UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND ANALYSIS OF ROBOT GRIPPER FOR 10 KG PAYLOAD

Report submitted in accordance with partial requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering (Robotics & Automation)

By

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I hereby declare that this report entitled **"DESIGN AND ANALYSIS OF ROBOT GRIPPER FOR 10 KG PAYLOAD"** is the result of my own research except as cited in the references.

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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 (Robotics and Automation). The members of the supervisory committee are as follow:

……..

(PSM Supervisor)

ABSTRACT

The project of Design and Analysis of Robot Gripper for 10 kg payload is divided into two parts. The first part of the project is about the project's proposal and the second part is about project implementation. This report fully describes about the combination of both parts, which contains five chapters starting from introduction, literature review, methodology, results, discussion and conclusion respectively. The first chapter describes about scopes and objectives of the project and expected results. The main objective of the project is to design and analysis of Robot Gripper for 10 kg Payload. Meanwhile, the second chapter discusses about literature review on designing and analysis of grippers. The next chapter is methodology. This chapter describes about steps or procedures that is used to complete this project. In this project, design and analysis will rely heavily on design software, namely SolidWorks for the analysis, simulation and animation of the gripper's design. The following chapter discusses on the result and discussion about the gripper's design, material selection, and the working architecture of the gripper. Finally, the overall project and its achievements are concluded in chapter five.

ABSTRAK

Projek *Design and Analysis of Robot Gripper for 10 kg Payload* in terbahagi kepada dua bahagian utama. Bahagian pertama projek ini berkenaan dengan cadangan projek manakala bahagian kedua adalah berkenaan dengan implimentasi projek. Laporan ini menerangkan tentang kombinasi kedua-dua bahagian tersebut, dimana ia mengandungi lima bab, bermula dengan pengenalan, kajian ilmiah, metodologi, keputusan, perbincangan, dan berakir dengan kesimpulan. Bab pertama menerangkan skop dan objektif projek dan keputusan yang dijangka. Objektif utama projek ini adalah untuk merekabentuk dan menganalisa *Robot Gripper* yang boleh mengangkat bebean 10 kg. Manakala, bab kedua menerangkan tentang kajian ilmiah mengenai proses merekabentuk dan menganalisa *Robot Gripper*. Bab ketiga pula menerangkan tentang cara-cara projek ini dilaksanakan. Projek ini bergantung sepenuhnya kepada penggunaan program SolidWorks untuk menganalisa dan merangsang pergerakan *gripper* tersebut. Bab yang seterusnya pula membincangkan keputusan projek dan juga membincangkan tentang rekabentuk *gripper* tersebut, bahan yang digunakan, dan konsep pergerakan *gripper* tesebut. Laporan ini diakhiri dengan kesimpulan keseluruhan dan pencapaian projek.

DEDICATION

Dedicated to my Friends and Family

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

GM	-	General Motors
DC	-	Direct Current
PSM	-	Projek Sarjana Muda
kg	-	Kilograms
mm	-	Milimeters
lb	-	Pounds
lbf	-	Pounds x Feet
N	-	Newton
N/m^2	-	Unit for yield strength of material, $\frac{Newton}{Meter^2}$
UTeM	-	Universiti Teknikal Kebangsaan Malaysia Melaka
FOS	-	Factor of Safety
Ø	-	Diameter

CHAPTER 1
INTRODUCTION

1.1 Introduction

A robot gripper is an end-effector or sometimes called end-of-arm tooling that is used on industrial robots for material handling, e.g. grasping, holding, lifting, moving and controlling materials. Robot grippers are very important tools because without it, industrial robot cannot be used in material handling applications.

Robot grippers are meant to replace human hands because they are very good for repetitive cycles, handling heavy loads, and operate under extreme temperatures and environments where human hands cannot operate. Since robot grippers are usually custom designed for its particular applications, this project will discuss in detail about the design of a robot gripper specifically designed for pick and place application of a standard commercial 10 kg rice bag.

In this project, all aspects with regards to designing a robotic gripper for the purpose of material handling will be discussed. It will start from defining the purpose of designing this gripper, actual design of the gripper, finite analysis of the design, and finally a simulation of the robot gripper in its intended working environment and proposed layout of the automation system.

1.2 Objective

The main objective of this project is to design and perform analysis on a robot gripper specifically for the use of material pick and place application. This robot gripper will be handling rice bags with the load of 10 kg. This is objective can be achieved with the aid of simulation software. On top of that are some additional objectives that are related to this project:

a) To conduct research on the topic that is related to this project.
b) To implement the knowledge gained from the research to design a robot gripper that is able to pick and place rice bags with 10 kg load.
c) To conduct full finite analysis of the design.
d) To produce complete assembly drawing of the robot gripper.
e) To run simulation on the gripper's working condition.

1.3 Scope

Since designing a robot gripper is a vast and wide title, the scope for this project has been scaled down so that the project's objectives can be achieved. First and foremost, this project will cover:

a) Design of a robot gripper that is able to pick and place standard commercial 10 kg rice bags from conveyor to stacking pallet for stacking purposes.
b) Finite analysis of the design such as movement analysis and material stress for the load that the gripper will handle. This is done with the help of design software such as CATIA or SolidWorks.
c) Producing a complete engineering drawing for the final assembly of the robot gripper.
d) Simulate the Gripper in its working condition.

Stated above are the scopes that are covered in this project. As for the robot gripper, there are certain requirements that this gripper needs to meet. They are:

a) The gripper must be able to pick and place standard commercial 10 kg rice bags with general size of approximately 51 cm x 40 cm x 9 cm (L) x (W) x (H).
b) The gripper must be strong enough to pick and place the commercial rice bags but it must also be gentle so that it will not puncture or cause damage to those bags in the process.
c) The gripper must be designed so that it can be attached to COMAU SMART NS ROBOT ARM model robot that is available in the Manufacturing Faculty's Lab.
d) Pneumatic actuators are used as a driving force for this gripper.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter describes the literature review that is done to gain more information on this project. The beginning part of this chapter explains the history of Industrial Robots and types of robots that are available. This will be followed by information pertaining robot grippers or end effectors. Finally, information on gripper design consideration will be available at the end of this chapter.

An industrial robot is officially defined ISO [1] as an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. The modern concept of industrial robotic manipulators was only introduced in late 1950s by G. C. Devol (U.S. Patent 2988237) and later joined by J. Engelberger to start up Unimation Inc. They are the originators of the first industrial robot by Unimation Inc. in the 1959. The first installation of the Unimate robot for loading/unloading a die-casting machine at GM was in 1961 [2].

Early industrial robots were developed to perform operations in hostile environments such as inside radioactive chambers. Later, robots were applied to perform work in undesirable environments and in applications which were dull and monotonous. Today industrial robots can be found in almost all manufacturing applications, ranging from machine servicing to welding to painting. Usage of robots for pick and place applications is the fastest growing segment of robotic [3], [4]. This is where the robot picks up an item, perhaps changes its orientation and puts it back, or moves it to another location and releases it there.

There are many types of industrial robots that are being used in industries nowadays. A simple example is an industrial robot manipulator with six degrees of freedom. It has the features of a human chest, upper arm, forearm and wrists respectively [3]. Therefore, it can be said that robots are designed to emulate human hand. The only difference is that it is much bigger compared to human hand.

Same as humans, industrial robots needs some sort of device so that it can interact with the world around it in a form of grasping, manipulating parts and so on. This device is called robot gripper or sometimes called end effectors or end-of-arm tooling [5]. End effectors should not be considered as accessories, but as a major component in any industrial robot application. Proper selection and design of end effectors can make the difference between success and failure in many process applications, particularly when one includes reliability, efficiency, and economic factors. End effectors consist of the fingers, the gripper, and the wrist.

According to the Robotic Industry Association, there are currently over 118,000 robots being used in the United States alone. The industry has seen significant growth over the past five years, having record sales in 1999 and 2000 with new unit sales exceeding one billion dollars in the year 2000 [6].

Since cost of grippers may be as high as 20% of a robot's cost, depending on the application and part complexity [7], no wonder robotic grippers are a $ 31M industry [6]. Engineers and designers are striving very hard to keep the cost of robotic grippers as low as possible. Therefore, developing a multipurpose gripper is not a good solution because it involves exaggerated cost. This is one of the main reasons why grippers are design for specific application only. This is to ensure that simple design can be produced, thus cutting the initial cost for an automation system.

Even though there is a rationale behind the statement above, the decision to design grippers, either it is a multipurpose gripper or a single application gripper depends on the types of application that the particular company is using the robot for. It all depends on the cost benefit analysis that the company requires.

2.2 Industrial Robot

All common commercial industrial robots are serial-link manipulators, usually with no more than six kinematically coupled axes of motion. By convention, the axes of motion are numbered in sequence as they are encountered from the base up to the wrist. The first three axes account for the spatial positioning motion of the robot. Their configuration determines the shape of the space through which the robot can be positioned. Any subsequent axes in the kinematic chain generally provide rotational motions to orient the end of the robot arm and are referred to as wrist axes. There are two primary types of motion that a robot axis can produce in its driven link, either revolute or prismatic. It is often useful to classify robots according to the orientation and type of their first three axes [3], [8], [9], [14].

Robot component consists of:

a) Arm
b) Gripper
c) Actuators
d) Sensors
e) Controllers

2.3 Gripper Types

Gripper is an end-of-arm device often used in material handling applications. Grippers range in size from smaller than a matchbox to models weighing several hundred pounds, capable of thousands of pounds of grip force. Generally, the gripper is a device that is capable of generating enough grip force to retain an object while the robot performs a task on the part such a pick-and-place operation. Each gripper must be capable of performing the task of opening and closing with a prescribed amount of force over many years of daily operation [10], [11].

The most commonly used grippers are finger grippers. These grippers generally have two opposing fingers or three fingers like a lathe chuck. The fingers are driven together such that once gripped any part is centered in the gripper. This gives some flexibility to the location of components at the pick-up point. Two finger grippers can be further split into parallel motion or angular motion fingers.

Angular jaw gripper open and close around a central pivot point, moving in an arcing motion. An angular gripper is used when there is a need to get the tooling out of the way. The advantage for an angular gripper falls on its simple design and only requires one power source for activation. However, it has several disadvantages including jaws that are not parallel and a changing centre of grasp while closing.

Meanwhile, parallel jaw gripper moves in a motion parallel in relation to the gripper's body. A parallel gripper is used for pulling a part down inside a machine because the fingers fit into small areas better. An advantage of parallel type gripper is that the centre of the jaws does not move perpendicular to the axis of motion. Thus, once the gripper is centred on the object, it remains centred while the jaws close. Space constraints might lead to the use of parallel over angular [4], [10], [11], [12], [13]. Figure 2.1 and Figure 2.2 shows the Parallel Jaw and Angular Jaw Gripper.

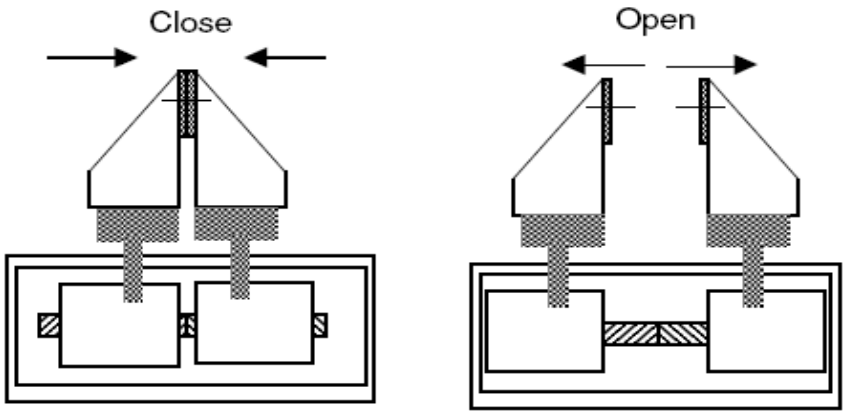

Figure 2.1: Parallel Jaw Gripper

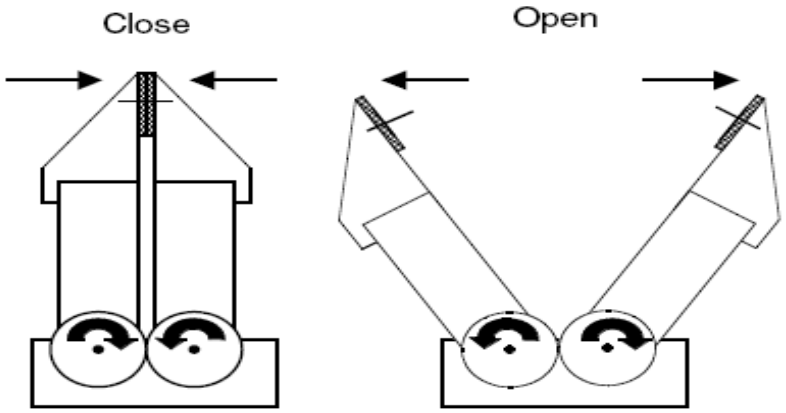

Figure 2.2: Angular Jaw Gripper

For some tasks however where flexible or fragile objects are being handled, the use of either vacuum or magnetic grippers is preferable. With these, the surface of the gripper is placed in contact with the object and either a magnetic field or a vacuum is applied to hold them in contact. Therefore, the types of basic gripper can be summarized in Table 2.1 [11].

Table 2.1: Summary of Gripper Types

Type	Application/Ideal Part	Description	Mechanism
Angular 2-jaw or 3-jaw	Pick-and- place, spheres	Jaws rotate about a fixed pivot point	Toggle arms, Cams, Gears
Parallel(P-3400) 2-jaw or 3-jaw	General use, material handling, rod/billet stock, wheel rims	Jaws translate, often though parallel motion	Toggle arms, Cams, Gears, Wedges
Collet	Pins, contacts, round stock	Collet grips round part on OD o ID	Sliding Taper
Vacuum	Windshields, windows. Shrink wrapped products	Suction cups grip smooth pats	Air pressure/vacuum
Magnetic	Sheet metal	Electro-magnet picks-up ferrous objects	Magnetic field
Needle	Fabrics	Sharp pins extend/retract at opposing angles	Cam
Expansion	Glassware	Inflatable bladder expands inside cavity	Air pressure

There are additional two types of gripper that are used in industries. These grippers are a combination of the basic parallel and angular type. The first gripper is four-bar jaw linkage gripper. Each jaw is a four-bar linkage that maintains the opposing jaws parallel while closing. A disadvantage of this design is the changing centre of grasp while closing the jaws [10].

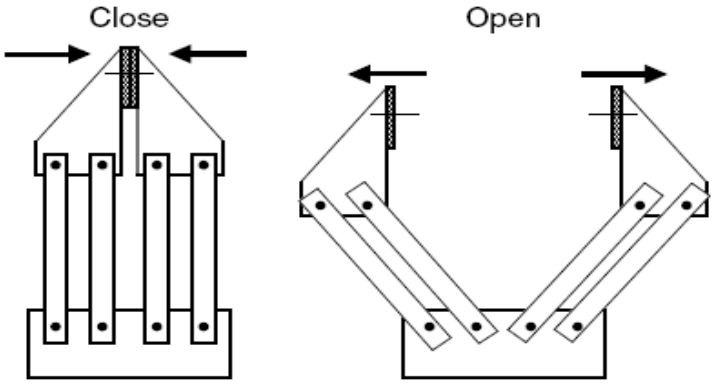

Figure 2.3: Four-bar Linkage Jaw Gripper Type

Meanwhile, the second type is the multiple jaw/chuck style. The gripper's jaws operated similarly to a machine tool multi-jaw chuck as seen in lathe machine chuck. This gripper is suitable for holding round and rod-like objects. The disadvantage however for this type of gripper is that its design caused it to become heavier and its limited to certain application only [10].

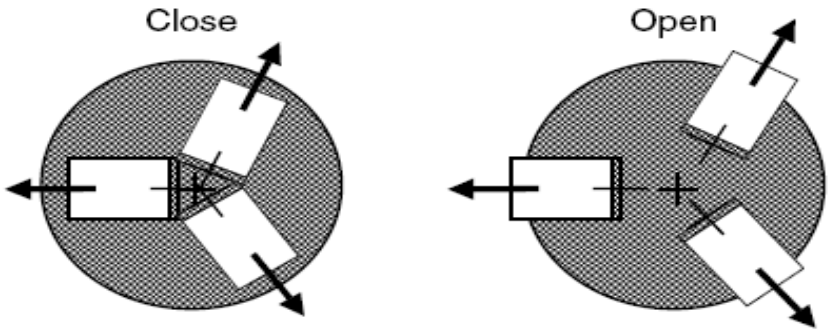

Figure 2.4: Multiple Jaw Chuck Type