

DESIGN AND OPTIMIZATION OF SMALL SCALE FACTORY
MANUFACTURING SYSTEM

LEE WEN YIN

Report submitted in partial fulfillment of the requirements
for the award of Bachelor of
Mechanical Engineering with Manufacturing Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

Signature

Name of Supervisor: MUHAMAD ZUHAIRI SULAIMAN

Position: LECTURE

Date:

STUDENT'S DECLARATION

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

Signature

Name: LEE WEN YIN

ID Number: ME06025

Date: 20-11-2009

ACKNOWLEDGEMENTS

I am grateful and would like to express my sincere gratitude to my supervisor En. Muhamad Zuhairi Sulaiman for his germinal ideas, invaluable guidance, continuous encouragement and constant support in making this research possible. He has always impressed me with his outstanding professional conduct, his strong conviction for science, and his belief that a Degree program is only a start of a life-long learning experience. I appreciate his consistent support from the first day I applied to graduate program to these concluding moments. I am truly grateful for his progressive vision about my training in science, his tolerance of my naïve mistakes, and his commitment to my future career.

My sincere thanks go to all my friends and members of the staff of the Mechanical Engineering Department, UMP, who helped me in many ways and made my stay at UMP pleasant and unforgettable.

I acknowledge my sincere indebtedness and gratitude to my parents for their love, dream and sacrifice throughout my life. Special thanks should be given to my committee members. I would like to acknowledge their comments and suggestions, which was crucial for the successful completion of this study.

**Dedicated to my parents,
brothers and
all my best friends**

ABSTRACT

Investigation on manufacturing system of small scale factory has been carried out in this project. The main manufacturing system focused in this thesis is the factory layout. Poor layout design is determine as a major problem contribution in small scale factory. It will affect the productivity and also line efficiency. Through the study aim is to propose new layout to the factory to improve the productivity and reduce the waste to get more profit so that they can survive even facing competition from bigger factory. This study starts with selection of a suitable factory to be the case study target. After that, visit the factory and identify the problems that occur in the factory layout that affect the productivity of the factory. Get all the data needed and redesign the factory layout to improve productivity of the factory. Simulate the layout using computer aided tools to know the effectiveness of the new layout design. In this study, the application of computer aided tools is Witness software. Two layouts are designed to improve the productivity of the factory. Manual calculation is used to calculate the data get from the factory before insert into software. Mean time and worker efficiency is calculated to improve the accuracy of the simulation result. Productivity and line efficiency of the layout is get from the result to know the performance of the layout. Propose layout 2 can contribute 16.5% increment of productivity compares to original layout and 14.4% of productivity compares to propose layout 1. Propose layout 2 can get higher value of productivity and line efficiency so propose layout 2 is a better layout that can increase the performance of the factory.

ABSTRAK

Tesis ini membenteng tentang sistem manufaktur bagi kilang yang kecil. Isu utama sistem manufaktur yang dibenteng dalam tesis ini adalah susun atur kilang. Susun atur kilang yang lemah telah dikenal pasti sebagai masalah utama bagi kilang yang kecil. Ia akan mempengaruhi produktiviti dan kecekapan pembuatan. Sasaran utama pengajian ini adalah mencadangkan susun atur kilang yang baru untuk meningkatkan produktiviti dan mengurangkan pembaziran. Ini dapat meningkatkan penguntungan supaya dapat bertahan samasa manghadap cabaran daripada kilang yang lebih besar. Pengajian ini bermula dengan mencari kilang yang sesuai untuk kajian. Selepas itu, melawat kilang dan mengenalpasti masalah dalam susun atur kilang yang mempengaruhi produktiviti kilang itu. Mendapatkan semua nilai yang diperlukan dan mereka semula susun atur kilang untuk meningkatkan produktiviti. Mensimulasikan susun atur dengan menggunakan komputer untuk mengenalpasti keberkesanan susun atur yang baru. Program Witness digunakan dalam pengajian ini. Dua susun atur yang baru direka untuk meningkatkan produktiviti kilang itu. Semua nilai yang didapati dalam kilang itu dikira untuk isi dalam program itu. Mengambil kira masa berati dan kecekapan perkerja untuk meningkatkan ketepatan keputusan simulasi. Mendapatkan nilai produktiviti dan kecekapan pembuatan daripada keputusan untuk mengetahui prestasi susun atur kilang. Susun atur kedua boleh meningkatkan nilai produktiviti sebanyak 16.5% berbanding dengan susun atur asal dan 14.4% berbanding dengan susun atur pertama. Susun atur kedua yang dibentangkan mendapat nilai produktiviti dan kecekapan pembuatan yang lebih tinggi. Jadi, susun atur kilang kedua adalah susun atur kilang yang lebih baik dan dapat meningkatkan prestasi kilang itu.

TABLE OF CONTENTS

		Page
SUPERVISOR’S DECLARATION		ii
STUDENT’S DECLARATION		iii
ACKNOWLEDGEMENTS		iv
DEDICATION		
ABSTRACT		v
ABSTRAK		vi
TABLE OF CONTENTS		vii
LIST OF TABLES		x
LIST OF FIGURES		xi
LIST OF SYMBOLS		xii
CHAPTER 1	INTRODUCTION	
1.1	Introduction	1
1.2	Background	1
1.3	Objective	2
1.4	Scope	3
1.5	Company Background	3
1.6	Problem Statement	4
CHAPTER 2	LITERATURE REVIEW	
2.1	Introduction	5
2.2	Manufacturing System	5
	2.2.1 Types of Operations Performed	6
	2.2.2 Number of Workstations and System Layout	6
	2.2.3 Level of Automation	7
	2.2.4 Part of Product Variety	7
2.3	Layout	9

2.3.1	Process Layout	9
2.3.2	Product Layout	9
2.3.3	Fixed-position Layout	10
2.3.4	Group Technology or Cellular Layout	10
2.4	Work Measurement	11
2.4.1	Historical Experience	11
2.4.2	Time Studies	12
2.4.3	Predetermined Time Standards	13
2.4.4	Work Sampling	13
2.5	Witness Software	14

CHAPTER 3 METHODOLOGY

3.1	Introduction	15
3.2	Data Observation of Current Manufacturing System Properties	15
3.2.1	Type of Manufacturing System	15
3.2.2	Layout	16
3.2.3	Work Stations	17
3.2.4	Process	17
3.2.5	Work Transport System	19
3.2.6	Level of Automation	19
3.2.7	Product Variety	20
3.3	Current Productivity	20
3.4	Simulation	20
3.5	Methodology Flow Chart	23

CHAPTER 4 RESULTS AND DISCUSSION

4.1	Introduction	24
4.2	Data Analysis	24
4.2.1	Raw Data	24
4.2.2	Mean Time	25
4.2.3	Worker Efficiency	26
4.3	Witness Analysis	27
4.3.1	Original Layout	28
4.3.2	Propose Layout 1	29

4.3.3	Propose Layout 2	30
4.4	Productivity	31
4.5	Line Efficiency	32
4.6	Discussion	33
4.6.1	Productivity	33
4.6.2	Line Efficiency	33
4.7	Limitation of Software	34
CHAPTER 5 CONCLUSION		
5.1	Introduction	35
5.2	Conclusions	35
5.3	Recommendation	36
REFERENCE		37
APPENDICES		
A	Figure of Manufacturing Process	38
B	Result of Original Layout	39
C	Result of propose layout 1	40
D	Result of propose layout 2	41

LIST OF TABLES

Table No.	Title	Page
2.1	Factors in Manufacturing Systems Classification	6
2.2	Three Types of Manufacturing System	7
2.3	Manufacturing Systems Classification Schemes	8
4.1	Process time	24
4.2	Material transfer time	25
4.3	Mean value of the data	26
4.4	Time for worker efficiency	26
4.5	Time to insert into software	27
6.1	Result of Original Layout	39
6.2	Result of Propose Layout 1	40
6.3	Result of Propose Layout 2	41

LIST OF FIGURES

Figure No.	Title	Page
1.1	A typical manufacturing system	2
3.1	Process Layout of the factory	16
3.2	Process of the Manufacturing System	17
3.3	Example of product after process	18
3.4	Examples of semi-auto machine	19
3.5	Icon represents the process	21
3.6	Icon represents the material	21
3.7	Symbol of link	21
3.8	Text box of icon	22
3.9	Methodology flow chart	23
4.1	Graph Process Time versus Sample	25
4.2	Graph Material Transfer Time versus Sample	25
4.3	Original Layout	28
4.4	Propose Layout 1	29
4.5	Propose Layout 2	30
4.6	Graph Productivity versus Layout	31
4.7	Graph Line Efficiency versus Layout	32
6.1	Figure of Manufacturing Process	38

LIST OF SYMBOLS

M	Average Manning Level
ω_u	Number of Utility Workers Assigned To The System
ω_i	Number of Workers Assigned Specifically To Station
ω	Total Number of Workers Assigned To The System
S	No Product Variety
B	Hard Product Variety Typical
X	Soft Product Variety Typical
s	Second
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

This chapter briefly discuss about the background of this study. Objective and scopes will be listed and briefly explain about the background of the case study company. Problem statement will also discuss in this chapter.

1.2 BACKGROUND

In the early industrial revolution, manufacturing was not undertaken systematically. Any jobs were done by worker either alone or in small groups. Factories in modern sense did not exist. After the industrial revolution, the nature of manufacturing changed. By 1850, most production took place in factories. While manufacturing technology has improved widely, the factories of the mid-nineteenth century would be immediately recognizable to modern engineers. Factories normally consist of a number of individual processes linked together, it call manufacturing system. Figure 2.1 presents a sample of typical manufacturing system.

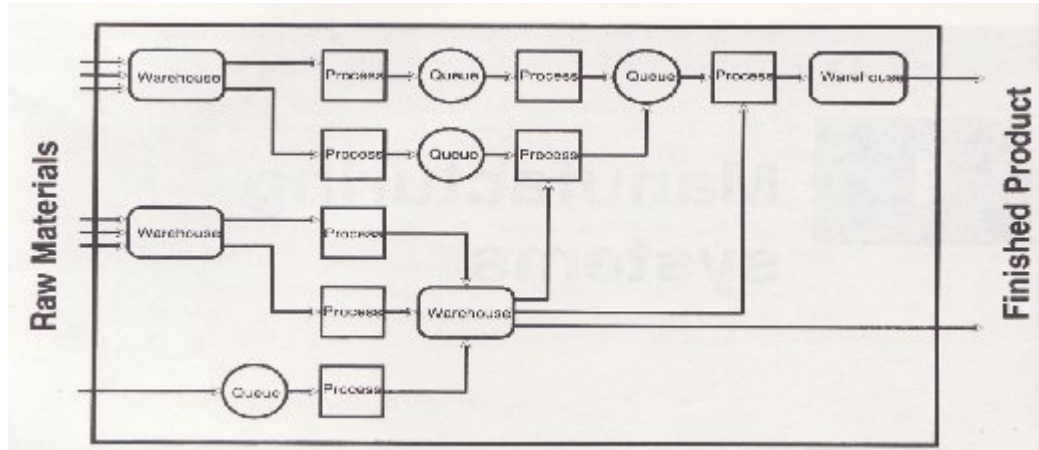


Figure 1.1: A typical manufacturing system

Source: Harrison (2002)

The manufacturing system has been supported by a number of functional departments. The activities of these departments are coordinated by production planning over the short or medium term. Note also that there are links between the organization and the outside world.(Harrison, 2002) The entire system is to transforming basic raw materials into products for end users.

1.3 OJECTIVE

The objective of this project is to:

1. Study and enhance the knowledge to investigate of manufacturing system of small scale factory.
2. Improve manufacturing system of the factory for the production optimization purpose.
3. Propose the solution to increase the productivity.

1.4 SCOPE

This project is focuses on case study in factory. There are three scopes in this project. First scope of this project is focus on small scale factory manufacturing system. Second scope is emphasis on layout and line assembly and the last scope is to propose possible optimization of the performance for improving the selected manufacturing system.

1.5 COMPANY BACKGROUND

Twin Star Furniture Marketing is a furniture manufacture company. The company started in year 1989; almost 10 years history. The factory is located in Batu Pahat; Johor. The factory address is 6, Jalan Budi 15, Taman Industri Wawasan, 83000 Batu Pahat, Johor.

The owner of this company is Pua Siew Lian. The company now is operating by 2nd generation. The main product of this company is sofa. Besides that, the company also produces bed. It is almost 70% of the product is sofa. The company produces many types of sofa.

The factory has around 40 workers. All the workers are labour. The labours are come from Bangladesh. Basically, Twin Star Furniture Marketing is a supplier. The company will send the product to the customers which are traders. The traders will sell the products in shops. The company main customers are in Singapore.

1.6 PROBLEM STATEMENT

Many of the factories especially the small scale factory have less awareness on manufacturing system optimization and lack of knowledge about it and just follow the traditional way of management. The company do not realize the benefit of the manufacturing system.

The knowledge of manufacturing system can be use to improve the system of a factory to get a better performance. It can help to increase productivity and reduce waste to get more profit. So, it is important for factory to learn the knowledge of manufacturing system so that they can face the competition from others factory and they can survive even facing competition from bigger factory.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter introduces the fundamental concepts that are necessary to understand and step using to improve the manufacturing system of factory. There are including the classification of manufacturing system and procedure to implement manufacturing. It will briefly discuss about the layout and work measurement to make our work more efficiency.

2.2 MANUFACTURING SYSTEM

Manufacturing system is defined to be a collection of integrated equipment and human resources. The integrated equipment includes production machines, tools, material handling, work positioning devices and computer system. Human resource is the people who perform the process on the raw material to become a product.

Manufacturing system can classification based on the factors that define and distinguish the different types. The factors are: (1) types of operations performed, (2) number of workstations and system layout, (3) level of automation, and (4) part of product variety. The four factors are defined in Table 2.1.

Table 2.1: Factors in Manufacturing Systems Classification

Factor	Alternatives
Types of operations performed	Processing operations versus assembly operation Type of processing or assembly operation
Number of workstations and system layout	One station versus more than one station For more than one station, variable routing versus fixed routing
Level of automation	Manual or semi-automated workstations that require full-time operation attention versus fully automated that require only periodic worker attention
Part of product variety	All work units identical versus variations in work units that require differences in processing

Source: Groover (2001)

2.2.1 Types of Operations Performed

Types of operations performed are (1) processing operations on individual work units and (2) assembly operations to combine individual parts into assembled entities. Other parameters to determining the manufacturing system are type of material processed, size and weight of the part or product, and part geometry. Manufacturing system that performs machining operations must be distinguished according to whether they make rotational or non-rotational parts. The distinction is important because machining processes, machining tool required and material handling system must be engineered differently for the two cases.

2.2.2 Number of Workstations and System Layout

Number of workstations exerts a strong influence on the performance of the manufacturing system in terms of production capacity, productivity, cost per unit, and maintainability. Amount of work that can accomplish by the system will increase with the increase in the number of work station. It will also make the system become more complex and therefore more difficult to manage and maintain. The layout of the stations is an important factor to determine the most appropriate material handling system.

2.2.3 Level of Automation

The workstations of a manufacturing system can be manually operated, semi-automated, or automated. The proportion of time that direct labour must be in attendance at each station is closely correlated with the level of automation. The average manning level of a multi-station manufacturing system is a useful indicator of the direct labor content of the system

$$M = \frac{\omega_u + \sum \omega_i}{\omega} \quad (2.1)$$

where M = average manning level for the system; ω_u = number of utility workers assigned to the system; ω_i = number of workers assigned specifically to station i , for $i = 1, 2, \dots, n$; and ω = total number of workers assigned to the system (Groover, 2001). Utility workers are workers who are assigned to perform function such as relieving workers at station for personal breaks, maintenance and repair of the system, tool changing and loading and/or unloading work units to and from the system.

2.2.4 Part of Product Variety

Manufacturing system can be characterized by its capability of dealing with variations in the parts or products it produces. Examples of possible variations are type and colour of plastic of moulded parts in injection moulding, electronic components placed on a standard size printed circuit board, geometry of machined parts and parts and options in an assembled product on a final assembly line.

Table 2.2: Three Types of Manufacturing System

System type	Symbol	Typical Product Variety
Single model	S	No product variety
Batch model	B	Hard product variety typical
Mixed model	X	Soft product variety typical

Source: Groover (2001)

Manufacturing systems can be distinguished according to their capability to deal with variety in the work units produces. For single model, products made by the manufacturing system are identical. Different products are made by using batch model. Changeover of the manufacturing system is required because the differences in product style are significant enough that the system cannot cope unless changes in tolling and programming are made. Mixed model is also making different products but the system is able to handle these differences without the need for changeover in setup or program.

Table 2.3: Manufacturing Systems Classification Schemes

Type	Description	Operation	Product Variety Case
I M	Single station manned cell	Processing (machining)	S or B
		Processing (stamping)	S or B
		Assembly (welding)	S or B or X
I A	Single station Automated cell	Processing (machining)	B or X
		Assembly (mechanical)	S or X
II M	Multi-station manual system with variable routing	Processing (machining)	X
		Processing (machining)	B
II A	Multi-station automated system with variable routing	Processing (machining)	X
III M	Multi-station manual system with fixed routing	Assembly	S or B or X
III A	Multi-station automated system with fixed routing	Processing (machining)	S
		Assembly	S
III H	Multi-station hybrid system with fixed routing	Assembly and processing (spot welding, spray painting, and mechanical assembly)	X

Source: Groover (2001)

Table 2.3 shows the classification schemes of the manufacturing systems. The manufacturing is classified into seven types. The manufacturing systems classification scheme is defined by four factors: type of processing or assembly operations

performed, number of workstations and layout, automation level, and flexibility to deal with part or product variety.

2.3 LAYOUT

The arrangement of the department in a factory is defined by the general pattern of work flow. There are four types of layout:

- i. Process layout
- ii. Product layout
- iii. Fixed-position layout
- iv. Group technology layout or cellular layout

2.3.1 Process Layout

This layout also called a job-shop or functional layout. It is a format in which similar equipment or functions are grouped together. A part being worked on the travels, according to the established sequence of operations, from area to area, where the proper machines are located for each operation. This type of layout is typical of hospital, where areas are dedicated to particular types of medical care, such as maternity wards and intensive care units.

2.3.2 Product Layout

It also called a flow-shop layout. It is one in which equipment or work processes are arranged according to the progressive steps by which the product is made. The path for each part is in a straight line. Production lines for shoes, chemical plants, and car washes are all product layout.

2.3.3 Fixed-position Layout

The product in this layout remains at one location. Manufacturing equipment is moved to the product rather than moving the product to the equipment. Ship yards, construction sites and movie lots are examples of this layout.

2.3.4 Group Technology or Cellular Layout

This layout groups dissimilar machines into work centres to work on products that have similar shapes and processing requirements. Group technology refers to the parts classification and coding system used to specify machine types that go into the cell. Group technology layout is similar to a process layout in that the cells are designed to perform a specific set of processes, and it is similar to product layout in that the cells are dedicated to a limited range of products. (Chase, 2001)

Many manufacturing factories present a combination of more than one layout types. A good factory layout can provide real competitive advantages by facilitating material, information flow processes and also enhance employees' work life. Marks of a good layout for a manufacturing system are:

- i. Straight-line flow pattern.
- ii. Backtracking kept to a minimum.
- iii. Production time predictable.
- iv. Little inter stage storage of material.
- v. Open plant floors so everyone can see what is happening.
- vi. Bottleneck operations under control.
- vii. Workstations close together.
- viii. Orderly handling and storage of materials.
- ix. No unnecessary rehandling of materials.
- x. Easily adjustable to changing conditions.

2.4 WORK MEASUREMENT

Work measurement is a term which covers several different ways of finding out how long a job or part of a job should take to complete. It can be defined as the systematic determination, through the use of various techniques, of the amount of effective physical and mental work in terms of work units in a specified task.

Work measurement use to set reasonable targets for the worker and forms a basis of comparison between work methods and performance of workers. It is important to know how much time each task taken to carry out line balancing.

The time taken to complete any job is the time which a qualified worker would take, if working without overexertion throughout a normal period while applying himself to the job. The definition assumes that the worker has the required knowledge, skill, attitude and other attributes necessary to carry out the jobs.(Khanna, 2007)

Properly set labour standards represent the amount of time that it should take an average employee to perform specific job activities under normal working conditions. Labour standards are set in four ways:

- i. Historical experience.
- ii. Time studies.
- iii. Predetermined time standards.
- iv. Work sampling.

2.4.1 Historical Experience

Labour standards can be set by using the labour-hours were required to do a task the last time it was performed. Historical standards have the advantage of being relatively easy and inexpensive to obtain. But the accuracy of the standards does not know, whether they represent a reasonable or a poor work pace, and whether unusual occurrences are included because these variable are unknown.