MODEL GANTRY CRANE WITH DYNAMIC FEEDBACK SWING CONTROL

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Industrial Electronics) With Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

May 2008

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek: Model Gantry Crane With Dynamic Feedback Swing Control

Sesi Pengajian: 2007/08

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To my beloved mom and dad

ACKNOWLEDGEMENT

Assalammualaikum W.B.T.

First of all I would like to thank ALLAH S.W.T because for HIS blessing, I have completed my final year project for courses Bachelor of Electronic Engineering (Industrial Electronics) successfully.

I would like to extend my deepest gratitude to my supervisors, Puan Azdiana Binti Md.Yusop for her consistent supervision, guidance, support, and encouragement throughout this project.

My appreciation also to my beloved family for their patience and understanding throughout my studies in Universiti Teknikal Malaysia, Melaka (UTeM).

Last but not least my thank goes to the person who directly and indirectly involved and distributed in completing this project and not forget to all my friends who give their full commitment and their best effort. Thank you very much.

ABSTRACT

The use of gantry crane system for transporting payload is very common in industrial application. However, moving the payload using the crane is not easy task especially when strict specifications on the swing angle and on the transfer time need to be satisfied. To overcome this problem, an intelligent gantry crane system had been introduced. Dynamic feedback swing controller is designed for the gantry position and speed, as well as the load angle and angular velocity in order to move the payload of uncertain mass as quickly, accurately, and safely as possible. Responses of the position of the trolley and sway angle of the mass are presented by using SIMULINK in MATLAB software.

ABSTRAK

Pengunaan system *"gantry crane"* untuk membawa sesuatu beban adalah perkara asas atau kebiasaan didalam bidang industri. Walaubagaimanapun, untuk membawa sesuatu beban atau barang dengan mengunakan *"crane"* bukanlah sesuatu tugas yang mudah, terutama sekali bila mana sudut ayunannya dan juga masa pemindahannya perlu dititikberatkan. Untuk menghadapi masalah ini, pelbagai system *"gantry crane" yang* bijaksana telah direkacipta. Pengawal ayunan berkonsepkan suap balik telah direkabentuk bagi mengawal kedudukan *"gantry"* dan kelajuannya seperti megambil kira dan mengkaji sudut ayunan bebandan sudut pecutannya dengan harapan *"gantry"* ini dapat membawa beban tertentu dengan pantas, tepat, dan selamat yang mungkin. Tindak balas bagi kedudukan troli dan sudut ayunan beban akan ditunjukkan dengan menggunakan SIMULINK yang terdapat didalam perisian MATLAB.

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M	-	Trolley mass
m	-	Payload mass
/	-	Length of hoisting rope
F_x	-	Input force
g	-	Gravitational acceleration = $9.81 ms^{-2}$
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

CHAPTER I

INTRODUCTION

1.1 Project Introduction

The industrial use of gantry cranes is ever increasing, with a demand for greater safety and faster transfer of loads. The uncontrolled pendulum motion of loads suspended from gantry crane endangers both the operating personal and the often fragile load being transported. The operator, by skillful manual drive of the gantry controls, ensures that this unavoidable pendulum motion subsides as quickly as possible, since extended loading and unloading time costly.

Increasingly however, relatively high speed operating condition mean that manual suppression of load swing by the operator is not possible, so alternative mechanical or control engineering solutions have be found.

Mechanical solutions such as cable bracing or scissor action systems are extremely expensive to install and maintain. Active crane swing composition, on the other hand is a relatively inexpensive means of achieving greater safety and faster transfer of loads.

In many machines, load positioning is achieved by using the closed-loop control system. 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 but will be time consuming i.e. reduce the facility availability as well as productivity.

Moreover, the gantry crane needs a skillful operator to control manually based on his or her experiences to stop the swing immediately at the right position. Furthermore to unload, the operator has to wait the stop from swinging. The failure of controlling crane also might cause accident and may harm people and surrounding. Many solutions have been proposed to reduce swing angle by using the dynamic feedback swing control technique.

This project will focus on closed loop control system based on the dynamic model of the gantry crane of relatively fixed coefficients of gantry mass and friction. The controller algorithm is that of a state variable feedback system, where gantry position and speed as well as cable angle and angular velocity are fed back as state variables to be controlled and/or regulated. The controller is implemented on small scale gantry crane designed.

1.2 Objective of Project

The main objective of this project is to design a model gantry crane system with dynamic feedback swing control method that will drive the system from initial position into a target position without vibration and reducing swing angle.

1.3 Problem Statement

To move 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. Most of the common gantry crane results in a swing motion when trolley is suddenly stopped after a fast motion. So, to overcome the problem the dynamic feedback swing control is applied to the gantry crane system. The dynamic modeling of gantry crane, designed to transport a small scale models containers using industrially applicable detection and control of dynamic cable swing resulting from very high speed operation, and environmental disturbances such as steady or gusting winds. A state variable feedback controller is designed for the gantry crane position and speed, as well as the load angle and angular velocity in order to move the containers of uncertain mass as quickly, accurately, and safely as possible.

1.4 Scope of Project

i) Literature study on the gantry crane system
ii) Study on dynamic feedback swing control to get the better output for gantry crane.
iii) Derive the dynamic feedback input function from the specified output function.
iv) Implement the input function into the closed-loop system.
v) Develop and analyze the dynamic model by using the SIMULINK in the MATLAB software.
vi) Design, and built the model gantry crane by using closed-loop systems (involved several types of sensors).
vii) Integrate between the hardware and software after all design completed.

1.5 Methodology

Phase1:-

Every week, meet and discuss with supervisor Mrs.Azdiana Binti Md.Yusop and show the project progress. Get more information about the gantry crane from supervisor, internet, books, journal, thesis, and so on.

Phase2:-

Make a literature review for the project system including study about the component that will be used, their characteristic and understand deeply about the circuit and how it operates and get the datasheet of component involved.

Phase3:-

For this phase, it called as software development, where involve analyze and study to design a dynamic feedback swing controller. Derive the dynamic feedback input function from the specified output function.

Phase4:-

For this phase, it called as hardware design. All components must have extra features to make sure the troubleshooting circuit can be done easily. Mechanical drawing for gantry crane also has been done using AutoCAD software.

Phase5:-

For this final phase, it called performance test. In this phase the software part and hardware part need to be combine together to get the result and to achieve the objective of project. The final result is then be compared with the theoretical. After that, the circuit that already constructed will be tested its functional, ability & weakness. If there is any error detected, the troubleshooting process will be done in order to make sure the circuit is well functioning.

1.6 Thesis Outlines

This thesis consists of five chapters. The following chapters are the outline of the implementation of dynamic feedback swing control of the gantry crane.

Chapter I Will discuss briefly the overview of this project such as introduction, objectives, methodology and thesis outlines.

Chapter II Contains the research and information about the project on several important concepts of dynamic feedback swing control, technology and tools used in the study. Every facts and information, which found through journals or other references, will be compared and the better methods have been chose for the project. This chapter will also include several types of crane.

Chapter III Includes the detail about designing and modeling the gantry crane system. Simulation results, analysis, observation and discussion of the performance of the dynamic feedback swing control technique are presented in. This chapter all those methodology should be followed to get a better performance.

Chapter IV Includes the detail about the hardware design involved schematic diagram, PCB layout, components required and working principle for each circuit.

Chapter V Describes more about the discussion, and project findings. The result is then presented in figures or plotted graph. This chapter also discuss about the conclusion of the project and the future recommendations.

CHAPTER II

LITERATURE REVIEW

This chapter contains the research and information about the project on several important concepts of dynamic feedback swing control, technology and tools used in the study. Every facts and information, which found through journals or other references, will be compared and the better methods have been chose for the project. This chapter will also include several types of crane.

2.1 Definition of Crane

A crane is a machine for lifting and lowering a load and moving it horizontally, with the hoisting mechanism an integral part of the machine (refer Figure 2.0). Cranes whether fixed or mobile are driven manually or by power. An automatic crane is a crane which when activated operates through a preset cycle or cycles. A cab-operated crane is a crane controlled by an operator in a cab located on the bridge or trolley.

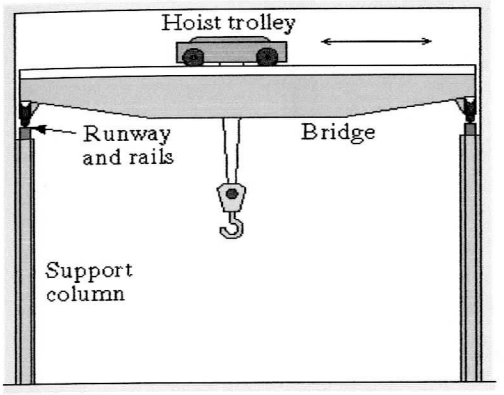
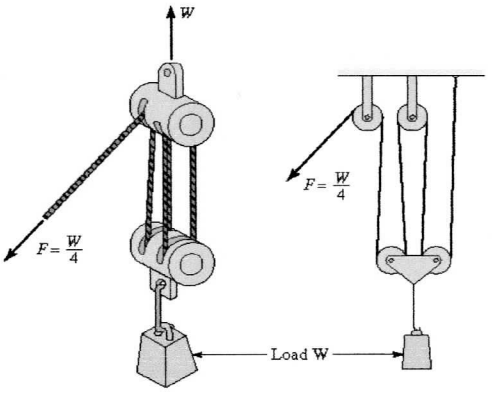
Cranes	Hoists
used for horizontal movement of materials	used for vertical lifting of materials
	

Figure 2.0 Differences between Crane and Hoist

A semi-gantry crane is a gantry crane with one end of the bridge rigidly supported on one or more legs that run on a fixed rail or runway, the other end of the bridge being supported by a truck running on an elevated rail or runway. Storage bridge crane means a gantry type crane of long span usually used for bulk storage of material the bridge girders or trusses are rigidly or non-rigidly supported on one or more legs. It may have one or more fixed or hinged cantilever ends.

Cantilever gantry crane means a gantry or semi-gantry crane in which the bridge girders or trusses extend transversely beyond the crane runway on one or both sides (refer Figure 2.1). Floor-operated crane means a crane which is pendant or nonconductive rope controlled by an operator on the floor or an independent platform.

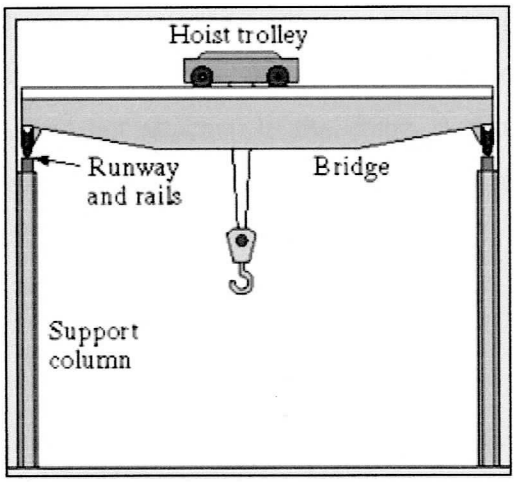


Figure 2.1 Bridge Crane

Gantry crane means a crane similar to an overhead crane except that the bridge for carrying the trolley or trolleys is rigidly supported on two or more legs running on fixed rails or other runway (refer Figure 2.2). Hot metal handling crane means an overhead crane used for transporting or pouring molten material. Overhead crane means a crane with a movable bridge carrying a movable or fixed hoisting mechanism and traveling on an overhead fixed runway structure.

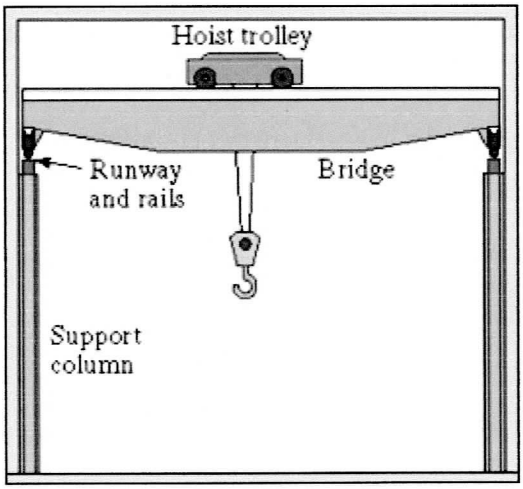


Figure 2.2 Gantry Crane

Power-operated crane means a crane whose mechanism is driven by electric, air, hydraulic, or internal combustion means. A pulpit-operated crane is a crane operated from a fixed operator station not attached to the crane. A remote-operated crane is a crane controlled by an operator not in a pulpit or in the cab attached to the crane, by any method other than pendant or rope control.

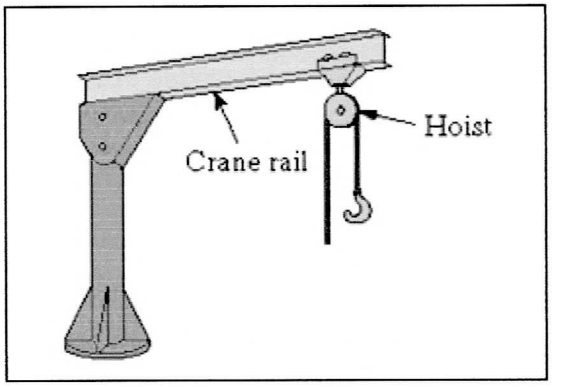


Figure 2.3:- Tower/Jib Crane

Figure 2.3 show that the tower or jib crane. A jib crane contains a tilted strut (the *jib*) that supports a fixed pulley block. Cables are wrapped multiple times round the fixed block and round another block attached to the load. When the free end of the cable is pulled by hand or by a winding machine, the pulley system delivers a force to the load that is equal to the applied force multiplied by the number of lengths of cable passing between the two blocks. This number is the mechanical advantage.