



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DESIGN AN INDUSTRIAL ROBOT MILLING
MACHINE APPLICATION USING ABB IRB 120**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Industrial Automation and Robotics) with Honours.

by

MUHAMMAD AFIQ BIN MOHD PAUZI

B071510609

940901-01-6537

FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING

TECHNOLOGY

2018/19

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: Design an Industrial Robot Milling Machine Application Using ABB IRB 120

Sesi Pengajian: 2018/19 Semester 1

Saya **Muhammad Afiq Bin Mohd Pauzi** mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. ****Sila tandakan (X)**

SULIT* Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972.

TERHAD* Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.

TIDAK
TERHAD

Yang benar,

Disahkan oleh penyelia:

.....
Muhammad Afiq Bin Mohd Pauzi

.....
Mohamed Azmi Bin Said

2 Jalan Pulai Perdana 6,
Taman Sri Pulai Perdana,
81110 Johor Bahru,
Johor.

Cop Rasmi Penyelia

Tarikh:

Tarikh:

*Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini

DECLARATION

I hereby, declared this report entitled Design an Industrial Robot Milling Machine Application Using ABB IRB 120 is the results of my own research except as cited in references.

Signature:

Author : Muhammad Afiq Bin Mohd Pauzi

Date:

APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Automation and Robotics) with Honours. The member of the supervisory is as follow:

Signature:

Supervisor : Mohamed Azmi Bin Said

ABSTRAK

Pada zaman kini, teknologi semakin hari semakin berkembang dengan pesat tidak mengira di dalam bidang elektrik, elektronik, telekomunikasi, mekanikal mahupun pembuatan. Terdapat pelbagai ciptaan dan inovasi yang lahir dan telah diaplikasikan di dalam kerja harian kita. Inovasi yang paling ketara ialah menggabungkan antara dua teknologi dan menjadikan satu aplikasi. Untuk projek ini, ia merupakan gabungan dua teknologi yang berbeza iaitu antara robot dan mesin pengilangan menjadi satu aplikasi dalam sistem pembuatan yang dapat memudahkan kerja pengilangan yang kompleks. Teknik pengilangan ialah kaedah memotong, mengisar dan membentuk blok daripada bahan logam, kayu, plastic dan lain-lain menggunakan alat pemutar. Selain itu, ia juga merupakan salah satu teknik yang digunakan di dalam sistem pembuatan yang sering diaplikasikan pada industri di serata dunia. Projek ini mengaplikasikan kerja pengilangan menggunakan robot ABB IRB 120 daripada perisian simulasi. Tumpuan dalam simulasi ini adalah untuk menyediakan titik pergerakan bagi bentuk bahan kerja secara automatik. Bahan kerja pengilangan juga telah direka bentuk menggunakan perisian reka bentuk. Walaubagaimanapun, pembangunan projek ini merupakan di dalam peringkat awal serta reka bentuk motor gelendong yang akan dipasang pada robot merupakan dalam skala kecil bersesuaian dengan saiz robot.

ABSTRACT

Technologies are growing rapidly day by day involving electrical, electronics, mechanical and manufacturing field. There are many inventions and innovations are born and have been applied in our daily routine. The most significant innovation is a combination between two technologies and applied on industries. This project is a combination between two different inventions which are industrial robot arm and milling machine to apply in manufacturing system for facilitation of complex manufacture process. Mechanical milling is a method of cutting, grinding and shaping a block of metal, wood, plastic and other uses rotating tool. The project applies the milling work using ABB IRB 120 robot in simulation software. The focus of this simulation is to provide the path for milling movement automatically. The work piece for milling has also been designed using CAD/CAM design software. However, the development of this project is in the early stages and the designation of the spindle motor to be mounted on the robot was on a small scale compatible with the size of the robot.

DEDICATION

So here I'm again adding more colors to my life of sin,
Adding more beautiful meaning to resolve the things,
Adding more stress to make all the changes,
So I can turn my life and change it back on to the right lane.
We had every change from A to Z while we wish you were live for eternity.
From all the mess and all the fuss,
Pretend to forget this how to us.
Feels like something else of what I could be in years,
Oh, my brothers and sisters please forgive me for all the tears,
For all the hard times that I've cause in the past 4 years
And to my angel, thanks to you, respect to you.
I know I only miss you. I won't be here without you.
Thanks for all the fun, thanks for all the joy,
Thanks for all the years that we all enjoy.
I've done my time, I had my days, I had it all.
I pray for you, Allah bless you all.
Allah bless you all.

ACKNOWLEDGEMENTS

First of all, Alhamdulillah, all praise and gratitude to the Almighty Allah SWT for giving me a good health, an air to breathe twenty four hours a day, strength and my positive surrounding that gives me spirit and motivations until I complete my final year project. Thank you to my parents, Mdm. Normala Binti Harun and Mr. Mohd Pauzi Bin Setapa for keep supporting me in spiritual and physical and also a million thank you for their patience waiting for me to finishing my degree. Only Allah SWT can repay all of your kindness. I also indebted of the kindness given by my one and only supervisor, Mr. Mohamed Azmi Bin Mohd Said for teaching, guiding and monitoring me with my project by time to time. Honestly, I cannot run this project without your guidance. Infinite of gratitude to all of my friends and people surround me who involving in this project directly or indirectly and also giving me some ideas to develop this project.

TABLE OF CONTENTS

	PAGE
TABLE OF CONTENTS	v
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF APPENDICES	xvi
LIST OF SYMBOLS	xvii
LIST OF ABBREVIATIONS	xviii
CHAPTER 1 INTRODUCTION	1
1.0 Introduction	1
1.1 Milling Machines	2
1.2 Robots	2
1.3 Project Background	3
1.4 Problem Statement	3
1.5 Objective	4
1.6 Work Scope	4
1.7 Report Outline	5
CHAPTER 2 LITERATURE REVIEW	6

2.0	Introduction	6
2.1	Utilization of Robot Arm for Milling Machine	6
2.2	Milling Machines	8
2.2.1	Milling Tool	9
2.2.2	Spindle	11
2.2.3	Milling Operations	12
	2.2.3.1 Peripheral Milling	13
	2.2.3.2 Face Milling	14
2.3	Industrial Robot	15
2.3.1	Advantages of Using Robot	15
2.3.2	Articulated Robots	16
2.3.3	ABB IRB120	18
2.3.4	Rapid Code	21
	2.3.4.1 MoveL	21
	2.3.4.2 MoveJ	22
	2.3.4.3 MoveC	23
2.4	Machining Robotics	23
2.4.1	G-Code to RAPID Translator for Robot-Studio	24
2.4.2	Implementation of Industrial Robot for Painting Applications	25

2.4.3	A New Parametric Design Tool for Robot Milling	26
2.4.4	Boot The Bot: Java-based Simulation, Code Generator and Live Controller for ABB Robots	28
2.4.5	Robot-assisted 3D Printing of Biopolymer Thin Shells	30
2.5	RobotStudio: Machining PowerPack 6.06	32
CHAPTER 3 METHODOLOGY		33
3.0	Introduction	33
3.1	Project Methodology	35
3.2	Project Work Flow	37
3.3	Controller: RobotStudio 6.06	39
3.4	Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) software	42
3.4.1	SolidWorks 2016	42
	3.4.1.1 Menus	43
	3.4.1.2 Command Manager	43
	3.4.1.3 Shortcut Bars	44
3.4.2	Machining PowerPac 6.06 in RobotStudio 6.06	44
3.5	Design	49
3.5.1	Work Piece	49
3.5.2	Milling Tool for ABB IRB120	50

3.5.3	3D Printing	56
3.6	Configure Tool Frame in RobotStudio 6.06	57
3.7	Simulation using RobotStudio's Machining PowerPac6.06	58
CHAPTER 4 RESULT AND DISCUSSION		62
4.0	Introduction	62
4.1	3D Printing Result	62
4.2	Simulation of the Milling Process	66
4.3	Analysis and Comparison	68
4.3.1	TCP Tracing	68
4.3.2	Shape of the Work Piece	70
4.3.3	Amount of Cutting Plane	73
4.3.4	Movement Type	75
4.3.5	Velocity	77
4.4	Discussion	78
CHAPTER 5 CONCLUSION		79
5.0	Introduction	79
5.1	Conclusion	79
5.2	Future Recommendation	80

REFERENCES

81

APPENDIX

83

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1:	IRB 120 and IRB 120T Maximum Payload and Reach	19
Table 2.2:	Manipulator weight	19
Table 2.3:	Description of Position A, B and C.	21
Table 3.1:	Explanation of RobotStudio Tab	40
Table 4.1:	Differences between MoveJ and MoveL	75

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1:	Movement for Milling Machine in Cartesian Axis	7
Figure 2.2:	Motion of Articulated Robot in 6 Degree of Freedom	7
Figure 2.3:	Common types of knee-and-column milling machine: (a) horizontal (b) vertical	8
Figure 2.4:	Bed Type Milling Machine for Horizontal Spindle.	9
Figure 2.5:	Example of milling tool mounted in a milling tool holder	9
Figure 2.6:	Common Option Flute for End Mill Designation	11
Figure 2.7:	Application of End Mill	11
Figure 2.8:	Basic Structure and Components of Spindle	11
Figure 2.9:	Direction of the cutter direction: (a) up milling, (b) down milling	13
Figure 2.10:	Types of face milling: (a) conventional face milling, (b) partial face milling, (c) end milling, (d) profile milling, (e) pocket milling, (f) surface contouring.	14
Figure 2.11:	ABB IRB 140	17
Figure 2.12:	ABB IRB 1410	17
Figure 2.13:	(a) ABB IRB 1600-6&8/1.2 and 6&8/1.45 (b) ABB IRB 1600ID	18
Figure 2.14:	ABB IRB 120 and its axis.	20

Figure 2.15: Dimension of IRB 120 Robot	20
Figure 2.16: MoveL motion between two points	22
Figure 2.17: MoveJ motion	23
Figure 2.18: RobotStudio Programming of Paths and Targets	26
Figure 2.19: Design to Product Workflow for Kuka KR60H	27
Figure 2.20: KRL-Visualisation in Grasshopper	28
Figure 2.21: Example of Boot The Bot program	29
Figure 2.22: Robot with platform or mandrel with controller and ABB's FlexPendant	30
Figure 3.1: Project Methodology	34
Figure 3.2: Implementation in ABB IRB 120 Milling Robot	35
Figure 3.3: Process Flow in Design and Simulation	38
Figure 3.4: Overview of developing an end effector of robot	39
Figure 3.5: ABB RobotStudio Tab	40
Figure 3.6: Example of SolidWorks software	42
Figure 3.7: Program using Menus	43
Figure 3.8: CommandManager in Solidworks program	44
Figure 3.9: Program SolidWorks using Shortcut Bars	44
Figure 3.10: CAM Converter in Machining PowerPac	45
Figure 3.11: Machining in Machining PowerPac	45
Figure 3.12: Opening Machining PowerPac in RobotStudio	46

Figure 3.13: Geometry tab	47
Figure 3.14: Tool tab	48
Figure 3.15: Program Tab	48
Figure 3.16: Operation Tab	48
Figure 3.17: Simulation and Export RAPID Command	49
Figure 3.18: Orthographic view of the Work Piece	50
Figure 3.19: Dimension of ABB IRB 120's End Effector	51
Figure 3.20: Dimension of Motor Spindle	52
Figure 3.21: Dimension of End Mill	52
Figure 3.22: Dimension of Motor Case (Bottom)	53
Figure 3.23: Dimension of Motor Case (Top)	53
Figure 3.24: Dimension of Robot Holder	54
Figure 3.25: Orthographic view of Milling Tool	55
Figure 3.26: Exploited View of Milling Tool	55
Figure 3.27: Example of Using Up!	56
Figure 3.28: 3D Printer	57
Figure 3.29: Configured Tool in RobotStudio 6.06	58
Figure 3.30: Tool Frame, User Frame and Configured Tool in Simulation	59
Figure 3.31: Path Creation	59
Figure 3.32: Target Configuration	60

Figure 3.33: Simulation Status	61
Figure 3.34: Instruction window for path editing	61
Figure 4.1: Robot Holder	63
Figure 4.2: Motor Spindle with Holder	63
Figure 4.3: End Mill	64
Figure 4.4: Exploded view of the 3D printed milling tool	64
Figure 4.5: 3D Print Result	65
Figure 4.6: Auto-generated Path	66
Figure 4.7: Generated Path after altered	66
Figure 4.8: Rapid Code (Robot Target)	67
Figure 4.9: Rapid Code (Path Movement)	68
Figure 4.10: Without TCP Tracing	69
Figure 4.11: With TCP Tracing	69
Figure 4.12: Types of Work Piece	70
Figure 4.13: Face milling of the Hemisphere with TCP tracing	71
Figure 4.14: Face and side milling of the square shaped	71
Figure 4.15: Full milling operation for UTeM block	72
Figure 4.16: Cutting Plane (Recommended by Default)	74
Figure 4.17: Cutting Plane (Set Manually)	74
Figure 4.18: TCP Tracing of MoveJ	76

Figure 4.19: TCP Tracing of MoveL	76
Figure 4.20: Output (Corner path failure)	77
Figure 4.21: Output Warning	78

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
	Appendix 1: Create Tool Frame Library	83
	Appendix 2: RobotStudio simulation with Machining PowerPac	86

LIST OF SYMBOLS

Z	-	Zone
V	-	Velocity
g	-	Gram
kg	-	Kilogram
m	-	Meter
mm	-	Millimeter

LIST OF ABBREVIATIONS

3D	3 Dimensional
TCP	Tool Centre Point
NC	Numerical Control
CNC	Computer Numerical Control
PLA	Polylactic Acid
ABS	Acrylonitrile, Butadiene and Styrene

CHAPTER 1

INTRODUCTION

1.0 Introduction

Milling machine is one of the well-known machinery operations for production. Manufacture is an application of physical methods to produce parts or products that involve set up of multiple parts. Robot arm or articulated arm is currently famous for doing any particular job or application including milling operation. This articulated arm robot can make a better performance than current milling machines since the milling machines can only move in Cartesian while robot arm can moves with an addition roll, pitch, and yaw. Thus, this project is using the ABB IRB 120 to develop a milling robot. In this chapter, a briefing of overall process and overall project will be stated as an introduction to the other next chapters. This chapter is including a project background for the history of this project, problem statement, objectives, project guideline and briefing of the main components.

1.1 Milling Machines

A union of machinery, tools, power, and labor elaborate the processes to accomplish manufacturing. In this new era that technologies are increasing rapidly, a process of machines that includes engineering process can be implemented to ease human labor. The process of milling machine is involves from electrical power converting into mechanical power to use for manufacturing. Milling is the function of machining in which a work part is fed past a rotating cylindrical tool with numerous cutting edges to get rid of excess medium of the work piece. The existence of first milling machine is found on 1818 created by Eli Whitney in United States. The first milling machine was served as a prototype is then has been improved and innovated until now.

1.2 Robots

A robot is a general-purpose programmable machine that set by a computer or guided by an external control device to autonomously run an intricate series of actions. The regulations of the robots can be used by external device or embedded within. The creation of robots is constructed to take on human form but most robots are machines designed to achieve task with no regards of their appearance. The prominent feature is the robot's mechanical arm or manipulator, which their behavior and designation are referred as animal-like or human-like. The main purpose of developing a robot is to help human labor to replace their work which in repetitive working such as packaging, dirty place like at a landfill and also in hazard such as in radioactive or hot place.