

“I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for award of Bachelor of Engineering Mechanical With Honours.”

Signature :

Supervisor's Name: MR. ZAIRULAZHA BIN ZAINAL

Date :

GANTRY CRANE WITH ON –OFF MOTOR COMMAND : DESIGN AND
IMPLEMENTATION

MOHAMMAD NASIRUDDIN BIN MAHFOZ

This report is submitted in partial fulfillment of requirements for the Bachelor
Degree of Mechanical Engineering (Design And Innovation) With Honours

Faculty of Mechanical Engineering
Universiti Teknikal Malaysia Melaka

May 2009

“I hereby declare that this report is the result of my own work except for quotes as cited in the references.”

Signature :
Author : MOHAMMAD NASIRUDDIN BIN MAHFOZ
Date :

ACKNOWLEDGEMENT

First and foremost, I would like to thank God for His blessing. He gave me physical and mental strength to carry on my final year project up to completion

I take this opportunity to express my profoundest gratitude and deepest regards to all those who gave me the possibility to successfully complete this PSM. I am deeply indebted to my Project Supervisor, Mr Zairul Azha Bin Zainal. I wishes to express a million thanks for his exemplary guidance, monitoring and constant encouragement through out the development of the project. In those moments of uncertainty and doubts when things used to turn dark without a clear understanding of the knowledge that he tried to share, his kind and patient way of explaining had indeed a soothing effect. The blessing, help and guidance given from time to time shall indeed carry me a long way in the journey of life on which I am about to embark in the near future.

I wish to express my sincere gratitude and appreciation to all my friends for their helpful suggestions in developing this project, for their support and encouragement to me.

Last but not least, to all my well-wishers who had helped me both directly and indirectly, I virtually fall to short words to express my gratitude. Therefore, I end this acknowledgement with only two words “Thank You!” in their reminiscence.

ABSTRACT

The use of gantry crane systems for transporting payload is very common in building constructions. However, moving the payload using the crane is not an easy task especially when strict specifications on the swing angle and on the transfer time need to be satisfied. This project is only involved in the development of the lab scale gantry crane by studying the behaviour and the parts related as well to the project. The hardware development will be interfaced with software development to get results. The actual gantry crane system will be interfaced with Visual Basic Programming.

CONTENTS

CHAPTER	TITLE	PAGE
	SUPERVISOR VERIFICATION	i
	PAGE TITLE	ii
	DECLARATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	CONTENTS	vi
	LIST OF TABLES	xii
	LIST OF FIGURES	xiv
	LIST OF SYMBOLS	xvii
	LIST ABBREVIATIONS	xviii
	LIST OF APPENDIXS	xix
I	PROJECT INTRODUCTION	
	1.1 Introduction	1
	1.2 Objective	2
	1.3 Problem Statement	2
	1.4 Scope of Work	3
	1.5 Methodology	4

II LITERATURE REVIEW

2.1	Background of a Gantry Crane	6
2.2	Motion Control System	19
2.2.1	Stepper Motor	19
2.2.1.1	Operation Principle of Stepper Motor	21
2.2.2	DC Motor	22
2.2.3	Comparison between the DC Motor and Stepper Motor	25
2.3	Serial Port	27
2.3.1	Serial connection	28
2.3.2	Transmitting data	31
2.3.3	Receiving data	32
2.4	Potentiometer	33
2.4.1	Principle of potentiometer	34
2.4.2	Construction of potentiometer	35
2.4.2.1	Linear Taper Potentiometer	35
2.4.2.2	Logarithmic potentiometer	35
2.4.2.3	Rheostat	36
2.5	Application of potentiometer	37
2.5.1	Audio control	37
2.5.2	Television	38
2.5.3	Transducer	38
2.5.4	Computation	38
2.6	Microcontroller	39
2.6.1	Overview microchip PIC	41

III MATHEMATICAL MODELING

3.1	Desired Motion	43
3.2	Modeling of the Gantry Crane	44
3.3	Derivation of the Equations of Motion	45
3.4	Linearization	48

IV RESEARCH METHODOLOGY

4.1	Introduction	49
4.2	Hardware Development	51
	4.2.1 Crane design system	51
4.3	Design of Gantry crane	55
	4.3.1 Part design	55
	4.3.2 Body part	56
	4.3.3 Trolley	57
	4.3.4 Product assembly	58
4.4	Hardware system development	59
4.5	Prototyping	62
	4.5.1 Manufacturing process of main body part	62
	4.5.2 Manufacturing process of trolley part	67
	4.5.3 Assembly process	68
4.6	Interface circuit	71
	4.6.1 Microcontroller	71
	4.6.1.1 Microcontroller schematic	73
	4.6.2 MAX 232 CPE motor driver Ic	75
	4.6.3 Power supply	76
	4.6.4 Schematic diagram	78
	4.6.5 PCB layout design	80

4.7	Software development	
4.7.1	Visual basic	81
4.7.2	Visual basic programming	83
4.7.3	Software development for microcontroller	85
4.7.3.1	Flow Chart for Basic Programming Language	85
4.7.3.2	MP Lab	86
4.7.3.3	Basic language	87
4.7.3.4	PIC programmer	87
V	ANALYSIS AND RESULT	
5.1	Analysis	91
5.1.1	Structural analysis	91
5.1.2	Scope of analysis	92
5.1.3	Procedure analysis of link shaft	93
5.2	Result	97
5.2.1	Stress	97
5.2.2	Displacement	98
5.2.3	Strain	99
5.2.4	Discussion For Link Shaft	100
5.3	Analysis of housing bearing	101
5.4	Result	
5.4.1	Stress	101
5.4.2	Displacement	103
5.4.3	Strain	104
5.4.4	Discussion For Housing Bearing	105
5.5	Data Result Experiment for Implementation between Visual Basic Software and Crane Hardware.	106

VI CONCLUSION AND RECOMMENDATION

6.1	Conclusion	116
6.2	Recommendation	117

REFERENCES**APPENDIX A****APPENDIX B**

LIST OF TABLES

NO	TITLE	PAGE
2.1	Comparison between servo motor and stepper motor	25
2.2	Difference types of microcontrollers	40
4.1	Dimension of lab scale crane	52
4.2	Dimension of trolley	54
4.3	Main function of the control panel	84
4.4	The description of debug icon	86
4.5	Micro pro icon	88
5.1	Analysis of link shaft	100
5.2	Analysis of housing bearing	105
5.3	Table of data obtained during experiment for crane position	108
5.4	Table of data obtained during experiment for crane sway angle	111
5.5	Crane's position over time	113
5.6	Crane's sway angle over time	113

LIST OF FIGURES

NO	TITLE	PAGE
1.1	Project flow chart	4
2.1	Crane body frame	7
2.2	Monorail system	8
2.3	DC chain system	9
2.4	DR rope hoist	10
2.5	Air hoist	11
2.6	Electric wire rope hoist	12
2.7	Electric chain hoist	13
2.8	Ex – proof chain block	14
2.9	Fixed height steel gantry crane	15
2.10	Pillar and wall-mounted slewing jib crane	16
2.11	Super – post panama portainer crane	17
2.12	Double grider crane	18
2.13	Dc motor	22
2.14	Force in DC motor	23
2.15	Magnetic field in DC motor	23
2.16	Torque in DC motor	23
2.17	Current flow in DC motor	23
2.18	Pin connector	29
2.19	System of potentiometer	33
2.20	Potentiometer	33

2.21	Micro controller based system	39
2.22	Some of the various PICs from Microchip	41
3.1	Model of gantry crane	44
4.1	Scope of methodology	50
4.2	Main body of lab scale crane	51
4.3	Trolley system of the lab scale crane.	52
4.4	Trolley system	53
4.5	Part in trolley system	53
4.6	Main body part	56
4.7	Trolley part	57
4.8	Part assembly	58
4.9	Lab scale gantry crane system	60
4.10	Basic concept of automatic gantry crane system	61
4.11	Disc saw	63
4.12	Drilling process	64
4.13	Welding process	65
4.14	Sample of part use bending process	65
4.15	Facing step using grinder	66
4.16	Part assembly of trolley part	67
4.17	Main part	68
4.18	Base part	68
4.19	Trolley assembly	69
4.20	Motor controller circuit	69
4.21	Block diagram for PIC 16F72	73
4.22	Microcontroller schematic	74
4.23	Block diagram of 12 V power supply to microcontroller	76
4.24	Block diagram of 5V power supply to the motor drive	77
4.25	Schematic circuit	78
4.26	PCB layout	80
4.27	Flow chart of the programming sequence	82

4.28	Control panel of Automation system using visual basic Programming	83
4.29	Flow chart for basic programming language	85
4.30	An icon for the debugging is added to the icon bar	86
4.31	The equipment used for program the IC	88
5.1	COSMOSWorks Manager tab	93
5.2	Define the static study	93
5.3	Material selection	94
5.4	apply fix restraint and force	95
5.5	Mesh the assembly	96
5.6	Run the analysis	96
5.7	Von misses stress analysis	97
5.8	Displacement analysis	98
5.9	Strain analysis	99
5.10	Von misses stress analysis	102
5.11	Displacement analysis	103
5.12	Strain analysis	104
5.13	Connect USB port to computer	106
5.14	Initial position of crane box	106
5.15	Crane system control box in Visual Basic	107
5.16	Measure position by using measuring tape	107
5.17	Graph of experimental result for crane position without Controller	109
5.18	Graph of theoretical result for crane position without controller	109
5.19	Set time using stopwatch	110

5.20	Crane System's Control Box in Visual Basic	110
5.21	Graph of experimental result for crane angle without controller	112
5.22	Graph of theoretical result for crane angle without controller	112

LIST OF SYMBOLS

M	- Trolley mass
m	- Payload mass
l	- Length of the hoisting rope
F_x	- Input force
G	- Gravitational acceleration = 9.81ms^{-2}
G	- Centre point
S	- Point of suspension
x	- Trolley position
\dot{x}	- Velocity
\ddot{x}	- Acceleration
θ	- Sway angle
$\dot{\theta}$	- Angular velocity
$\ddot{\theta}$	- Angular acceleration

LIST OF ABBREVIATIONS

A/D	- Analog-to-digital
CPU	- Central Processing Unit
D/A	- Digital-to-Analog
DAQ	- Data Acquisition Board
DC	- Direct Current
EEPROM	- Electrically Erasable Programmable Read Only Memory
EIA	- Electronic Industries Alliance
FFT	- Fast Fourier Transform
I/O	- Input / Output
MCU	- Microchip Microcontroller
NI	- National Instruments
PIC	- Peripheral Interface Controller
RAM	- Random-Access Memory
RTW	- Real Time Workshop
RS	- Recommended Standard
ROM	- Read-only Memory
SNA	- Specified Negative Amplitude shaper
UMZV	- Unity Magnitude Zero Vibration Shaper

LIST OF APPENDIXS

NO	TITLE
A	APPENDIX A- PIC Source Code
B	APPENDIX B – Visual Basic Setup

CHAPTER I

PROJECT INTRODUCTION

This chapter will be discussed about the design and implementation of lab scale gantry system with on-off motor commands mechanism. The project introduction, project objective, problem statement, and scopes of work and methodology will also be presented.

1.1 Introduction

Gantry cranes are widely used for transporting heavy loads and hazardous materials in building constructions. The crane should move the load as fast as possible without having any excessive payload motion at the final position. However, most of the common gantry cranes result in a swing motion when payload is suddenly stopped after a fast motion. The swing motion can be reduced however; it is often time consuming processes which eventually affect the productivity (operational efficiency) in building constructions.

This project attempts to design the actual gantry crane system and interface it with visual basic programming. This project also covers about the hardware development of the lab – scale gantry crane which is consist the mechanical and electronic parts. The objective of the project is to build up the lab scale gantry crane and do the simulation using visual Basic programming. The task also covered about the conceptual design of the lab scale gantry crane system. The selection of the appropriate

component and study electronics and mechanical parts related as well as to do mechanical drawing for gantry crane also do in this project. The development of the system is about the arrangement of the lab scale gantry crane system also discuss in this project. So the whole project are to develop the lab scale gantry crane system that can be integrated with the software and make sure to be successful.

1.2 Objective

The objective of this project is to design a gantry crane system with on-off motor commands mechanism that can move as robustness, quickly, accurately and safely as possible without vibration from an initial position to target position and also do interfacing between hardware and software for the prototype.

1.3 Problem Statement

Gantry cranes are widely used for factories, transportation, nuclear installation and also construction. The crane has to move the load as fast as possible without causing any excessive movement at the final position or during it moves. However, moving the payload using the crane is not an easy task especially when strict specifications on the swing angle and on the transfer time need to be satisfied. Moreover, the gantry crane needs a skilful and experience operator to control manually for stopping the swing immediately at the right position. Beside this, the operator also needs time to wait the string stop from vibration after movement the load. Until today, the vibrations still clarify as serious problem in a mechanical system.

1.4 Scopes of Work

While doing the project, the scope of work plays a very important role. There is a guideline which student should attain to fulfill the requirement of project. The scopes of work are listed as below:

- i. Study the basic concept and the dynamic behavior of gantry crane system, sensors, DC motors, and other electronic part.
- ii. Fix the weight of the load and the length of the string for gantry crane.
- iii. Design the gantry crane layout by using the CATIA.
- iv. Study the response of the system in term of structural analysis using COSMOSWORK.
- v. Construct the gantry crane that can be use for automatic control.
- vi. To do interfacing between hardware and software for the prototype and get the parameter for the position of the trolley and sway angle of the mass by using Visual Basic Programming.

1.5 Methodology (Flow Chart)

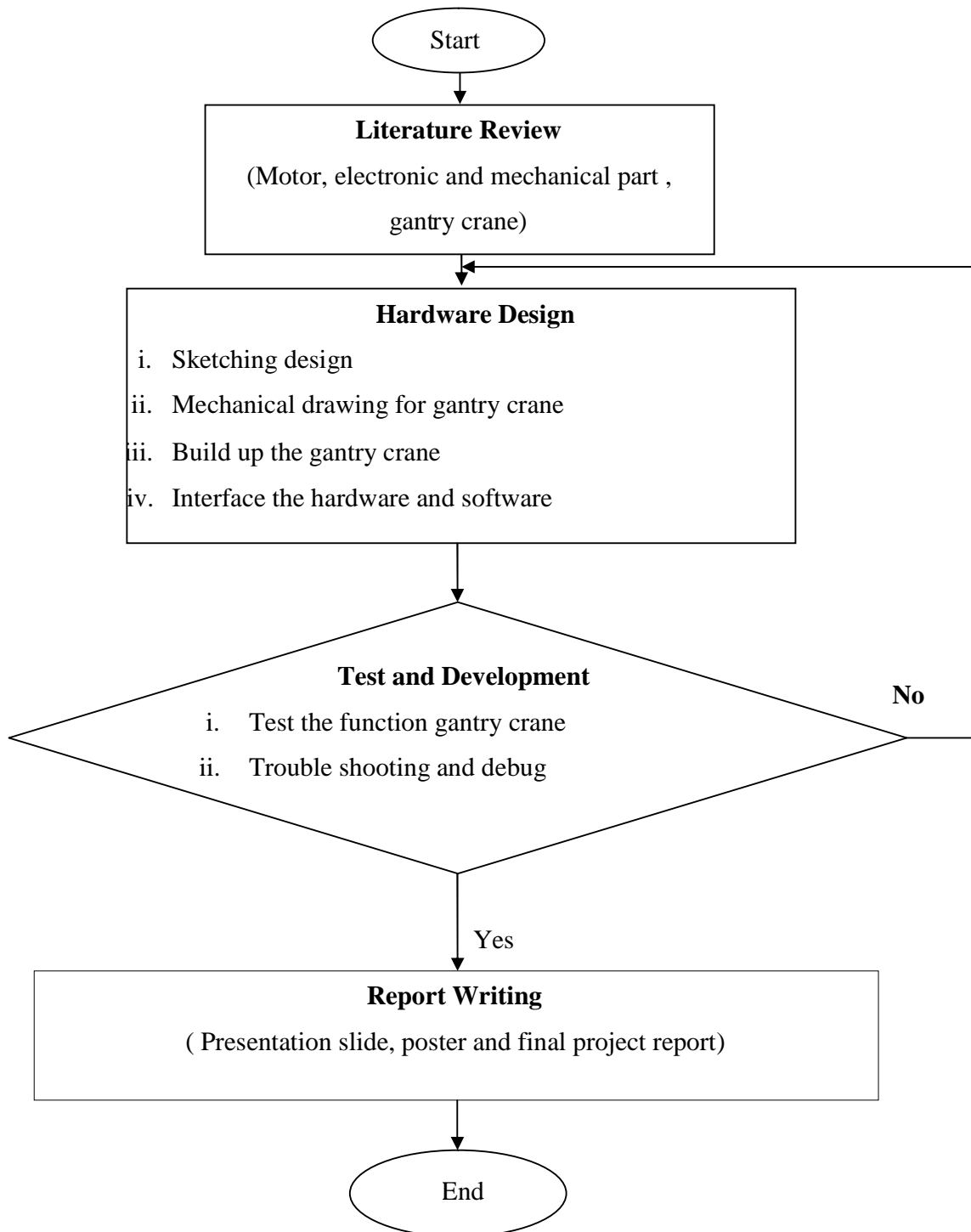


Figure 1.1 : Project flow chart

CHAPTER II

LITERATURE REVIEW

Literature review is done in this chapter to make a review of the dynamic behavior of gantry crane. This chapter also will clarify the way to choose the suitable motor and electronic part such as potentiometer, motor controller and implementation of the PC interfacing to actual gantry crane

2.1 Background of a Gantry Crane

Gantry cranes commonly used in numerous industrial applications, such as the loading and unloading of containers, nuclear waste handling facilities, factory automation and basically in any industry which requires heavy goods to be lifted and moved.

The study of the control of the crane is complex, as different industrial applications require different control systems. Some applications require a fast traversal time, and optimization motion of the cart is required. Others require very little or no swing of the goods as they are being moved. Some require that all three dynamics of the crane be optimally controlled like load positioning swing cancellation and load height.

Gantry cranes are particularly suited to lift heavy objects in shipbuilding where the crane straddles the ship allowing massive objects like ship engines to be lifted and moved over the ship. Two famous gantry cranes built in 1974 and 1969 respectively are Samson and Goliath, which reside in the largest dry dock in the world in Belfast, Northern Ireland [1]. Each crane has a span of 140 meters and can lift loads of up to 840 tonnes to a height of 70 meters, making a combined lifting capacity of over 1,600 tonnes, one of the largest in the world [1].

However, gantry cranes are also available running rubber types so that tracks are not needed, and small gantry cranes can be used in workshops, for example for lifting automobile engines out of vehicles.