NATIONAL TECHNICAL UNIVERSITY COLLEGE OF MALAYSIA

Improve Manufacturing Process by Using Line Balancing Method to Reduce Cycle Time

Thesis submitted in accordance with the requirements of the National Technical University College of Malaysia for the Degree of Bachelor of Manufacturing Engineering (Honors) (Manufacturing Process)

By

Elvie Rosmieza Bt Mohd Zawawi

Faculty of Manufacturing Engineering

June 2006

APPROVAL

This thesis summitted to the senate of KUTKM and has been accepted as fulfillment of the requirement for the degree of Bachelor of Engineering (Honours) Manufacturing (Process). The members of the supervisory committee are as follows:

....

Main supervisor

Faculty of Manufacturing Engineering

PROF. MADYA DR. ADI SAPTARI
Pensyarah
Fakulti Kejuruteraan Pembuatan
Kolej Universiti Teknikal Kebangsaan Malaysia
Karung Berkunci 1200, Ayer Keroh
75450 Melaka

DECLARATION

I hereby, declare this thesis entitled " Improve Manufacturing Process By Using Line Balancing Method To Reduce Cycle Time" is the results of my own research except as cited in the reference

Signature:..

Author's Name: ELVIE ROSMIEZA BT MOHD JAWAWI

Date: 14/05/06

ABSTRACT

Manufacturing is the transformation of raw materials into finished goods for sale, or intermediate processes involving the production or finishing of semi-manufactures. It is large branch of industry and of secondary production. Some industries, like semiconductor and steel manufacturer use the term fabrication. Manufacturing cycle time (the time that elapses from work order release to completion) affects the cost of developing and manufacturing a product. However, most cost models consider only the setup and processing times and ignore the move times and queue times, which form most of the manufacturing cycle time. This paper discusses the production impact of manufacturing cycle time. It presents methods for estimating the manufacturing cycle time of a selecting product that will be made in a manufacturing system that makes other products as well. It identifies the benefits of reducing manufacturing cycle time and shows how those benefits yield increased productivity. One objective during product development is to reduce the time spent by the product in the manufacturing system, known as the manufacturing cycle time. Reducing the manufacturing cycle time has many benefits, reducing idle time for worker and machine, reduced costs, improved product quality (process problems can be found more quickly), faster response to customer orders, and increased flexibility. In addition, a shorter manufacturing cycle time means helps reduce the time-to-market. This paper also explains about how the precedence diagram can be applied to determine the suitable cycle time besides reducing production time. The significant of this project is to simulate the problem in the industry which is student will learn how important of time in the industry.

ACKNOWLEDGEMENTS

Assalamualaikum....

First of all I will thank you to Allah S.W.T because give the chances to finish my project in the necessary condition. Hereby, I will also want to thanks to the main people that give as much as supporting during guiding me to finish this project. They are my supervisor Prof. Madya Dr. Adi Saptari that gives me more guidance during the journey of the project.

My thankfully is to the other lecturers that are also give me some guidance how to write the best and appropriate report. Here also, I would like to thanks to the manager and its organization of Circle Ring Network Sendirian Berhad, Shah Alam that give me chance to make my analysis study in their production line. I'm also want to thanks to my beloved people that important in my life: my parent that never stop to give me the best supporting and guiding me during finished my project.

TABLE OF CONTENTS

\

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

1. INTRODUCTION

Improve manufacturing process by using line balancing method to reduce cycle time is the title of the project that discuss some analysis about the manufacturing management industry. In this case, we have to choose type of the product as for design of the process. From this selection, it is important to recognize the cycle time of the production from the selection product. Each operation of the workstation can be influence the design of the layout and the production time. This project requires the student to understand the concept of manufacturing and design of production process. In this introduction, the explanation of how manufacturing design will be built by using line balancing or process flow. The paper also require student to make some observation in the industry to observe about overall process production including the type of product that selected as main analysis, type of machining that were using in the industry, type of material, process flow of the product, production time that including cycle time for one product, quality of the product and layout of the manufacturing cell in the entire industry.

1.1 Problem Statements

Productivity improvement has been concern of industry. There are many ways to improve productivity, these involve in any activity in the value chain (supply chain) process in the company. This project is concern on the improvement of manufacturing process. In particular, this research is an alternative to reduce idle efficiency of a company. Therefore, as my observation, many industries have the same big problem: **reducing cycle time of the product** and they have difficulty to make improvement in productivity. The main factor that we clearly define cause they cannot reduce the using of process flow or product layout, quantity of using material, machinery and the unnecessary of layout manufacturing plant also influence the production time (the correlation with human factor). One of the major necessary steps in production is to design of manufacturing process. Design, according to expert, determines 70% of the total cost incurred. This step controls the following: sequence of production, production time, resource allocation (man and material), and at the end the quality of manufacturing product. One method used for analyzing design of manufacturing process by means of the line balancing. This chart will assist designer to investigate the time required to complete a product, the sequence of manufacturing process, the right machine to use, the material used and even the labor. Therefore, this title of this project is applicable with the subject of manufacturing process to analyze the problem in the industry, besides to improve the product quality. From this problem, we can create an idea of how this concurrent engineering problems can be improve by make some observation of the weakness in the industry and then make some improvement the current problems occurs in industry by analyze the root problems. Other than that, we can found that in Malaysia, the using of human in the industry still popular because they human can give more advantage than technology machining. Therefore, by studying the line balancing method that involving the human in manufacturing process should be improve compare by using machining.

Besides that, there are still have problems in the assembly line balancing in the entire industry that cannot be reduced such as assembly line producing multiple products, due to variable process time, line balancing problems deals with multiple workstations, human factors, product characteristics and length of cycle time. Therefore, it is important this subject must be considered to analyze or study this topic as the current problem in the current engineering.

1.2 Objective of the Research

1. To understand the role of manufacturing or process design.
2. To improve of current manufacturing process and assembly time by the reducing idle time of workers or machine time

3. To apply line-balancing methodology in improving productivity and reduce production time and cycle time.

1.3 Scope of project

This project will require student to select product, do investigation what sequence of manufacturing process involved, what kind of machinery to use to complete the part, record data the time of each process, (if investigation in the company, this data may be available or it may figure out in the lab), record material used, and assembly process.

Do analysis of cycle time in each operation in the workstation using the line balancing, this method is part of design for manufacturing and design for assembly, come out with the recommendation to increase the productivity (reduce the time required to complete manufacturing process), alternative a new manufacturing process, which will give better in production time, or processing time of the selected product.

In these contexts, an assembly line may consist of one or more operations. The total assembly time equals to the sum of the separate operation process time. The number of operations and operation contents are basically determined by the structure of the assembly and the complexity of assembly work. An assembly is usually composed of number of components or subassemblies. If the total assembly work is too complex, engineers tend to break the entire assembly work into a number of operations, making each operation responsible for one or more subassemblies. Depending on its complexity, a subassembly may further be broken into components and then operations may be defined for one or more components.

Line balancing is a simple process design criterion is to balance the assembly line so that each operation takes approximately the same amount of time. A balanced line often means better resource utilization and consequently lower production cost.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introduction of the topics

In this literature review, the topic discuss about the design manufacturing process analysis by using line balancing method to increase process layout and reduce the production time. In this case, the main point of this topic is about how to improve the design analysis by using operation in each workstation to improve the productivity of the product. This is including increasing process layout and reducing production time.

In this case, what are the meaning of the design manufacturing, process analysis, what is the assembly line balancing that the most important component that give big impact to process layout and production time, and what the relationship of the three main components to this purpose.

2.1.1 The History of manufacturing

As for introduction, word *manufacturing* is can be derived from the Latin *manu factus*, means made by hand. The word manufacture first appeared in 1567, and the word manufacturing appeared in 1683. Although it is difficult to be more precise, manufacturing dates back to about 5000-4000 B.C. It is older than recorded history, because primitive cave or rock markings and drawings the rock; appropriate tool had to be made for these application. Manufacturing of products for various uses began with the production of articles made of wood, ceramic, stone, and metal. The material and process first used to shape products by casting and hammering has been gradually developed over the centuries, using new materials and more complex operations, at increasing rates of production and at higher levels of quality. The first materials used for making household utensils and ornamental objects included metals such as gold, copper and iron, followed by silver, lead, tin bronze, and brass. The production of steel in about 600-800 A.D. was a major development. Since then, a wide variety of ferrous and nonferrous metals have been developed. Today, the materials used in advanced products such as computers and supersonic aircraft include engineered or tailor-made materials with unique properties, such as ceramics, reinforced plastics, and composite materials, especially alloyed metal. Until the industrial revolution, which began in England in the 1750s, good has been produced in batches, with much reliance on manual labor in all aspects of production. Modern mechanization began in England and Europe with the development of textile machinery and of machine tools for cutting metals. This technology soon moved to the United States, where it was developed further, including the important advance of designing, making, and using interchangeable parts. Prior the introduction of interchangeable parts, a great deal of hand fitting was necessary, because no two parts were made exactly alike. Although the Romans had factories for mass-producing glassware, manufacturing methods were at first very primitive and generally very slow, with much manpower involved in handling parts and running the machinery. Today, with the help of CIM or computer-integrated manufacturing systems, production methods have been advanced. (Kalpakjian and Schmid R.S, 2001).

In the modern sense, manufacturing involves making products from raw materials by means that the several of processes, machinery, and operations, through a well-organized plan for each activity required. What is the definition of manufacturing? As for the theoretical of the meaning, manufacturing can be subjected to: in its broadest sense, is the process converting the raw material into the product. It must be flow through many processes such as the product design, the selection of the raw material, the flow of the process or operation for each part of the product until the product will be manufactured or produced. Manufacturing also is the backbone of any industrialized nation. It is gives significant to the industrial in any type of production. Its importance is emphasized by the fact that, as an economic activity and it comprises approximately 20% to 30% of the value

of all goods and services produced. A country 's level of manufacturing activity is directly related to its economic health. Generally, the higher the level of manufacturing activity in a country is the highest standard of living of its people.
(Kalpakjian and Schmid R.S, 2001).

Manufacturing also involves activities in which the manufactured product is itself used to make other products.

2.1.2 Design manufacturing

After knowing what are the concept of the manufacturing and its history of the manufacturing, what is the design and design manufacturing? As the basic theoretical, design can be subjected to create or make new something new than current design. It may be involve shape of the object or make new object that we cannot recognize yet. The concept of the design always applied in manufacturing in industrial. Therefore, design manufacturing is creating new operation or sequence of the any process that to produce or manufacture of the product. It is not involving the converting the raw material to the product but we have to create a new idea to produce a new product by new processes.

As basic theories of design manufacturing is similar to design process is the design process for a product first requires a clear understanding of the functions and the performance expected of that product. The product may be new, or it may be a revised version of an existing product. Traditionally, design and manufacturing activities have taken place sequentially rather than concurrently simultaneous. Designers would spend considerable effort and time in analyzing components and preparing detailed part drawings; these drawings would then forwarded to other departments in the organization, such as materials departments, where, for example particular alloys and vendor sources would be identified (Kalpakjian and Schmid R.S, 2001)

2.1.3 Basic Theory of design manufacturing

The main basic of design manufacturing can be referred that design and manufacturing must be interrelated; they should never be viewed as separate disciplines or activities. Each part or component of the product must be designed so that it not only meets design requirements and specifications, but also can be manufactured economically and efficiently. This approach improves productivity and allows a manufacturer to remain competitive. This broad view has become recognized as the area of Design for manufacture. It is a compressive approach to production of goods, and it integrates the design process with material, manufacturing methods, process planning, assembly, testing, and quality assurance. Effectively implementing design for manufacture requires that designers have a fundamental understanding of the characteristics, capabilities, and limitations of material, manufacturing processes and related operations, machinery, and equipment. This is also includes such as: variability in machine performance, in dimensional accuracy, and in surface finish of work piece; processing time; and the effect of processing method on part quality. Designers and product engineers must be able to assess the impact of design modifications on manufacturing-process selection and on assembly, inspection, tools and dies and product cost. Establishing quantitative relationship is essential in order to optimize the design for ease of manufacturing and assembly at minimum product cost or productivity. (Kalpakjian and Schmid R.S, 2001).

One of the thesis that also involving in design manufacturing about a tool for reducing manufacturing cycle time from the journal that were created by two researcher Jerey W. Herrmann and Mandar M. Chinholcar. They have describes about the using of DFP or design for production tool determines how manufacturing a new product design affects the performance of the manufacturing system by analyzing the capacity requirements and estimating the manufacturing cycle time. They have use the term design for production to describe methods evaluate a product design by comparing its manufacturing requirements to available capacity and estimating manufacturing cycle time. By DFP and DFM concept that it create a product design that satisfies the product's functional requirements and the DFP design guideline. Specify the desired throughput and work order size. DFP will become more important as product variety increases and product life cycles decrease. Factories are faced with an explosion of varying cycle times because of increased product variety, and historical cycle times will not be accurate enough for a new product to be manufactured in the future, when the product mix will be different. Also, because production lines outlive individual products, it is important to design new products that can be manufactured quickly using existing equipment. Previous researchers have developed various DFP methods for different problem settings, and this paper brief reviews the relevant literature. The paper's primary contribution is to describe a decision support tool that performs DFP analysis. The tool quantities are how introducing a new product increases congestion in the factory. This tool employs an approximate queuing network model that estimates the manufacturing cycle time of the new product. This provides feedback that the product development team can use to reduce manufacturing cycle time. The tool can be used during conceptual design and requires less data than simulation models. Design for manufacturing (DFM) is used to improve a product's manufacturability. Both DFM and DFP are related to the product's manufacture. DFM evaluates the materials, the required manufacturing processes, and the ease of assembly. Like DFM, DFP can lead a product development team to consider changing the product design. In addition, DFP can provoke suggestions to improve the manufacturing system. Mandar M. Chincholkar and Jeffrey W. Herrmann, 2001).

DFM approaches that generate process plans and estimate processing times can be reduce. DFP step, since some DFP methods use this information. Traditional DFM approaches can also improve manufacturing cycle time since they minimize the number of parts and reduce the processing time of each operation. They distinguish DFP approaches by their focus on evaluating manufacturing capacity and manufacturing cycle time. DFP methods can be done concurrently with DFM. Boothroyd *et al* recommend that design for assembly analysis occur during conceptual design so that the product development team can reduce the part count. DFP at this stage will determine the capacity and manufacturing cycle timesaving that follow. They suggest that design for manufacture then occur during detailed design to reduce manufacturing costs. Using DFP methods at that point can guide the DFM efforts by identifying the manufacturing steps that cause throughput and cycle time problems, where processing time reductions will significantly reduce manufacturing cycle time. Mandar M. Chincholkar and Jeffrey W. Herrmann, 2001).

2.2 Process

In the topic of study state that process also including in the design manufacturing. In this component part of the topic of the project, process is including how the design can be analysis. This is critical component that important in the topic discussion. As for definition, *process* is according to manufacturing meaning is the sequence of the operation or the flow of the operation in manufacturing design. Then, *analysis* can be defined as make some inspection on the data or any problems or study on the case or statement that have been made experiment. Usually, analysis is done after we get the data from the observation, researching or experiment to get the result of the data. Through the data or reading data, analysis must be done to conclude the experiment. The data is usually finding in the industry. The main purpose of the collecting data is to improve the process layout of the product and reducing the production time including cycle time of the product.

2.2.1 Process analysis on cycle-time regarding process flow

Flow time (also known as *throughput time* or *lead time*) - the average time that a unit requires to flow through the process from the entry point to the exit point. The flow time is the length of the longest path through the process. Flow time includes both processing time and any time the unit spends between steps.

Cycle time - the time between successive units as they are output from the process. Cycle time for the process is equal to the inverse of the throughput rate. Cycle time can be thought of as the time required for a task to repeat itself. Each series task in a process must have a cycle time less than or equal to the cycle time for the process. Put another way, the cycle time of the process is equal to the longest task cycle time. The process is said to be in balance if the cycle times are equal for each activity in the process. Such balance rarely is achieved.

Process time - the average time that a unit is worked on. Process time is flow time less idle time (Cunningham, J. Barton and Ted Eberle (1990).

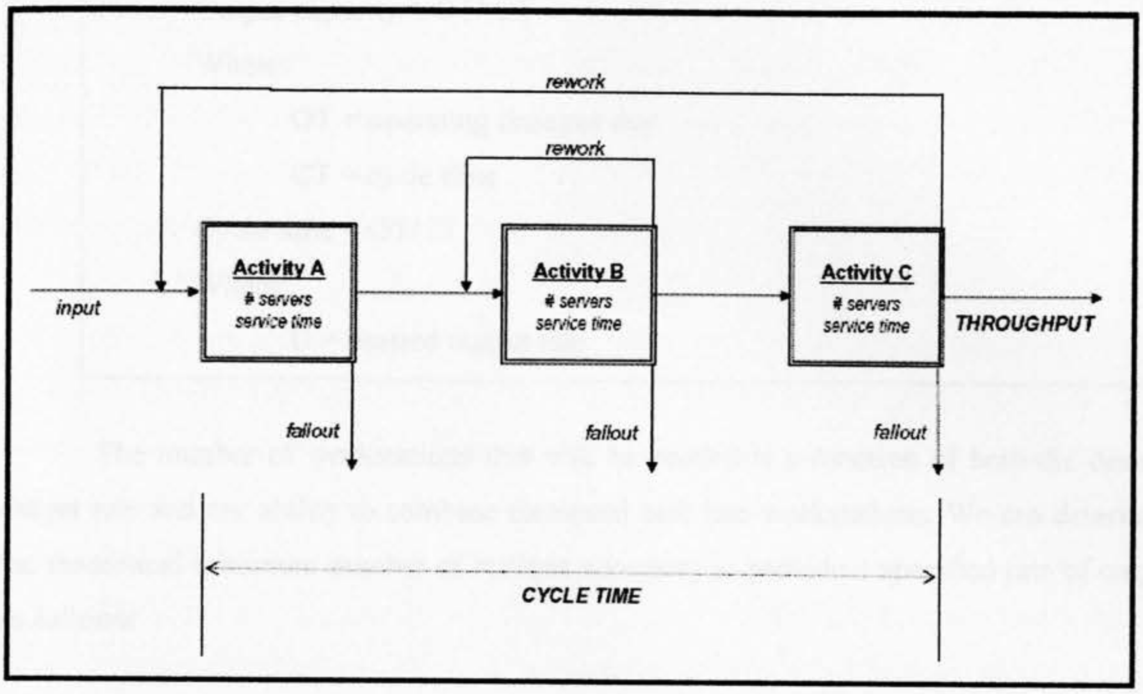

Figure 2.1: the characteristic of cycle time in production line. (Milas, Gene H. 1990)

In other definitions of cycle time is the maximum time allowed at each workstation to perform assigned tasks before the work moves on. The cycle time also establishes the output rate of a line. For instances, if the cycle time is two minutes, units will come off the end of the line at the rate of one every two minutes (Shunk, Dan L, 1992).

Regarding to the process flow, there is correlation between process flow and the cycle-time and the production time. The purpose of this two-correlation is to improve the productivity of the product. The terms of productivity is an index that measures output relatives to the input used to produce them? Productivity ratio can be computed for a single operation, a department, an organization, or an entire country. It is starting at production line, which is there, are two-correlation that involved on producing productivity: process flow product and its cycle time in each operation. By the process flow, we can determine the suitable cycle time of the production.

The process analysis on the cycle time regarding of the process flow can be define by the following formula:

Output capacity = OT/ CT

Where:

OT = operating time per day

CT = cycle time

Cycle time = OT/ D

Where:

D = desired output rate

The number of workstations that will be needed is a function of both the desired output rate and our ability to combine elemental task into workstations. We can determine the theoretical minimum number of stations necessary to provide a specified rate of output as follows:

$N_{min} = \sum t / CT$

Where:

N_{min} = theoretical minimum number of stations

D = desired output rate

$\sum t$ = sum of task time

Production time = 1/production rate

Throughput time = production time × number of stations

From this analysis, we can determine of the output of production for a month, week and daily production. Therefore, cycle time and line balancing has ability to improve productivity of the product in the industry (William J. Stevenson, 1998).

2.2.2 Previous study about process analysis cycle time

Production Lines

This is example analysis of cycle time by regarding of process flow that can be use to get the require result cycle time in production time. When portions of the process are arranged into time-paced production lines, the operation time does not entirely determine the amount of resource time used by the operations in the line. A line is characterized by its cycle time, the time interval between the departure times of units leaving the line. The operations in a line are paced to this cycle time. When the operation time is less than the cycle time, the resource performing the operation remains idle for a time equal to the difference between cycle time and operation time.

A line can accommodate operations with times greater than the cycle time by providing parallel stations. For example, if an operation time is 9 minutes and the cycle time is 5 minutes, two parallel stations must be required. Each station requires two line cycles for a unit of product.

For this case we use the *time* (time function) to compute the extra resource time required for an operation that is part of a production line. As illustrated previously, we must choose the *Time Function* feature when building the process definition.

To illustrate the use of the time function feature, we use the example previously to show defects, but here we assume that the processing operations and inspection operation are arranged in a paced line. Although the operations have different processing times, the line is operated so that every unit of product remains at each station for the same amount of time.

The line function is invoked by including the word "line" as part of the *Type* definition in column B below. The time function is computed in column L. For a line operation, the function depends on the cycle time of the line included as the P1 entry in column J. It also depends on the number of parallel stations provided for the operation placed in column K. For an operation in a line with a time longer than the cycle time, more than one station must be provided. Multiple stations process units simultaneously. The delay in time caused by the line operation is computed with the formula below and presented in column L.

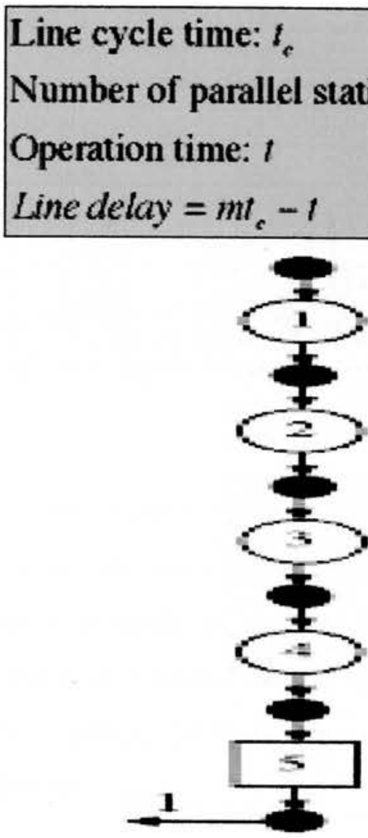

Figure 2.2:The flow diagrams that was example to create cycle time (Osborn Jack and Linda Moran, 1990)

Table 2.1: example calculation of cycle time Osborn Jack and Linda Moran, 1990)

◇	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Process: fun_line					Flow Time Interval:	Week						
2	Structure:	Tree				Oper. Time Interval:	Hour			Throughput Time:	4.5725	Hour	
3	Drive:	Pull				Oper. Int. per Flow Int.:	40			Work in Process:	5.7156		
4	Flow Out:	50	per Week										
5	Name	Type	Index	Next	Pull Out	Oper. Time	Lot Size	Defect Rate	Prop.	P1	P2	Time Funct.	Adj. Time
6	Start fun_l	Dummy	0		0								
7	Op1	Op-line	1	2	0	0.4	1	10.0%	1	0.5	1	0.1	0.5
8	Op2	Op-line	2	3	0	0.3	1	10.0%	1	0.5	1	0.2	0.5
9	Op3	Op-line	3	4	0	0.9	1	10.0%	1	0.5	2	0.1	1
10	Op4	Op-line	4	5	0	0.5	1	10.0%	1	0.5	1	0	0.5
11	Op5	In-line	5	6	0	0.1	1	0.0%	1	0.5	1	0.4	0.5
12	End fun_lir	Dummy	6		1								
13													
14		For Queue Type, P1 is the service rate and P2 is the number of servers.											
15		For Inventory Type, P1 is the replenishment rate and P2 is the safety stock.											
16		For Lot Type, the input lot size is in the "Lot Size" column and P1 is the output lot size.											
17		For Line Type, P1 is the cycle time and P2 is the number of parallel stations.											
18													