PERFORMANCE ANALYSIS OF INDUSTRIAL ROBOT UNDER LOADED CONDITIONS AND VARIOUS DISTANCES

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This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Robotics and Automation) (Hons.)

by

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I hereby, declared this report entitled "Performance Analysis of Industrial Robot under Loaded Conditions and Various Distances" is the results of my own research except as cited in references.

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Author's Name : AZMEER SHAH BIN ARISTON SHAH

Date : 21 JUNE 2017

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotics and Automation) (Hons.).
The members of the supervisory committee are as follow:

…….....

Dr. Syamimi Binti Shamsuddin

(Supervisor)

ABSTRAK

Ciri-ciri prestasi robot seperti ketepatan dan kebolehulangan adalah penting untuk robot industri dalam industri pembuatan. Dua faktor ini dipengaruhi oleh nilai beban yang dibawa lengan robot dan juga jarak yang dilalui semasa robot melaksanakan pelbagai tugasan di dalam ruang kerjanya. Matlamat utama projek ini adalah untuk menyelidik ketepatan dan kebolehulangan robot Yaskawa Motoman MH5F dengan menggunakan kaedah sinar laser interferometri untuk bebanan berbeza dan pelbagai jarak. Interferometer adalah instrumen yang jitu direka untuk mengukur sesuatu secara tepat. Laser interferometri adalah satu kaedah pengukuran yang diakui jitu dan tepat. Laser interferometri adalah kaedah mencampuri dua gelombang atau lebih yang digunakan untuk mengenalpasti kontras di antara mereka. Hasil kajian yang lepas menunjukkan prestasi robot secara langsung dipengaruhi oleh penambahan beban dan jarak. Terdapat 12 set eksperimen yang dijalankan di mana setiap set telah diulang sebanyak 30 kali. Di akhir eksperimen ini, nilai kebolehulangan dan kejituan robot yang diperolehi masing-masing adalah ±0.0047 mm dan ±0.237 mm. Justeru itu, ini membuktikan robot Yaskawa Motoman MH5F mempunyai kebolehulangan yang baik berbanding spesifikasi teknikal robot iaitu ±0.02 mm. Juga, hanya kebolehulangan melawan faktor jarak sahaja yang menunjukkan korelasi linear positif dimana hubungan antara satu sama lain diwakili dengan persamaan model $y = 0.0000035x + 0.003716667$.

ABSTRACT

Robot's performance characteristics such as accuracy and repeatability are important for industrial robots in manufacturing industries. These two factors are significantly affected by load amount carried by the robot arm and also the distance travelled when it is performing various tasks within its working envelope. The aim of this project is to investigate the accuracy and repeatability of Yaskawa Motoman MH5F robot using the laser interferometry method for different payload and various distances. An interferometer is a precise instrument designed to measure things accurately. Laser interferometry is a recognized measurement method that is accurate and precise. Laser interferometry is the method of interfering two or more waves which is utilized to recognize contrasts between them. Findings from the previous studies show that a robot's performance was directly influenced with increased load and distance. There were 12 sets of experiment conducted where each had been repeated for 30 times. At the end of the experiment, the robot repeatability and accuracy value obtained are ±0.0047 mm and ±0.237 mm respectively. Hence this proved that Yaskawa Motoman MH5F robot has better repeatability compared to the robots technical specification which is ±0.02 mm. Also, only repeatability against distance factor shows positive linear correlation where the relationship between each other is represented with a model equation of $y = 0.0000035x + 0.003716667$.

DEDICATION

Only

my beloved father, Ariston Shah Bin Muhaimin

my appreciated mother, Pauziah Binti Isnin

my adored sister, Azyanti

for giving me moral support, money, cooperation, encouragement and also understandings

Thank You So Much & Love You All Forever

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

DOF	-	Degree of Freedom
EOAT	-	End of Arm Tooling
FKP	-	Fakulti Kejuruteraan Pembuatan
PSM	-	Projek Sarjana Muda
SCARA	-	Selective Compliance Assembly Robot Arm
USB	-	Universal Serial Bus

LIST OF SYMBOLS

kg	-	Kilogram
mm	-	Millimetre
N	-	Newton
ppm	-	Parts Per Million

CHAPTER 1
INTRODUCTION

This chapter covers the introduction of the project entitled „Performance Analysis of Industrial Robot under Loaded Conditions and Various Distances". This chapter covers project background which consists of introduction of industrial robots and their characteristics. Moreover, this chapter elaborates the problem statements, objectives, scope of project, project planning and organization of report.

1.1 Project Background

Robot is a powerful element which is capable of performing many various tasks and operations accurately without requiring common safety and comfort elements humans need (Niku, 2001). An industrial robot is a manipulator configuration to move materials or parts and execute a selection of modified tasks in manufacturing and production settings. Rather than customary types of automatic transfer and loading devices, robots can be outlined with the goal that they handle a majority of altogether various work pieces. Robots can be customized to do an extraordinary number of various motions and work with the speed and effectiveness of automated specific purpose machine (Colestock, 2005).

The ABB industrial robots shown in Figure 1.1 are widely used in automotive industry and almost cover the entirely automotive production process. The robot task or operation including welding operation, body assembling and painting process.

Figure 1.1: ABB IRB‟s industrial robot (Waurzyniak, 2012)

Industrial robot is closely related to their characteristics such as payload, accuracy and repeatability. All of the factors are will be emphasized especially in selection, design and maintenance of a robot. This also will determine the performance of the robot‟s backlash for a longer time period. The payload indicates the maximum mass the robot can lift before either failure of the robots or dramatic loss of accuracy. In this case, the robots can possibly operate exceeding their maximum payload, but at the maximum level, it may become less accurate and may not follow its intended path accurately because of excessive deflections. The end of arm tooling is also considered part of the payload for the robot.

1.1.1 What is a Robot?

According to Robart Ayres and Steve Miller (1981), the term “robot” originated from the Czech word “robotnik” which means serf. It was first presented into the favourite language by Carel Capek, a Czech Playwright, in “Rossum‟s Universal Robots” (R.U.R).

An American company, Unimation Inc., founded by Joseph Engelberger and George Devol in 1962, was the first company to manufacture industrial robots. The Robot Institute of America defines the industrial robot as a programmable, multi-purpose manipulator intended to transfer material, tools or specified devices through variant programmed movements for the performance of various jobs (Xie, 2003).

Many industrial automation tasks perform a repetitive works and sometimes deal with dirty environments. These types of tasks can be easily carried by the robot as the human workers usually less interested to the tasks that involve no intelligence or exercise any decision-making skills. Hence, the task likes loading packages onto the conveyor as in Figure 1.2 can be conducted perfectly by robots with a precision and reliability that mankind may lack.

Figure 1.2: A Fanuc industrial robot (Kumar *et al*., 2006)

Robots are not only known in industries. Robots are also slowly penetrating the society thus this can be classified as an industrial robot and social/service robots. The International Federation of Robotics states that a service robot is a robot which function semi or fully autonomously to conduct helpful employment to the mankind and equipments, except for manufacturing operations (Kumar *et al*., 2006). Figure 1.3 shows a robot called Pearl which gives the functions such as:

i. To aid as a cognitive orthotic to its customers.
ii. To aid as a spatial command for navigating the environment.

Figure 1.3: Pearl is a nursebot, which is also categorized as a social or service robot (Fong *et al*., 2003)

As a cognitive orthotic, Pearl can remind people to utilize the restroom, eat and turn on the TV for a most loved show. As a guide, Pearl not only able to remind a psychotheraphy arrangement, it can also lead the route to the practice room. This shows that robots are becoming more common in human lives.

1.1.2 Introduction to Industrial Robot

To remain competitive, the manufacturing industry is concerned about the robustness and accuracy of industrial robots. Ayres and Miller (1981) describe industrial robots as programmable manipulators which can move parts or equipments through a determined consecution of motions. The robot‟s behaviour that can be customized by changing the control settings, without altering the hardware is called reprogrammability. The robot able to repeat the same task for a long time periods with great precision which actually same as a machine tool. The similarity of robot with the operator is flexible enough to be assigned with a new task and it can attach with accessory tools to improve its range of physical capabilities.

Xie (2003) state that industrial robot is an automated, servo-controlled, freely programmable, useable manipulator and with respective axes for the manipulation of the work pieces, tools or special devices. It is also called as a robotic manipulator or arm because of the popular appears of the industrial robot is same as arm with waist, shoulder, elbow and wrist. Figure 1.4 shows the industrial robots from ABB Pick and place robot which capable of performing two pick and place operations per second.

Figure 1.4: The ABB pick and place robot (Kumar *et al*., 2006)

In industrial world, some of the tasks are unrealistic for humans to perform due to the dangerous of the occupation such as casting and welding work with the extraordinary temperature environment that would be unsafe for person. The existence of the robot in assisting mankind or cut down the person‟s work so, many occupations in plants which were generally performed by individuals are currently robotized. This cause to less expensive mass-produced products, including cars and gadgets enterprises. The science fiction author, Isaac Asimov had introduced the Three Laws of Robotics (Predko, 2004):

i. A robot may not injure a human being or through inaction, allow human to come to harm.
ii. A robot must obey the orders given it by human being except where such orders would conflict with the First Law.
iii. A robot must protect its own existence as long as such protection does not conflict the First and Second Law.

The advantages of using industrial robots especially in manufacturing industries are as follows (Niku, 2010):

- Robotics and automation can increase profitability, safety, effectiveness, quality and consistency of items.
- Robots can work in risky situations without the requirement forever support, solace or worry about security.
- Robots require no natural solace, for instance lighting, air conditioning, ventilation and loud protection.
- Robots work consistently without encountering exhaustion or fatigue, do not get distraught, do not have discomfort and need no therapeutic protection or get-away.
- Robots have repeatable accuracy at all circumstances, unless something occurs to them or unless they overtire.
- Robots can be significantly more precise than people. Common straight exactness is a couple of a huge number of an inch. New wafer-handling robots have smaller scale inch exactnesses.
- Robots and their add-on and sensors can have abilities past that of people.
- Robots can handle various stimuli or operations at the same time. People can just process one dynamic input.

Even though the industrial robot can give convenience and benefits to the industries as well as human, it also can draw the disadvantages at the same time. The limitations of the industrial robots are (Dhillon, 2012):

i. Robots need ability to react in crises, unless the circumstance is anticipated and the reaction is incorporated into the system. This include:
    - Improper or wrong reactions
    - An absence of basic leadership control
    - Lost power
    - Harm to the robot and another tools
    - People wound

ii. The robot have restricted capacities in

- Degrees of freedom (DOF)
- Agility
- Sensors
- Vision systems
- Continuous reaction

iii. Robots are expensive in terms of:

- Starting expense of tools
- Establishment costs
- Requirement for peripherals
- Requirement for practice
- Requirement for programming

1.1.3 Industrial Robot Performance

Payload of the industrial robot is considered also as the performance of industrial robot. It is define as the weight or load a robot can carry and still maintain within its specifications. The accuracy is defined as how accurately a specified point can be reached by the robot. This is a function of the resolution of the actuators, as well as its feedback devices. The maximum distance should be considered the accuracy if the robot travel to a point in space while it often be off by some amount. This is due to the effect of a control system that is not necessarily continuous.

Meanwhile, the repeatability is the important case to be considered for the industrial robot in order to measure the performance. Niku (2001) describes repeatability is how precisely a similar position can be come to if the movement is continual many times. The robot mechanism will have some natural variance in it which means that when the robot is repeatedly instructed to return to the same point, it will not always stop at the same position.

Suppose a robot is driven to the same point for a certain taken time, since many factors may affect the accuracy of the position thus the robot only will be within a certain radius from the desired point. The radius of a circle that is formed by this repeated motion is called repeatability.

1.2 Problem Statement

The increasing usage of robots in manufacturing operations is due to its flexibility and ability to be reprogrammed easily as an automatic programmable transfer and handling machine. The payload or weight lifted by the robot affects the accuracy and repeatability of the robots. Repeatability is considered much more important compare to accuracy because the robot had being set or programmed to perform a task and repeat it. However, due to some factor, the positional errors occurred and affect the production performance.

The main obstacle in robotics applications is the positional errors always occurred when it is under real working conditions. The problem with industrial robots is that their precision will be affected after carrying out the same tasks repeatedly and continuously. The accuracy and precision may be less as the error become bigger when the robot continuously performing its job. In addition, there will be a problem where the robot will generate heat after repeating the desired task in industry which will affect the robot‟s performance.

This implies that robots have to perform accurately under loaded conditions at any location within the working envelope. Thus, the aim of this study is to evaluate the performance of an industrial robot under payload and various distances within its working envelope.