UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INCREASING ABB FLEXPICKER ROBOT'S DEGREE OF FREEDOM FOR AUTOMATED PRODUCT ASSEMBLY TASK

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

by

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APPROVAL

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 (Robotic and Automation) with Honours. The member of the supervisory committee is as follow:

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ABSTRAK

Tujuan utama projek ini adalah untuk meningkatkan darjah kebebasan untuk ABB FlexPicker robot yang tersedia di Makmal Robotik, FKP, UTeM. Darjah kebebasan robot ditingkatkan dengan mereka bentuk “end-effector” baru yang flexible supaya boleh melakukan tugas pemasangan produk yang kompleks secara automatik . Reka bentuk ini berfungsi untuk melaksanakan proses pengambilan dan penempatan objek di arah menegak dengan sudut tertentu tidak seperti “end-effector” semasa yang digunakan untuk melaksanakan hanya dalam arah lurus. Ini akan berguna dalam memilih dan meletakkan objek dalam sudut yang berbeza arah, tugas pemasangan yang rumit dan juga proses pembersihan vakum dalaman. Objektif projek ini adalah untuk mereka bentuk dan membangunkan prototaip “end-effector” untuk meningkatkan darjah kebebasan robot ABB FlexPicker. Tiga rekaan “end-effector” yang berbeza telah dihasilkan dengan menggunakan perisian SolidWorks. Reka bentuk ini dianalisis berdasarkan beberapa kriteria dan reka bentuk yang terbaik dipilih. Bagi menyokong keputusan, analisis penentuan sudut lenturan yang boleh dicapai oleh fleksibel end-effector dengan jumlah beban yang berbeza telah dijalankan. Kedua, ujian penyokongan berat dijalankan untuk mengenal pasti jumlah maksimum beban yang dapat disokong oleh “end-effector”. Daripada analisis, didapati bahawa “end-effector” boleh mengangkat berat sehingga 1kg kerana tekanan vakum yang mencukupi; walau bagaimanapun, ia boleh melakukan lenturan sehingga 90 darjah untuk maksimum 600 gram beban sahaja. Cadangan untuk kerja-kerja masa depan telah dinyatakan dalam laporan ini.

ABSTRACT

The main purpose of this project is to increase the DOF (degree of freedom) for ABB FlexPicker robot available in Robotic Lab of FKP in UTeM. The DOF of the robot is increased by designing a new flexible end-effector that can perform more complex automated product assembly task. This design is functioned to perform pick and place at vertical direction with a specified angle unlike the current end-effector which use to execute in only straight direction. This will be useful in picking and place an object in different angle of direction, complex assembly task and also deep vacuum cleaning process. The objectives of this project are to design and develop prototype of flexible – end effector in order to increase degree of freedom of an ABB FlexPicker robot. Three different designs of end-effectors are developed using SolidWorks software. These designs are analyzed based on several criteria and the best design is selected. The selected design is fabricated using a suitable method. To support the result an analysis on the angle of bending that the flexible end-effector can achieve with different amounts of load is conducted. A weight lifting test is carried on to identify the maximum amount of load can be supported by the end-effector. From the analysis, it is found that the end-effector can lift weights up to 1kg due to sufficient vacuum pressure; however, it could perform bending up to 90 degrees for only maximum load of 600 grams. Suggestion for future work is also included in this report.

DEDICATION

Specially dedicate to my beloved family, supervisor, lecturer, seniors and friends who have guided and inspired me through my journey in education. Also thank you to their support, beliefs and motivation.

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2D	-	Two Dimension
3D	-	Three Dimension
CAD	-	Computer Aided Design
CATIA	-	Computer Aided Three-dimensional Interactive Application
DC	-	Direct Current
DOF	-	Degree of Freedom
FKP	-	Fakulti Kejuruteraan Pembuatan
IR	-	Infrared receiver
LCD	-	Liquid Crystal Display
PSM	-	Projek Sarjana Muda
UTeM	-	Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.1 Project Background

Parallel robots are a relatively young type robot that has been developed over 25 years ago and has been implemented in productions for about 15 years. Parallel robots are robots with closed-loop mechanism and consist of three or more rotary or prismatic axes that functional parallel to each other. Parallel robots are designed for high speed applications, manufacturing, packaging, material handling and assembly purpose. A majority of high speed robot is based on delta design which has been developed in 1988 by the Ecole Polytechnique Fédérale de Lausanne (EPFL). Delta architecture robots are highly dynamics due to its lightweight and parallel design. The first commercial Delta robots were produced by BOSCH and ABB. However, ABB FlexPicker is the most sold and fastest commercial parallel robot in world today (Martin, Bernd, and Harald, 2014) (Brinker and Corves, 2015).

Figure 1.1: ABB Delta robot – FlexPicker IRB 340

Delta robot - FlexPicker IRB 340 (shown in Figure 1.1) by ABB that was installed in Robotic Lab at Block B of Faculty of Manufacturing Engineering (FKP) is one of the top most leading robot for industrial use for picking up lightweight products. This robot consists of 4 degree of freedom (DOF); Scara motions which is well adapted to pick and place tasks. All the arms were linked in parallel with three DOF of translation to carry an object from one point to another and a theta axis that enables rotation about a given axis in world coordinates.

The aim of this project is to go one step further and to show that is indeed possible to increase the degree of freedom of the ABB FlexPicker robot in FKP by at least one degree of freedom for automated product assembly task. To do so, a suitable end-effector will be designed that will increase the degree of freedom of the robot. The current robot in FKP uses Vacuum gripper (shown in Figure 1.2) with a fixed end-effector. The vacuum gripper employs suction cups that are made of rubber type material to grip objects in parallel motion. Therefore, by designing a suitable end-effector could increase the flexibility and improving productivity.

Figure 1.2: End-effector and vacuum gripper

1.2 Project Motivation

The end of the end-effector design is to fulfill requirement by adding an extra degree of freedom to the ABB FlexPicker robot system. The design requirement must meet all the specifications to fit the ABB FlexPicker robot. The quote “I haven’t failed, I’ve just found 10,000 ways that won’t work” said by Thomas Alva Edison is taken as inspiration and motivation to complete this report. The great Thomas Alva Edison has failed 1000 times before he made the electric light and this inspired every engineer to no give up on failures and difficulties happen during the journey (David, 2012).

1.3 Problem Statement

The problem arises when the delta robot ABB FlexPicker robot in Robotic Lab at Block B of FKP has limited DOF (degree of freedom) to perform more complex automated product assembly task. The current robot consists of four DOF where by three translations in x, y, z and one rotation about a given axis. The vacuum gripper which was attached to the fixed end-effector provides minimal flexibility of movement. For example, it only picks and place an object in a vertical direction and does not provide gripping at any angles. An initiative to design a flexible end-effector was taken to solve this problem so that the robot can perform gripping at vertical direction with a specified angle. This flexible end-effector is believed to increase the robot's degree of freedom by at least one degree.

1.4 Objectives

1. To design a flexible end-effector in order to increase the degree of freedom of an ABB FlexPicker robot.
2. To develop a prototype of the designed end-effector.

1.5 Scopes

This project mainly concentrates on increasing the degree of freedom for the ABB FlexPicker robot that is located in Robotic Lab at Block B of FKP. A flexible end-effector is designed that is suitable to be installed to the robot. The design is made using SolidWork and then prototyped using suitable method. This end-effector is suitable for lightweight objects below than 1kg and the shape of the work piece is fixed to a square shape objects only.

1.6 Report Structure

This report is divided into five chapters. The first chapter includes the introduction, problem statement, objective and scope of this project. Chapter 2 presents the literature review of this project based on previous research and journals. Chapter 3 delivers the methodology of the project, which is consisted of flow chart, Gantt chart, design and the comparison of the design. Chapter 4 involves the result and discussion based on the prototype, weight lifting test, analysis on the angle of bending of the flexible end-effector relate to motor rotation and also sustainability. Chapter 5 presents the conclusion and recommendation for future improvement of this project. References and appendices are included in the end of the report.

CHAPTER 2

LITERATURE REVIEW

This chapter provides a literature review of the information and data which are obtained from the internet, journals, articles, books and other sources. In this chapter, it will discuss and explain about the degree of freedom of the ABB FlexPicker robot, the existing end-effector and the review on computer aided design (CAD) software.

2.1 Introduction about Delta Robot Technology; ABB FlexPicker IRB 340

Parallel robot is a closed loop mechanism which uses several chains of interconnected links controlled by different actuators either independently or joined. Parallel robots were called ‘parallel’ because they consist of three or more rotary or prismatic axes that functioned parallel to each other. High accuracy, high payloads and high inertia were achieved on this type of robot due to its design structure. Steward Gough is the first person who introduced parallel robot which were called parallel platform that were improved based on serial robot (Hongfei, 2012). Some of the well-known types of parallel robots are Delta, Tricept, and Gough-Steward robot.

One of the most leading types of robot is Delta model which was highly used in pick and place operation. The Delta model robot was invented in early 1980's by a research team lead by Professor Reymond Clavel from EPFL Polytechnic Switzerland with three translational and one rotational degree of freedom. There is no incertitude that his creation was really original and brainy, which it is the most successful parallel robot designed all the turn of the century (Bonev, 2001).

The basic idea of Delta robot came from the parallelogram arrangement of links and joints. It usually contained of three arms connected to universal joint (faceplate) at the bottom and gave three degrees of freedom. The movement of the three axes will move the faceplate in Cartesian coordinates. An additional level of freedom was possible to be added directly in the middle of the faceplate to generate rotation. All the joints were actuated by rotational actuators (AC or DC servo) or with linear actuators (Bonev, 2001). The Figure 2.1 shows the original technical drawing from U.S. Patent No. 4,976,582 is shown.

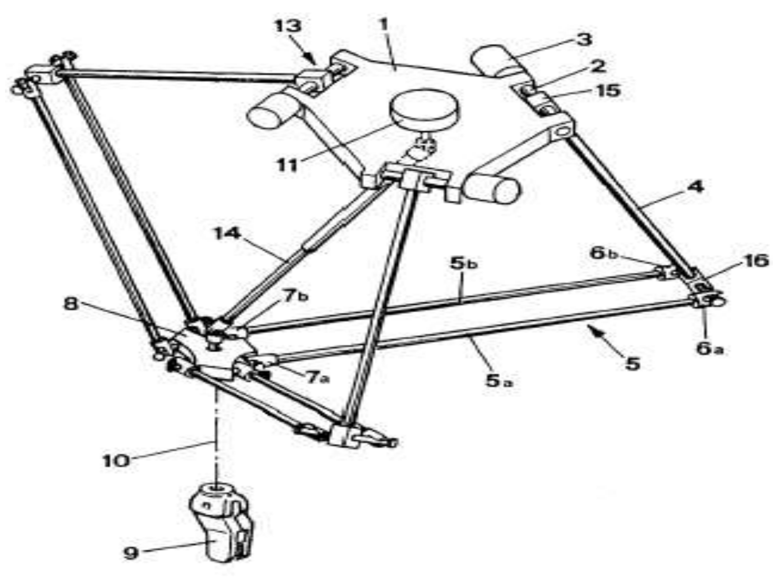

Figure 2.1: Schematic of Delta robot (from U.S. Patent No. 4,976,582)

Table 2.1: Parts of Delta robot (from U.S. Patent No. 4,976,582)

1	Base element	9	Working environment
2	Shaft	10	End-effector joints
3	Fixed parts	11	Fixed motor
4	Arm	12	Controlled system
5	(a)(b) Linking bars	13	Actuator
6	(a)(b) Revolute joints	14	Telescopic arm (optional)
7	(a)(b) Revolute joints	15	First extremity
8	Moveable element	16	Second extremity

There are several companies produces Delta robots such as ABB, Kawasaki, Fanuc and Bosch. The first commercial Delta robots were produced by Bosch and ABB. ABB becomes the leader in state-of-the-art high speed robotic picking and packaging technology for nearly 15 years. The IRB 340 is the first generation FlexPicker robot designed for high speed picks and place tasks (Figure 2.2). The designed principle was quite simple (Martin, Bernd, and Harald, 2014).

Figure 2.2: Pick and place operation of FlexPicker IRB 340 (Hanover, 2004)