looking for ways to improve. Because of this, many companies are striving to become "lean" by implementing lean manufacturing, which is a difficult process. Line balancing is part of the lean manufacturing. To aid in the implementation of line balancing manufacturing, simulation was used to reduce the trial-and-error period of line balancing manufacturing and find to optimum approach to implement the line balancing manufacturing principle.

This thesis content is about the line balancing and the method to solving the problem. The scope of this thesis focuses on optimizing the production line of a SME company using Witness simulation software. The implementation of this thesis will be done at the small medium industry located at Shah Alam. There are three alternatives solutions in order to manage bottleneck and optimize the production line. The first alternative simulate about eliminate the workstation for reducing the idle time. Assembly 1, assemble 2 and meter potting is the three processes that reduce the workstation. Next the second alternative is about adding the new workstation at the critical processes. There are three processes that add with new workstation to improve the production line. Programming, FOS passivation and final assembly processes is the process that add with new workstation. This alternative is suitable for use to produce extra capacity in production. Lastly, the third alternative is about reducing the cycle time to optimize the product output. All of the alternative will analyze and compare with the current production line. The best alternative selected to improve the production line. To improve this thesis, further research about simulation needing for improve the simulation result and can give more than three alternative for optimize the production line.

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CHAPTER 1

INTRODUCTION

1.1 Background

Line balancing is a tool that can be used to optimize the workstation or assembly line throughput. This tool will assist in the reduction of the production time and maximizing the output or minimizing the cost. Assembly line is a flow oriented production system where the productive units performing the operation referred to the workstation and the work pieces move from one station to one station with some kind of transportation system. Usually the chain conveyor system is utilized as the mode of transportation for the work pieces in the assembly line.

Normally there will be a problematic area in an assembly line or technically known as the bottleneck workstation. Bottleneck is based on the analogy of the shape of a bottle. When liquid is poured into a bottle, the liquid will flow slowly at the bottlenecks that have a smaller parameter compare to the wider body. That is the concept or application that is used for the term bottleneck in assembly line. At an assembly line, bottleneck is will create a queue and a longer overall cycle time. The example of the bottleneck concept can be referred at figure 1.

Cycle time, number of machine, number of workers, and shift pattern are the basic data enquired in order to perform the line balancing activity. The cycle times of each process in the factory were gathered to give a better understanding of the bottlenecks that might exist and of the work content at each station. Gathering detailed information on cycle times and work content for all workstation is important in order identify the bottleneck of the entire operation.

There are number of methods that can be use to analyze the data collection. This thesis will use simulation method to analyze production line identified in a case study. With this method it needs to construct a simulation model will be constructed to mimic the real world production system. The bottleneck workstation will be determined from the simulation results. The process that has the lowest performance will be declared as the bottleneck workstation. Simulation model experimental will be applied to balance the production line. Trial-and-error technique will be applied to solve this problem. “Witness 2006 Manufacturing Performance Edition” is the simulation software that used in this thesis. Through simulation modeling, the company can save cost to improve the assembly line performance compare to the traditional way of trial and error on the actual system. Depending on the accuracy of the data gathered, the simulation model is able to provide result to achieve efficient result which can be closed to 100% to the real world situation.

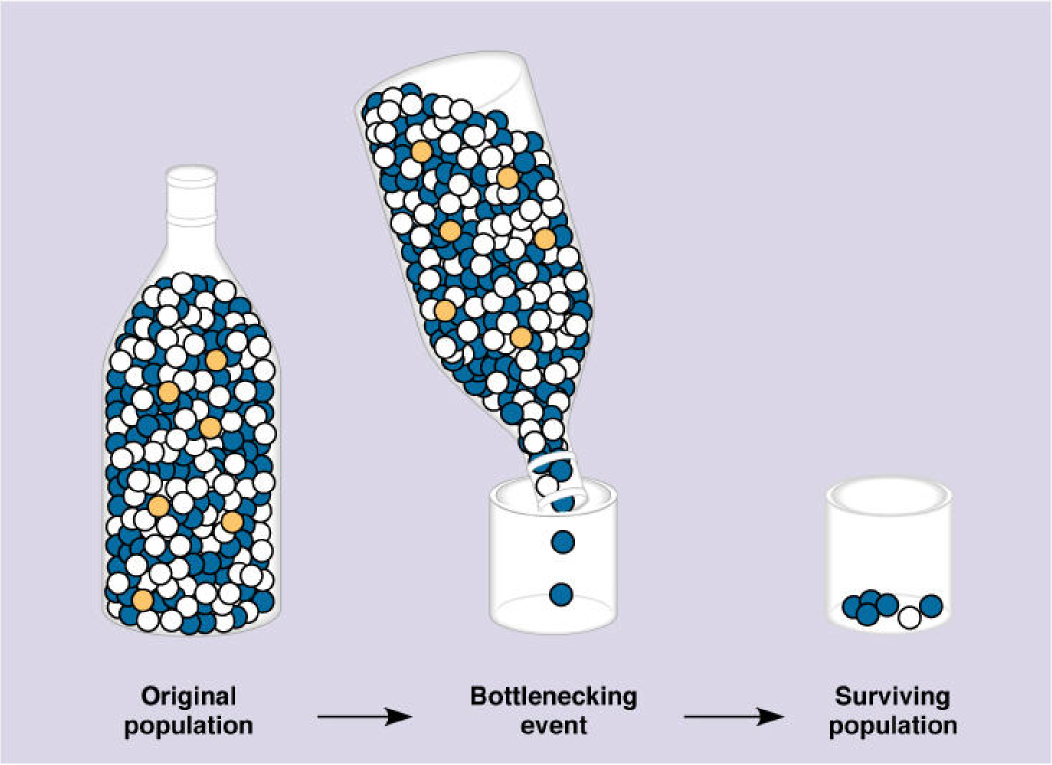

Figure 1: Bottleneck Concept (Jodge, M.D , 1999)

1.2 Problem Statement

In order to achieve highly productive assembly line, the optimum amount of resources in terms of workstations and labor will need to be determined. One way to do this is by performing a line balancing study. Line balancing tool can help to characterize the line capacity and take into account the dynamic behavior of the system. Line balancing tool also can assist in implementing changes in a quick and effective manner where experimentation with the real world system can be very costly. It also is able to evaluate and optimize the line throughput, machine utilization and cycle time. The line balancing problem is often express in one possible term which is to determine the minimum number of work stations needed and task allocation to produce maximum output rate.

1.3 Objectives

The objectives of this project are:

i. To develop a validated capacity model utilizing Witness.
ii. To identify bottleneck process.
iii. To manage the bottleneck process and balance the production line.

1.4 Scope of Project

The scope of this project is to perform detail study of the production line such as process flow, resource capacity, cycle time, shift patterns and etc. In this scope student need to identify a factory to perform the research. Student need to get the information data about the process flow and cycle time for all process. The data gathered will be entered in the witness simulation. Using Simulation, the dynamic behavior of the actual process is able to be captured. The simulation model has been verified and validated and the result of the study will be to determine the bottleneck process that occurs at the production line. In addition, witness simulation software will be used as the line balancing tool will be used to improve the production line.

1.5 Methodology Synopsis

Methodology is method or procedure that will be used to achieve the objectives of the study. For this thesis the methodology consist of has seven steps which are objectives definition, scope and requirement, data gathering and analysis, model construction, model verification and validation, simulation experimentation and optimization. The objectives and scope was explained earlier in this paper. The tools to be used for this project are the data collection form, the stop watch for time study and the witness simulation software. Each tool has its own function that will be use in this thesis. The gathering of process time set-up, breakdown data and other information will need to be conducted at the company selected for the case study. This thesis uses the simulation software to analyze the data. All the required data will need to be entered into the simulation software. The result of the bottleneck process will be presented in the graph format line balancing will be done in order to optimize the resource utilizes of the production system.

CHAPTER 2

LITERATURE RIVIEW

2.1 History of Manufacturing

History of manufacturing is not very precise. Manufacturing has been one of the human activities for a very long time. Before manufacturing revolution, ancient man produced stone articles only using his muscular power. An earlier manufacturing activity remained in the hand of the Artisan and their apprentices and earlier development in manufacturing took place under their supervision. The second revolution of manufacturing is focused on copper manufacturing where copper is the first metal melted by man. Excavation of Mohanjodaro and Harappa (5000-4000BC) show the metal and jewelry work. There are examples of in Greek and Roman civilization that craftsman used casting process. (History of Manufacturing and Production System ,http://paniit.iitd.ac.in/~pmpandey)

The concept of the machining is very old. Some of the researcher believed that the idea of the lathe machine concept has been derived from the potter's wheel that existed before 2500 Bc. Figure 2 show the example of the potter's wheel. Early 1700 BC, potter's wheel concept is applied to produce the round groove marks on wooden bowl until this concept is perfected before the 6th century.(The History of Manufacturing ,http://home.business.utah.edu/fincmb/day28/sld003.htm)

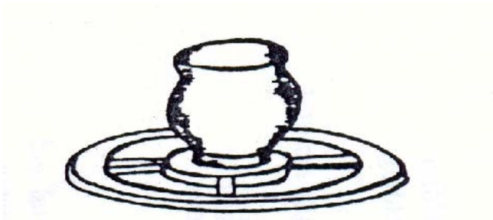

Figure 2: Potter's Whell (Davis, D.1999)

Before the revolution, the concept of tool has already been established. Basically the material to make the tool is stone piece and tree branch. The tree branch functions as a lever and stone piece as a head. The example of the tool that made from stone pieces and wooden branch is shown in Figure 2. Now revolution has changed the stone piece to the metal material. This makes the tool more perfect that before.

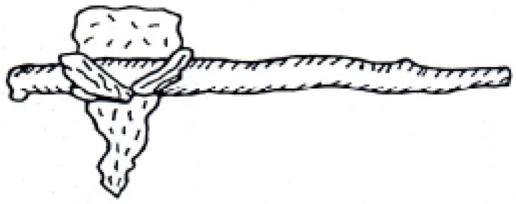

Figure 2.1: Hand-Held Tool with Tree Branch as a Lever. (Davis, D.1999)

First industrial revolution is in 1750s. England is the first country that experienced the industrial revolution. This revolution is focused on the production and the mechanization. The modern mechanization began in England and Europe with the development of textile machinery and the machine tools for cutting metals. This technology soon moved to United States where it was developed further, including the important advances of designing, making and using interchangeable parts.

The second industrial revolution started during mid 20^{th} century with enormous growth in solid state electronics computer that can perform task very rapid efficiency with lower cost. Thus the second revolution is focused on the flexible automation. Today with the help of computer-integrated manufacturing system, production method has gone through further advancement. The new technologies are able to give more benefit in improving the mass production rate.

2.2 Production System

In a factory, a production system function is to produce a product or output. The production system consists of man, machines, material, material handling equipment and method of manufacturing. Production system can be divided into two categories:

i. Production facilities
ii. Manufacturing support system

2.2.1 Production Facilities

A production facility in manufacturing sector is referring to the total of the product that will be produce in a month or year. There are three type of the production facilities;

i. Low quantity production
ii. Medium quantity production
iii. High quantity production.

2.2.1.1 Low Quantity Production

Low quantity production is one type of production facilities. The manufacturing firm that produced 1 to 100 products per year will be classified under low quantity production firm. The other characteristic for this type of production facilities is, the firm usually specializes and customizes in producing one product. Example of this type of production is aircraft manufacturing and special machinery. In this firm sector need the highly skilled for the labor force to make the product.

2.2.1.2 Medium Quantity Production

The second type of production facilities is medium quantity production. This type of production produces 100 to 10,000 product per year. The normal practice in two type production is termed as Batch production. In batch production, batch of one product is made in such a way that rate of production is more than demand rate. In the intermediate time, a batch of another product is manufactured. This change over involves non-production time because of tooling change and set up change. This is the drawback of batch production.

2.2.1.3 High Quantity Production

The factory that produce 10,000 to millions unit per year is classified as high quantity production type. The situation is characterized by high demand rate and the system is dedicated to the single item only. Usually the standard machine with special tooling will be used to produce the product. The layout arrangement will normally use the cellular layout where the workstations are arranged in sequence and the product moves through the sequence until the completing. Single model production line or mixed-model production line will be used as the workstation design for this type of system.

2.2.2 Manufacturing Support System

Manufacturing Support System is the tool to improve the production line. Lean or Just in Time manufacturing are examples of the tools that can be used control the production rate. Japan is the country that introduces these tools. The production is controlled by current demand. The main purpose is to eliminate of waste like material, machine capital main power, and inventory, waste of motion, waste from product defect and waiting or idle time.

2.3 Cycle Time Definition

Cycle time is one of the important data for the line balancing at any production line. Cycle time is the time it takes to finish one product or the total of time takes before the product leaves the workstation and move to the next workstation. The cycle time required to process a customer order might start with the customer order and end with the order being delivered. The overall process is made up of many sub-processes such as order entry, assembly, inspection, packaging, and delivery. Cycle time is inversely related to throughput, decrease cycle time leads to increased throughput, show in the following equation (Mejabi,2003):

$$\textbf{Cycle Time ,c} = \frac{\text{Total Operating Time}}{\text{Quantity of Production Produced}}$$

$$= \frac{1}{\text{Throughput}}$$

$$\textbf{Production Rate, p} = \frac{1}{\text{Cycle Time, c}}$$

2.3.1 Cycle Time Reduction

Cycle Time Reduction is identifying and implementing more efficient ways to do things. Reducing cycle time requires eliminating or reducing non-value-added activity, which is defined as any activity that does not add value to the product. Examples of non-value- added activity in which cycle time can be reduced or eliminated include repair due to defects, machine set-up, inspection, test and schedule delays. Reducing cycle time will have a significant impact on a company's bottom line when implemented.

Cycle time reduction is provides tremendous benefit to a company. From the cycle time reduction the non-value added activity will be reduce or eliminated. The benefit from this reduction is following below:

i. Reduced cost
ii. Increase throughput
iii. Streamlined processes
iv. Improved communications
v. Reduced process variability

vi. Schedule integrity
vii. Improve on-time delivery

2.4 Queueing System

Line balancing concept starts from the queuing theory. This application concept is referred to the problem at queuing system. The solution for this problem gives a idea to solve the line balancing problem.

The three main aspects in queueing theory are customers, queues, and servers (service mechanisms). The meaning of these terms is reasonably self-evident. In general, in a queueing system, customers for the queueing system are generated by an input source. (Martinich J.S, 1997) The customers are generated according to a statistical distribution (at least, that is the simplifying assumption made for modeling purposes) and the distribution describes their interarrival times, in other words, the times between arrivals of customers. When customer arrives, they will join a queue. At various times, customers are selected for service by the server (service mechanism). The basis on which the customers are selected is called the queue discipline. The head of the queue is the customer who arrived in the queue first.

Another piece of terminology which is sometimes used is the tail of the queue. The meaning of this varies depends upon the context and the source. It normally means either all of the queue except the head or the last item in the queue, in other words the customer who arrived last and is at the back of the queue. Both uses are in common usage, and the terminology front and back of the queue will be used to describe the customers who arrived least recently and most recently (respectively) to avoid ambiguity.

2.4.1 Little's Theorem

Queueing system has a theorem to make the analysis of the problem. Litte’s Theorem is the theorem that use in this system. Little's theorem states that;The average number of customers (N) can be determined from the following equation (Quirk,1999):

$$N = \lambda T$$

Here lambda is the average customer arrival rate and T is the average service time for a customer. Proof of this theorem can be obtained from any standard textbook on queueing theory. Here we will focus on an intuitive understanding of the result. Consider the example of a restaurant where the customer arrival rate (lambda) doubles but the customers still spend the same amount of time in the restaurant (T). This wills double the number of customers in the restaurant (N). By the same logic if the customer arrival rate remains the same but the customers service time doubles, this will also double the total number of customers in the restaurant.

2.4.2 Queueing System Classification

With Little's Theorem, we have developed some basic understanding of a queueing system. To further our understanding we will have to dig deeper into characteristics of a queueing system that impact its performance. For example, queueing requirements of a restaurant will depend upon factors like:

- How do customers arrive in the restaurant? Are customer arrivals more during lunch and dinner time (a regular restaurant)? Or is the customer traffic more uniformly distributed (a cafe)?
- How much time do customers spend in the restaurant? Do customers typically leave the restaurant in a fixed amount of time? Does the customer service time vary with the type of customer?
- How many tables does the restaurant have for servicing customers?