APPLICATION OF XY TABLE CONTINUOUS MOTION PROGRAMMING WITH PC BASED CONTROL

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This report submitted in accordance with the requirements of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotics & Automation) with Honours.

by

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This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation) with Honours. The member of the supervisory committee is as follow:

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ABSTRACT

The project of application of XY table continuous motion programming with PC based control is divided in two parts. First part of the project is about proposal and the second part is about project implementation. The application of XY table continuous motion programming with PC based control studied and investigated in this project as an improvement of previous research in order to enable the XY table for continuous motion. Further up, for high precision operation automation system the current two axis system is inadequate. Thus the third axis called Z-axis should be designed and added to the current XY positioning system. The continuous motion programming with the third axis may solve the current XY positioning system limitations in order to meet the current industrial automation requirements. This project is will be conducted to modify the current design, improve the current system in term of flow of programming method and mechanical structure. Finally a comprehensive report produced to conclude the findings and results obtained by the implementation of the project.

ABSTRAK

Projek aplikasi pengaturcaraan pergerakan berterusan meja XY dengan kawalan berasaskan komputer peribadi dibahagikan kepada dua bahagian. Bahagian pertama projek ini berkenaan dengan cadangan dan bahagian kedua adalah berkenaan dengan pelaksanaan projek. Dalam projek ini, aplikasi pengaturcaraan pergerakan berterusan meja XY dengan kawalan berasaskan komputer peribadi dikaji dan diselidik sebagai satu penambahbaikkan daripada kajian terdahulu bagi membolehkan pergerakkan berterusan meja XY tersebut. Tambahan lagi, sistem dua paksi yang sedia ada tidak memadai untuk sistem automasi operasi ketepatan tinggi. Oleh itu, satu paksi ketiga yang dinamakan paksi-Z perlu direkabentuk dan ditambahkan kepada sistem kedudukan yang sedia ada. Pengaturcaraan pergerakan berterusan dengan penambahan paksi-Z boleh menyelesaikan kekurangan yang ada pada sistem kedudukan XY yang sedia ada bagi memenuhi permintaan automasi industri pada masa ini. Projek ini akan dijalankan untuk menambahbaik rekabentuk pada masa ini, untuk memperbaiki system yang sedia ada dari segi kaedah aliran pengaturcaraan dan struktur mekanikal. Akhir sekali, satu laporan yang lengkap dihasilkan untuk merumuskan penemuan dan keputusan yang dicapai daripada aplikasi projek ini.

DEDICATION

For my beloved mum and dad.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

AC	-	Alternative current
ASIC	-	Application-specific integrated circuit
bps	-	Bytes per second
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
CLU	-	Control-loop-unit
CNC	-	Computer Numerical Control
CPU	-	Central processing unit
DC	-	Direct current
DOF	-	Degree of freedom
DPU	-	Data-processing-unit
FIFO	-	First In, First Out
FKP	-	Fakulti Kejuruteraan Pembuatan
FRL	-	Filter, regulator and lubricator
HP	-	Horse power
I/O	-	Input and output
IT	-	Information Technology
KE	-	Kinetic energy
LED	-	Light emitting diode
MCU	-	Machine Control Unit
MV	-	Motor voltage
PC	-	Personal Computer
PLC	-	Programmable Logical Controller
PM	-	Permanent magnet
PPS	-	Pulse per second

RPM	-	revolution per minute
SCADA	-	Supervisory Control and Data Acquisition
Servo	-	Servo motor
SOL	-	Solenoid
SVON	-	General-purposed digital output pin
VB.NET	-	Microsoft Visual Basic.NET
%	-	Percent
e.g.	-	For example
etc	-	and others
μ	-	Coefficient of Friction
rps	-	Revolutions per second
g	-	gram
mm	-	millimeter
N	-	Newton
F	-	Force
MPa	-	Mega Pascal
p	-	Pitch
l	-	Lead
$\Delta\theta$	-	Rotational displacement
Δx	-	Translational displacement
N	-	Net gear ratio
N_{ls}	-	Effective gear ratio
J_{eff}	-	Rotary inertia seen at the input shaft
W_l	-	Weight of the load
F_l	-	Load force
T_{eff}	-	Torque seen at the input shaft

CHAPTER 1
INTRODUCTION

1.1 Background

There are several motivating factors for this particular choice of a project. Programmable coordinate positioning systems employing motor controls have diverse applications and are extensively used in areas where precision linear and or, non-linear traversals are required. These precision machines are widely used in many modern manufacturing processes; a large proportion of these machines require the accurate positioning of some sort of tools or probes with respect to a work piece.

There are multitudes of different manipulators that find themselves attached to the XY positioning rails. Some of which include, lenses for microscope applications, laser heads, plotter heads, plasma cutting heads, robotic grippers for placement of parts, and general robotic manipulation instruments that need latitude and longitude positioning. Moreover, the design and integration of a linear positioning system employs knowledge in the areas of software and hardware design, control systems and power electronics.

However, controlling the XY coordinate positioning system has become a challenging task for engineers for maintaining the accuracy of motion and in reducing subsequent errors in this position. Hence they have introduced the positioning control system which controlled via computers. So, the application of XY table continuous motion programming with PC based control studied and investigated in this project as an improvement of previous research.

1.2 Problem Statement

The surface area of the XY table can move horizontal or vertical towards X-axis and Y-axis to perform the programmed task. With the existing XY table, an object such as workpiece or tool for machining application can be hold in a fix position. However this system restricts the operation for continuous motion when the positions of the tool or workpiece have to change. So, the tool or workpiece have to move along Z-axis in order to acquire continuous motion. Since there is no movable Z-axis in the current XY table, it has been a significant limitation in PC based positioning control system. In order to meet the current industrial requirement of automation application continuous motion programming is necessitated. Furthermore, for high precision operation automation system the current two axes are inadequate. Thus the third axis called Z-axis should be designed and added to the current XY positioning system. The continuous motion programming and the third axis may solve the current XY positioning system limitations in order to meet the current industrial automation requirements.

1.3 Scope of Project

Current XY table positioning system have two axes that can move horizontal or vertical towards X-axis and Y-axis to perform the programmed task .This mechanism operates in a single mode motion programming system. Therefore, this project is will be conducted to modify the current design, improve the current design in term of flow of programming method and mechanical structure. The research in this project is focused on application of XY table continuous motion programming with PC based control system. A technically improvised mechanical structure of the XY table is also expected to be designed based on the foundation laid earlier.

1.4 Objectives

The main objectives of this final year project include:-

(a) To design the mechanical structure of the Z-axis

(b) To apply continuous motion programming in current XY table

(c) To improve the current XY table in term of flow of programming method

CHAPTER 2
LITERATURE REVIEW

This chapter discusses about literature discourse and review of the application of XY table continuous motion programming with PC based control. Throughout the world, there have been many researches about the concept, designs and implementation of many types of XY table positioning system.

2.1 XY Table

In XY table, the X-axis and Y-axis are movable axes and can hold workpiece or tool for machining application. XY tables usually contain motor mounting plates, couplings, lead screws, and a large base and top plate. An XY table is made up of two elements which are a forcer and a platen. The forcer glides over the platen on frictionless air bearings and moves continuously in a linear motion across the platen. This action occurs due to linear motoring modules, typically between two and four, responding to currents. Variations among XY tables include the ways and the drive mechanism. The ways determine load capacity, straight-line accuracy, and stiffness, while the drive mechanisms determine smoothness and speed. Other factors imperative to XY tables are the accuracy, repeatability, and resolution required, as well as the appropriate motor for the application and whether or not an encoder is needed. The example applications of an XY table include CNC machining, milling and welding. All these applications involve automated positioning for time saving and reducing human error. The positioning is mostly controlled by PLC, CNC controller or PC based programming.

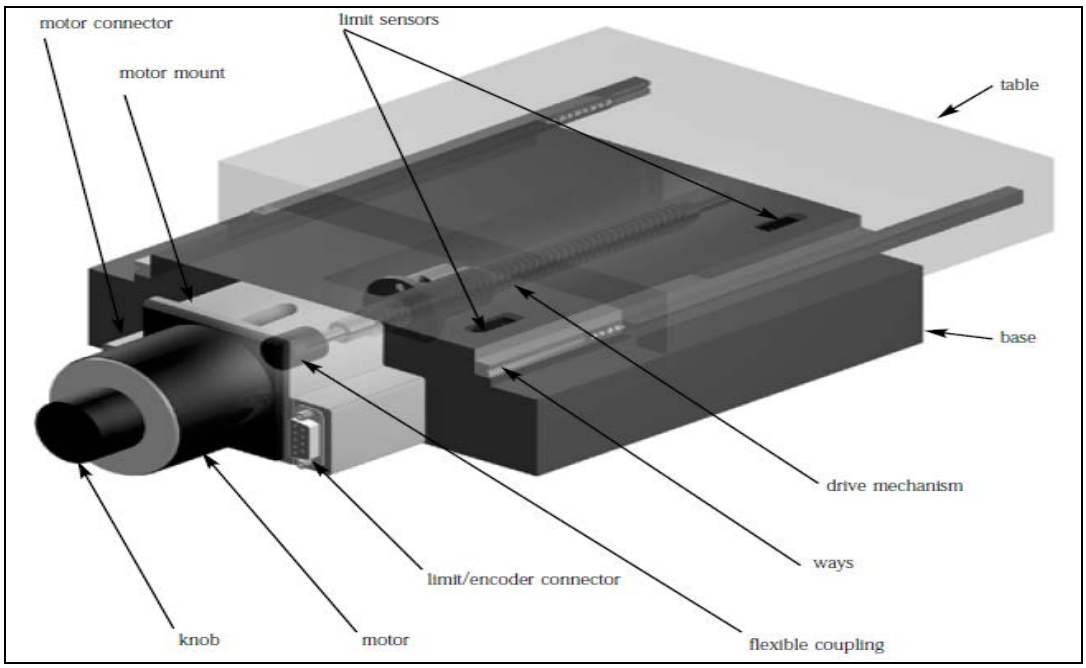

Figure 2.1: Main components of XY table
(Source: Danaher Precision Systems Product Catalogue)

The XY table consists of a travel mechanism, bearings, drive mechanism, motor and motor driver (Hi-Dong Chai, 1998). Figure 2.1 shows the typical components of XY table such as motor, limit sensors, drive mechanism, table, flexible coupling and other components. The characteristics and advantages depend on its appearance of XY table and the body frame of XY table.

Figure 2.2: XY table

The XY table studied in this project shown in Figure 2.2. The travel distance of this table designed as 1000mm along X-axis and Y-axis respectively. The top plane of the XY of the XY table designed with rows of steel bars so that the workpiece can be clamped. Thus, a variety size of workpiece can be applied for the operation. Each axis consists of two shafts, which are made of steel with these shafts act as guide rail to make a smooth movement and prevention from a vibration. Beside that on the below side of the body of XY table consists of four rollers. With rollers, the XY table is flexible to be moved or placed. Furthermore, this allows easy loading and uploading.

XY tables are most often mounted horizontally. Depending on the specifications, XY tables may also be used in microelectronics assembly, laser machining, and factory automation. The top table can be positioned with high precision and moved at high acceleration and deceleration. The present invention relates to an XY table which is used as a positioning table in semiconductor assembling equipment, machine tools, measurement equipment, etc (Takeo Suzuki,1998).

Otherwise, an automatic XY table used motor to control motion of table surface can be selected if complex project required a precise and skilled movement of the table. This is the other option of moving XY table surface, instead of doing it manually by turning levers. A machine can move table surface on a precise path since it can hook up to computer and the path is programmable. Data input is key in and then the work can be proceeding easily. Hooking up XY table this way can be very effective when looking for a very accurate and precise finish product. There are different ways for XY table built or used to fulfill and fit the requirements of the users.

The standard XY table is usually designed and built from heavy-duty steels including stainless and are meant to last for many years with nominal maintenance. Most XY table working surface are built for toughness in design to get a more rigidity and stressed relieved for minimal environmental effect. Precision rails and bearing blocks are used to give an accurate and repeatable operation. Most basic XY table is accurate. When working on a delicate project vibration need to be concern, thus, vibration control within the table is made for minimal vibration. XY table that

equipped with proper tools, which combined high precision, high speed and low settling time is regularly been selected to carry out the desired work (Kallmeyer, M. *et al*., 1998).

Moreover, an invention of XY table relates to an improved XY table. A plate or the like is cut along imaginary line or a marked line. For example, a thick iron plate cut by a gas torch or plasma torch. The cutting operation may be manual or automatic. It is, however, not easy to handle a heavy iron plate. In addition, a large iron plate cannot be easily cut by a reasonable size of cutting machine (Chen, M. F. *et al*., 2007).

The objective of this invention is to provide an XY table, which can be easily moved to a desired position for various operations. Specifically, this invention includes an XY table for processing an object such as an iron plate comprising a frame having an opened formed. Thereby, a moving member moving in an X-axis and Y-axis at a right angle to the X-axis, a head for cutting, marking or machining attached to the moving means for processing the object through the opening, and a setting mechanism for detachably setting the frame to the object.

There are a number of selections to make when choosing a motorized XY table. The major components should be considered when choosing XY table are the following (Hussain Z. Tameem, 1999):-

- load capacity
- stiffness
- straight-line accuracy
- the drive mechanism which determines speed and smoothness
- accuracy
- repeatability
- resolution
- the appropriate motor for the application
- encoder application